THE WILLINGNESS OF BROILER FARMERS IN THE GAUTENG PROVINCE TO ADOPT ALTERNATIVE FEEDS MADE FROM AMARANTHUS AND SORGHUM

by

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Submitted in accordance with the requirements

for the degree

MASTERS OF SCIENCE

In the

Subject

AGRICULTURE

at the

UNIVERSITY OF SOUTH AFRICA (UNISA)

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31 JANUARY 2022

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ACKNOWLEDGEMENTS

- Undertaking the master's study has been a massive task, which would not have been possible without the guidance, backing, and support of several institutions and individuals. I want to acknowledge the significant contributions they made in producing this dissertation.
- To my supervisors, Prof. Monnye Mabelebele and Mr Matome Maake, you have continuously believed in my academic potential and shown me steady support, commitment and guidance which you have provided me over the years. I am forever grateful for your time and effort in reading and providing constructive reviews on many versions of this thesis. Over the years, you have taught me what a scholar entails: critical thinking when undertaking research and being creative, which you did with high levels of patience, calmness, and grace. Your words of encouragement and your positive attitude have kept me motivated throughout. I am grateful for the many learning opportunities you have created for me over these years, such as putting together a good research paper, data analysis and interpretation.
- To my beloved immediate family, my parents (Ramatsimele Margaret and Mpadima Caiphus Marape), my sisters (Nnono, Mmaphakisho and Basetsana Marape) and my aunt (Dillis Phatudi-Mphahlele), you have supported me throughout my academic journey and for that I thank you. Your selfless acts of kindness are a constant reminder of where I come from.
- To my friends, Ikageng Maluleke, Thapelo Machaba, Michael Nchejane, Gomolemo Kototsi, Dr Precious-Pearl Leselo, Conce Moraba, Reabetjoe Mokoko, among others, thank you for your continuous prayers, support, encouragement and contribution towards this thesis.
- Thank you to the Gauteng Department of Agriculture Rural Development (GDARD) for permitting me and providing the Gauteng poultry farmers' list and contact details. Your efforts are genuinely appreciated.
- I would like to express my absolute gratitude to the sponsor, the University of South Africa and its Postgraduate Bursary staff for providing funding to further my studies.
- Above all, I am thankful to the Almighty God. I experienced several challenges, some of which were life-threatening, but through God's grace, I have been able to complete this study.

DEDICATION

This dissertation is dedicated to my mother, Ramatsimele Margaret Marape, for being the most dependable, supportive and amazing mother I know. For this reason, this master's degree is wholeheartedly dedicated to her.

ABSTRACT

In broiler production, feeding constitutes the highest variable cost accounting for up to 70% of the total production cost. As a result, broiler farmers have a challenge of high feed costs. High feed costs are influenced by increasing prices of feed ingredients, especially energy and protein sources. Therefore, there is a need to develop affordable chicken feed made from alternative energy and protein sources. This study aimed to assess broiler farmers' acceptability of alternative chicken feeds made from amaranthus and sorghum as energy and protein sources in the Gauteng Province. The objectives of the study were to profile farmers' socio-demographic characteristics; to determine the operation and production characteristics of broiler enterprises; to determine farmer's willingness to adopt alternative chicken feed made from amaranthus and sorghum as energy and protein sources; to ascertain factors influencing farmer's willingness to adopt alternative feeds made from amaranthus and sorghum as energy and protein sources, respectively; and to identify the challenges experienced by broiler farmers. The study was conducted in Gauteng using a quantitative research approach and survey design. Data were collected from 70 broiler farmers through telephonic interviews using a semi-structured survey instrument (questionnaire). The Statistical Package for the Social Sciences (SPSS) version 27 was used to analyse quantitative data. Descriptive statistics, Kendall's Tau, Pearson Correlation, Ordered Logistic Regression, Binomial test, Friedman's test and Wilcoxon signed ranks test were used to analyse the data. Themes, codes, frequencies and percentages were used to analyse qualitative data from open-ended questions. The findings of the socio-demographic characteristics of respondents showed that the majority (95.7%) of the respondents were married black African men (52.9%) above 55 years of age with nine years of farming experience. Most of the respondents (94%) had a basic formal education; in addition, about 50% owned their farmland privately, with an average size of 11.17 ha. One-third of the respondents depended on self-employment opportunities as their main source of income while the majority (54.3%) had an annual net farm income of between R10 000 and R90 000. The annual net farm income had a positive and significant correlation with gender, the carrying capacity of a poultry house and the number of production cycles per annum. It was also found that most (>50%) farmers had inadequate access to market and government services (extension and subsidised feed). The study further revealed that, on average, broiler farmers had two chicken houses with a carrying capacity of 1 804 and a 7.6%

mortality rate per cycle. On average, the number of production cycles were five; and the respondents utilised about 122 feedbags per annum. The majority (73%) of the respondents preferred the pellets feed form. The respondents achieved an average chicken live weight of 1.9 kg and anticipated an average weight of 2 kg. Moreover, farmers travelled 20 km on average to the nearest feed store. The number of chicken houses, the number of production cycles per year and the anticipated chicken live weight were positive and significant predictors of farmers' willingness to adopt alternative chicken feeds made from amaranthus and sorghum.

The study found that most respondents (90%) were willing to adopt alternative chicken feed made from amaranthus and sorghum as a source of energy and protein, respectively. The overall results of the mean rank showed that the accessibility of chicken feed (MR=1) was the most important attribute associated with the adoption of alternative chicken feed, followed by the desired chicken attributes (MR=2) and the affordability attributes (MR=3). The results of Friedman's test revealed that there was a statistically significant difference ($p<0.01$) between the three variables (desired attributes, affordability and accessibility). The Wilcoxon sign rank test discovered that farmers were significantly willing to adopt alternative chicken feed made from amaranthus and sorghum if it was more accessible than enabling them to achieve the desired chicken attributes. In addition, a significant number of broiler farmers were willing to adopt alternative chicken feed if it was more accessible rather than affordable. The mean rank results of accessibility variables showed that the most important factors are lower transport costs to buy feed, feed accessible at any time of the day and easily accessible supplier location attributes. The variables scored the same mean rank (MR=1). On the other hand, the important predicting variables for chicken attributes and affordability were live weight and the reduced number of feedbags purchased variables, respectively. Farmers' willingness to adopt chicken feed made from amaranthus and sorghum was positively and significantly ($p<0.05$) influenced by their number of chicken houses, number of production cycles per annum, and anticipated chicken live weight. The results showed the main challenges experienced by broiler farmers were high feed costs; low-quality feed; lack of access to markets; high transport costs; inadequate nutrients in feeds; low-profit margins; a high mortality rate; and reduced live weight. Based on the results of the current study, it is recommended that young people should be encouraged to

participate in broiler farming activities. Again, the alternative feed made from amaranthus, and sorghum should be accessible to increase broiler farmers’ adoption rate. Since the research is continuous, it is also recommended that an experiment be conducted to compare the performance of conventional chicken feed against non-conventional chicken feed made from amaranthus and sorghum, and the cost analysis of both.

KEYWORDS: Broilers, alternative chicken feed, amaranthus, sorghum, adoption of innovation, Gauteng

KAKARETŠO (SEPEDI ABSTRACT)

Ka go tšweletšo ya dikgogo tša nama, go fepa go akaretša karolo ya godimodimo ya ditshenyagalelo tše di balelwago go diphesente tše 70% tša palomoka ya ditshenyagalelo tša tšweletšo. Ka lebaka leo, barui ba dikgogo tša nama ba na le tlhotlo ya ditshenyagalelo tša godimo tša phepo ya dikgogo. Ditshenyagalelo tša godimo tša phepo di huetša ke theko ya godimo ya ditswaki tša phepo, kudu methopo ya enetši le proteine. Ka gona, go na le tlhokego ya go hlama phepo ya dikgogo ye e dirilwego go tšwa go methopo ye mengwe ya enetši le proteine. Thuto ye e be e ikemišeditše go sekaseka kamogelo ya barui ba dikgogo tša nama ya diphepo tše dingwe tša dikgogo tše di dirilwego go tšwa go morogo le mabelethoro bjalo ka methopo ya enetši le proteine ka profenseng ya Gauteng. Maikemišetšo a dinyakišišo tše e be e le go hlaloša dipharologanyo tša dipalopalo tša barui; go hlatha dipharologanyo tša ditshepedišo le ditšweletšo tša dikgwebo tša dikgogo tša nama; go laetša go ikemišetša ga barui go amogela diphepo tše dingwe tša dikgogo tše di dirilwego go tšwa go morogo le mabelethoro bjalo ka methopo ya enetši le proteine; go kgonthišiša mabaka ao a huetšago barui go amogela diphepo tše dingwe tšeo di dirilwego go tšwa go morogo le mabelethoro bjalo ka methopo ya enetši le proteine, ka go fapana ga tšona; le go hlatha ditlhohlo tšeo di itemogelwago ke barui ba dikgogo tša nama. Dinyakišišo tše di dirilwe ka Gauteng ka go šomiša tebelelo ya boleng ya go dira dinyakišišo le tshekatsheko. Datha e kgobokeditšwe go tšwa go barui ba dikgogo tša nama ba 70 ka dipoledišano tša mogala ka go šomiša sedirišwa sa tshekatsheko ya tekolonyakišišo (lenaneopotšišo). Go šomišitšwe karolo ya 27 ya Sedirišwa sa go Bala Dipalopalo sa Mahlale a Leago (SPPS) go sekaseka datha ya boleng. Dipalopalo tše di hlalošago, *Kendall's Tau, Pearson Correlation, Ordered Logistic Regression,* teko ya Karolopedi, teko ya Friedman le diteko tša maemo a saennwego tša Wilcoxon di šomišitšwe go sekaseka datha. Dihlogotaba, dikhouto, dikelo le diphesente di šomišitšwe go sekaseka datha ya boleng go tšwa go dipotšišo tše di ka botšošološwago. Dikutollo tša dipharologanyo tša dipalopalo tša bakgathatema di bontšhitše gore bontši bja bakgathatema e be e le banna ba bathobaso ba Maafrika bao ba nyetšwego (52.9%) ba mengwaga ya ka godimo ga ye 55 bao ba nago le maitemogelo a mengwaga ye senyane ya borui. Bontši bja bakgathatema (94%) ba be ba na le thuto ya motheo ya semmušo; go tlaleletša se, ba e ka bago ba diphesente tše 50% ba be ba na le naga ya polasa ya bona ya praebete, moo naga yeo e lego bogolo bja tekano ya dihektara tše 11.17 ha. Teetharong ya bakgathatema e be e

ithekgile ka dibaka tša go ipereka bjalo ka mothopo wa bona wo mogolo wa letseno mola bontši (54.3%) ba be ba na le palomoka ya letseno la ngwaga ka ngwaga la polasa la magareng ga R10 000 le R90 000. Palomoka ya letseno la ngwaga ka ngwaga la polasa le be le na le tswalano ye botse le ye bohlokwa le bong, bokgoni bja ntlo ya dikgogo bja go rwala palo ye e itšego ya dikgogo gammogo le palo ya ditšweletšo tša dikgogo ka ngwaga. Go hweditšwe gape gore bontši (>50%) bja barui ba be ba se na phihlelelo ye e lekanego go mmaraka le ditirelo tša mmušo (katološo le thušo ya ditšhelete tša diphepo). Thuto e utollotšwe gape gore, ka setlwaedi, barui ba dikgogo tša nama ba be ba na le dintlo tše pedi tša dikgogo tšeo di nago le bokgoni bja go rwala dikgogo tše 1 804 le tekano ya diphesente tše 7.6% tša tekano ya go hwa ga dikgogo go tšweletšo ye nngwe le ye nngwe. Ka kakaretšo, go bile le tekano ya ditšweletšo tša dikgogo tše hlano ka palo; ebile bakgathatema ba šomišitše mekotla ya phepo ye e ka bago 122 ngwaga ka ngwaga. Bontši (73%) bja bakgathatema bo ratile mokgwa wa go fepa ka tšhomišo ya didirišwa tše di bitšwago diphelete. Bakgathatema ba fihleletše tekano ya boima bja kgogo ye e phelago bja 1.9 kg gomme ba letela gore bo fihlelele tekano ya boima bja 2 kg. Go feta fao, barui ba ile ba sepela dikilometara tše 20 ka kakaretšo go ya lebenkeleng la kgauswi la go hwetša phepo. Palo ya dintlo tša dikgogo, palo ya ditšweletšo tša dikgogo ngwaga ka ngwaga le boima bjo bo letetšwego bja dikgogo tše di phelago e be e le dintlha tše botse le tše bohlokwa tša barui gore ba akanye go ikemišetša go amogela diphepo tša dikgogo tše dingwe tšeo di dirilwego go tšwa go morogo le mabelethoro.

Nyakišišo e hweditše gore bontši bja bakgathatema (90%) ba be ba ikemišeditše go amogela diphepo tša dikgogo tše dingwe tšeo di dirilwego go tšwa go morogo le mabelethoro bjalo ka mothopo wa enetši le proteine, ka go fapana ga tšona. Dipoelo ka kakaretšo tša maemo a magareng di bontšhitše gore phihlelo ya diphepo tša dikgogo (MR=1) e be e le ntlha ye bohlokwa kudu yeo e amanago le go amogelwa ga diphepo tše dingwe tša dikgogo, gwa latelwa ke ntlha ya nyakego ya dikgogo (MR=2) gammogo le ntlha ya go rekega ga diphepo (MR=3). Dipoelo tša teko ya Friedman di utollotšwe gore go be go na le diphapano tše bohlokwa tša dipalopalo ($p<0.01$) magareng ga dintlha tše tharo (ntlha ya nyakego, go rekega le phihlelelo). Teko ya maemo a maswao a Wilcoux e utollotšwe gore barui ba be ba ikemišeditše kudu go amogela diphepo tše dingwe tša dikgogo tše di dirilwego go tšwa go morogo le mabelethoro ge e le gore di be di fihlelelega go feta go ba

kgontšha go fihlelela dintlha tša dikgogo tše di nyakegago. Go tlaleletša se, palo ya go bonala ya barui ba dikgogo tša nama ba be ba ikemišeditše go amogela diphepo tše dingwe tša dikgogo ge e le gore di be di rekega go feta go fihlelelega. Dipoelo tša maemo a magareng a dintlha tša phihlelelo di bontšhitše gore mabaka a bohlokwa kudu ke ditshenyagalelo tša fase tša dinamelwa go reka diphepo, diphepo tše di fihlelelegago ka nako efe goba efe ya letšatši gammogo le lefelothekišo la moabi wa diphepo yo a fihlelelegago ga bonolo. Dintlha di fihleletše maemo a magareng a go swana a (MR=1). Ka go le lengwe, dintlha tše bohlokwa tše di akantšwego e be e le boima bja dikgogo tša go phela le phokotšo ya nomoro ya mekotla ya phepo ye e rekilwego, ka go fapana ga tšona. Go ikemišetša ga barui go amogela diphepo tša dikgogo tše di dirilwego go tšwa go morogo le mabelethoro go be go hlohleleditšwe ka tsela ye botse le ye bohlokwa ($p<0.05$) ke palo ya bona ya dintlo tša dikgogo, palo ya ditšweletšo tša dikgogo ngwaga ka ngwaga, le boima bja dikgogo tše di phelago bjo bo letetšwego. Dipoelo di bontšhitše gore ditlhohlo tše kgolo tšeo di itemogetšwego ke barui ba dikgogo tša nama e be le theko ya godimo ya diphepo tša dikgogo; diphepo tša boleng bja fase; go hloka phihlelelo ya mebaraka; ditshenyagalelo tša godimo tša dinamelwa; ditswaki tša diphepo tše di sa lekanego; dipoelo tša fase tša go dira letseno la tlaleletšo; maemo a godimo a go hwa ga dikgogo; gammogo le go fokotšega ga boima bja dikgogo tše di phelago. Go ya ka dipoelo tša nyakišišo ya bjale, go eletšwa gore baswa ba swanetše go hlohleletšwa go tšea karolo mešomong ya borui bja dikgogo tša nama. Gape, diphepo tše dingwe tše di dirilwego go tšwa go morogo, le mabelethoro di swanetše go fihlelelwa go oketša tekano ya godimo ya kamogelo ya barui ba dikgogo tša nama. Ka ge nyakišišo e tšwela pele, go eletšwa gape gore go dirwe teko ya go bapetša tshepedišo ya phepo ya dikgogo ya setlwaedi kgahlanong le phepo ya dikgogo ye e sego ya setlwaedi yeo e dirilwego go tšwa go morogo le mabelethoro, gammogo le tshekatsheko ya ditshenyagalelo tša bobedi bja diphepo.

MANTŠU A BOHLOKWA: Dikgogo tša nama, diphepo tše dingwe tša dikgogo, morogo, mabelethoro, kamogelo ya boitlhamelo, Gauteng

OPSOMMING (AFRIKAANS ABSTRACT)

In braaihoenderproduksie is voeding die hoogste veranderlike koste en dit is verantwoordelik vir tot 70% van die totale produksiekoste. Gevolglik is hoë voedingskoste ’n uitdaging vir braaihoenderboere. Hoë voedingskoste word beïnvloed deur ’n toename in voedingsbestanddele, veral energie- en proteïenbronne. Daar is dus ’n behoefte om bekostigbare hoendervoer te ontwikkel wat vervaardig word uit alternatiewe energie- en proteïenbronne. Hierdie studie is daarop gerig om braaihoenderboere se aanvaarding van alternatiewe hoendervoer wat van amaranthus en sorghum as energie- en proteïenbronne gemaak word, te assesseer in die Gauteng-provinsie. Die doelwitte van die studie was om boere se sosiodemografiese eienskappe te profileer; om die werking- en produksie-kenmerke van braaihoender-ondernemings te bepaal; om boere se gewilligheid om alternatiewe hoendervoer aan te neem wat gemaak word van amaranthus en sorghum as energie- en proteïenbronne te bepaal; om vas te stel wat die faktore is wat ’n invloed het op boere se gewilligheid om alternatiewe hoendervoer aan te neem wat gemaak word van amaranthus en sorghum as energie- en proteïenbronne, onderskeidelik; en om die uitdagings te identifiseer wat deur braaihoenderboere ervaar word. Die studie is uitgevoer in Gauteng deur gebruik te maak van ’n kwantitatiewe navorsingsbenadering en peilingsontwerp. Data is ingesamel by 70 braaihoenderboere deur telefoniese onderhoude met gebruik van ’n semi-gestruktureerde peilingsinstrument (vraelys). Die “Statistical Package for the Social Sciences (SPSS)”, weergawe 27, is gebruik om die kwantitatiewe data te ontleed. Beskrywende statistieke, “Kendall’s Tau”, Pearson se korrelasie, geordende logistiese regressie, biomiese toets, Friedman se toets en Wilcoxon se toets van betekende range is gebruik om die data te analiseer. Temas, kodes, frekwensies en persentasies is gebruik om kwalitatiewe data van die ope vrae te ontleed. Die bevindings van die sosio-demografiese kenmerke van die respondente het getoon dat die meerderheid getroude, swart Afrika-mans is bo die ouderdom van 55 jaar met nege jaar se ondervinding in boerdery. Die meeste van die respondente (94%) het ’n basiese formele opvoeding gehad; verder het sowat 50% getoon dat hulle in private besit was van hulle landbougrond, met ’n gemiddelde grootte van 11.17 hektaar. Een-derde van die respondente was afhanklik van selfwerksaamheidsgeleenthede as hulle hoofbron van inkomste, terwyl die meerderheid (54.3%) ’n jaarlikse netto plaasinkomste van tussen R10 000 en R90 000 gehad het. Die jaarlikse netto plaasinkomste het ’n positiewe en beduidende korrelasie met geslag, die

dravermoë van ’n hoenderhuis en die aantal produksiesiklusse per jaar. Daar is ook gevind dat die meeste boere (>50%) nie genoegsame toegang tot mark- en regeringsdienste (uitbreiding en gesubsidieerde voeding) het nie.

Die studie het verder getoon dat braaihoenderboere gemiddeld twee pluimveehokke met ’n dravermoë van 1 804 hoenders en ’n sterftesyfer van 7.6% per siklus het. Die gemiddelde produksiesiklusse was vyf, en die respondente het 122 voersakke per jaar gebruik. Die meerderheid (73%) van die respondente het die korrelvoedingsvorm verkies. Die respondente het ’n gemidddelde lewende gewig per hoender van 1.9 kg bereik en ’n gemiddelde gewig van 2 kg verwag. Daarby het boere gemiddeld 20 km gereis na die naaste voedingspakhuis. Die aantal pluimveehokke, die aantal produksiesiklusse per jaar en die verwagte lewende gewig van die hoenders was positiewe en beduidende voorspellers van boere se gewilligheid om alternatiewe hoendervoer gemaak van amaranthus en sorghum aan te neem.

Die studie het bevind dat die meeste respondente (90%) gewillig was om alternatiewe hoendervoer aan te neem wat van amaranthus en sorghum gemaak is as ’n bron van energie en proteïen, onderskeidelik. Die algehele resultate van die gemene rang het getoon dat die toeganklikheid van hoendervoer (MR=1) die belangrikste eienskap is geassosieer met die aanneming van alternatiewe hoendervoer, gevolg deur die gewenste hoendereienskappe (MR=2) en die bekostigbaarheidseienskappe (MR=3). Die resultate van Friedman se toets het onthul dat daar ’n statisties beduidende verskil ($P<0.01$) is tussen die drie veranderlikes (gewenste kenmerke, bekostigbaarheid en toeganklikheid). Die Wilcoxon se toets van betekende range het onthul dat boere beduidend gewillig was om alternatiewe hoendervoer gemaak van amaranthus en sorghum aan te neem indien dit meer toeganklik was om hulle in staat te stel om te voldoen aan die gewenste hoendereienskappe. Verder was ’n beduidende aantal braaihoenderboere gewillig om die alternatiewe hoendervoer aan te neem indien dit meer toeganklik eerder as bekostigbaar is. Die gemene rang-resultate van toeganklikheidsveranderlikes het getoon dat die belangrikste faktore laer vervoerkoste om voeding te koop, voeding wat enige tyd van die dag toeganklik is, en maklik toeganklike verskaffersligging-eienskappe is. Die veranderlikes het dieselfde gemene rang aangeteken (MR=1). Daarenteen was die voorspellende veranderlikes vir hoender-eienskappe en -

bekostigbaarheid lewende gewig en die verminderde aantal veranderlikes vir aangekoopte voersakke, onderskeidelik. Boere se gewilligheid om hoendervoer gemaak van amaranthus en sorghum aan te neem was positief en beduidend ($p<0.05$) en beïnvloed deur die aantal pluimveehokke, aantal produksiesiklusse per jaar, en die verwagte lewende gewig van die hoenders. Die resultate het getoon dat die hoof uitdagings wat deur braaihoenderboere ervaar word, insluit die hoë koste van voer; lae-gehalte voer; gebrek aan toegang tot markte; hoë vervoerkoste; onvoldoende nutriënte in voer; lae-wins marge; 'n hoë sterftesyfer; en verminderde lewende gewig. Gebaseer op die resultate van die huidige studie word daar aanbeveel dat jong mense aangemoedig moet word om deel te neem aan braaihoenderboerdery-aktiwiteite. Weereens, die alternatiewe voer gemaak van amaranthus en sorghum moet toeganklik wees om braaihoenderboere se aannemingssyfer te verhoog. Aangesien die navorsing aaneenlopend is, word daar ook aanbeveel dat 'n eksperiment uitgevoer moet word om die verrigting van gewone hoendervoer teenoor nie-gewone hoendervoer gemaak van amaranthus en sorghum te vergelyk, asook die koste-analise van beide soorte voer.

SLEUTELWOORDE: Braaihoenders, alternatiewe hoendervoer, amaranthus, sorghum, aanneming van innovasie, Gauteng

LIST OF ACRONYMS AND ABBREVIATIONS

AFMA	Animal Feed Manufacturers Association
ANF	Anti-Nutritional Factors
BFAB	Bureau for Food and Agricultural Policy
BFAB	Bureau for Food and Agricultural Policy
CDC	Centre of Disease Control
DAFF	Department of Agriculture, Forestry and Fisheries
DALRRD	Department of Agriculture, Land Reform and Rural Development
DF	Degrees of Freedom
DM	Dry Matter
DTI	Department of Trade and Industry
EU	European Union
FAO	Food and Agriculture Organisation
FCR	Feed Conversion Ratio
FOB	Free on Board
GDARD	Gauteng Department of Agriculture and Rural Development
GDP	Gross Domestic Product
GDRC	Global Development Research Centre
GM	Genetically Modified
HA	Hectare
HSRC	Human Science Research Council
IQF	Individual Quick Freezing
ITAC	International Trade Administration Commission
MDM	Mechanically Deboned Meat
ME	Metabolizable Energy
NAMC	National Agricultural Marketing Council
OLR	Ordered Logistic Regression
pH	Power of Hydrogen

SA	South Africa
SAG	South African Government
SAHRC	South African Human Right Commission
SAPA	South African Poultry Association
SARS	South African Revenue Service
SBM	Soybean Meal
SMME	Small, Medium Micro Enterprises
SPS	Sanitary and Phytosanitary Standards
SPSS	Statistical Package for Social Sciences
STATS SA	Statistics South Africa
TDCA	Trade, Development and Cooperation Agreement
US	United States
USA	United States of America
USDA	United States Department of Agriculture
UK	United Kingdom

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1 ORIENTATION OF THE STUDY

1.1 BACKGROUND AND INTRODUCTION

As a developing country, South Africa is experiencing a high occurrence of increasing socio-economic problems partially due to massive rural-urban migration (Asfaha & Jooste, 2006; Rong, 2010; Tacoliet *et al.*, 2015). Therefore, these problems have a high impact on unemployment, poverty, food insecurity, and malnutrition (Cook, 2002; Niles *et al.*, 2020). Section (27) (b) of the constitution of the Republic of South Africa states that "everyone has the right to sufficient food and water" (SAHRC, 2000). Therefore, increased food production is required to address food insecurity. According to the Department of Agriculture, Land Reform and Rural Development (DALRRD) (2020), agriculture is an important sector in the South African economy, and it remains a significant provider of employment, especially in rural areas and a major earner of foreign exchange. Furthermore, the value of primary agricultural production in South Africa increased by 15,9% to R332 953 million from R280 014 million in 2020. The volume of agricultural production in 2020 increased (by 5.48%), which could be due to a rise in field crops (summer grains) (20.21%) and horticultural production (0.74%). Moreover, the production of animal products also increased by 1.63%, primarily because of an increase in the production of poultry meat and eggs and stock slaughtered (pigs and goats) (DALRRD, 2020). This suggests that the farmers are under a lot of pressure to produce more crops and livestock and also meet the demands of the growing population which will ultimately contribute positively to the economy. The major contributor to the South African agricultural industry is the livestock production industry (cattle, dairy, pigs, sheep, goats and poultry) (DAFF, 2016).

The agricultural industry provides direct and indirect employment to over 110 000 people; it is also the second-largest consumer of maize and supports many marginal businesses, including the feed industry and those downstream in the value chain (SAPA, 2019). For example, SAPA (2015) indicated that the South African poultry industry employs roughly 14 500 people at the primary agriculture level, 27 600 at the secondary level and about 6 000 at the distribution level. The report further indicated that the sector contributes almost 60 000 jobs for indirect employees in supporting industries and another 18 137 jobs in the field crop sector (SAPA, 2015).

According to SAPA (2019), nearly 75% of poultry production in South Africa is meat production, while 25% is egg production. Furthermore, the total consumption of chicken and eggs was 2.879 million tonnes, which is 90.5% more than the combined 1.511 million tonnes of beef, pork, mutton and goat consumed over the same period. Out of 2.879 million tonnes, 2.328 million tonnes were poultry meat products, including imports, while 0.551 million tonnes were eggs and egg products (SAPA, 2019). The poultry industry has a demanding place in the South African agricultural economy (Agri Seta, 2018). South Africa is a net importer of chicken because it is cheaper to import than to produce chickens locally. It is cheaper to import because local producers compete with cheap imports, which tend to be 30-40 % cheaper than locally produced chickens (Banson, 2015; Andam *et al*., 2019). The main countries of origin for South African poultry imports are Brazil, EU countries, the United States, Argentina, Thailand, Canada, Chile, and many other countries South Africa imports from to augment local production. The top three major contributors of chicken meat are Brazil (61.5%), the United States (16.1%) and Argentina (4.9%) (SAPA, 2019). In 2017, South Africa imported 556 877 million tonnes (-0.6% in 2016) of chicken; in 2018, chicken imports increased to 566 210 million tonnes (+1.7% in 2017) (SAPA, 2018). On the other hand, South African Revenue Service (SARS) reported that even with all the AI-related trade bans against EU nations, poultry imports in 2018 (566 210 tonnes) were 1.7% higher than in 2017, which suggests that imports were 19% higher than the 5-year average (2013-2017) (SAPA, 2019). In 2020, South Africa imported 460 000 tonnes of poultry and exported almost 52 000 tonnes (BFAB, 2021).

Although South African poultry is the largest sector of agriculture, contributing more than 16% of the gross domestic product (GDP), it remains the net importer of chicken (Nkukwana, 2018). This is a concern because a drop in the employment rate subsequently affects production. However, the major problem in poultry production is feed costs. Feed costs are the highest production cost faced by poultry producers in South Africa and the rest of the world (Henseler *et al*., 2013; NAMC, 2015; Machethe, 2016; Ncube *et al.,* 2017). Despite high production costs, chicken production remains the cheapest protein supplier than all other animal proteins (Davids, 2013; BFAB, 2016; DAFF, 2018). This is why feed cost accounts for 55-75% of the total production expenses depending on the geographical location, season and country of production (Heft-Neal *et al*., 2008; Mohamed *et al*., 2015; Sebatta *et al*., 2018). As a result of this, feed prices have influenced the cost of raw materials. The prices of maize and soybean as conventional feed greatly affects the cost of broiler feed because, in broiler production, maize and soybeans constitute the majority of the raw materials for broiler feed (Nkukwana, 2018).

The cost of raw materials used for feed is high because drought has had a devastating effect on agricultural production, costing farmers millions of rands (Bareki & Antwi, 2017). For instance, the drought occurrence in 2015 pushed up feed prices due to low maize production in South Africa. Meaning that reduced yields translate into a high cost of feed, ultimately reducing farmers' profitability (BFAB, 2019). Profit margins decline because feed costs account for 40%–60% of total production costs (Patil *et al*., 2021). This has resulted in broiler production in South Africa failing to produce desired outputs to meet the demands of chicken meat. As a result, they import broiler chicken ultimately affecting employment in South Africa. In addition, South Africa is a net exporter of yellow maize but a net importer of soybean meal (BFAB, 2019). Consequently, the primary energy source for poultry is competitively priced in South Africa, the protein source is more expensive than protein sources from net exporters (Argentina, Brazil and the United States) of both energy and protein products (BFAB, 2019). Therefore, there is a need for poultry farmers to explore affordable and cost-effective alternative feeds to reduce high production costs and improve the profitability of their enterprises. Fasuyi (2018) and Selaledi *et al*. (2021) similarly emphasized that poultry farmers must look for alternative feeds that will not have detrimental effects on growth and production and could substitute the existing conventional energy and protein sources. Producing alternative feeds will minimise production costs; however, it will depend on market trends and the willingness of poultry farmers to adopt alternative chicken feeds (Joubert, 2017).

1.2 JUSTIFICATION OF THE STUDY

To meet the increasing demand from human and livestock populations, there is a need to search for alternative energy and protein ingredients locally. *Genus amaranthus* and sorghum are suitable crops because they contain high energy and nutritional protein. According to Pisarikova *et al*. (2006), amaranthus may be used as feed ingredient for broilers because it can substitute or complement cereals due to its high energy, protein content and good amino acid composition. The amaranthus crop is attractive because it can grow in areas that are too hot, dry and arid (Ribeiro *et al*., 2018). Like amaranthus, sorghum can also be grown with less irrigation and rainfall and can supply energy (Reddy *et al*., 2005; Moss *et al*., 2020). However, it requires supplementation with protein-rich ingredients to produce well-balanced poultry feed. In this area, an increase in the local production of sorghum and amaranthus can play a part in supplying poultry's energy and protein requirements. Moreover, these crops can significantly reduce feed costs for South African poultry farmers, thus decreasing production costs and increasing productivity.

1.3 PROBLEM STATEMENT

Maize is the primary conventional ingredient in broiler chicken feeds, primarily used for human consumption. Currently, farmers in South Africa find it difficult to produce enough maize for livestock and human consumption, especially during drought season. In South Africa, the broiler industry is the major consumer of maize, as it is the primary energy source used in broiler diets (Nkukwana, 2018). Furthermore, energy sources constitute the most significant component of poultry diets, followed by plant and animal protein sources; energy and protein both represent the most expensive nutrients in poultry feeds (Ahiwe *et al*., 2018). According to Donohue and Cunningham (2009), broiler feed consists of approximately 60% of maize and 25% of soybean meal, which is a required conventional ratio for a balanced diet in broiler production. Therefore, broiler production costs fluctuate as grain prices increase or decrease in the market (Shiferaw *et al*., 2011). The continuous increase in the cost of poultry feed ingredients (especially energy sources) has forced some farmers and feed manufacturers to use poor-quality energy feed ingredients (Ahiwe *et al*., 2018). However, Robertson and Perez-Maldonado (2010) indicated that using low-quality energy feed ingredients remains a major challenge because it results in poor feed intake, weight gain, and feed conversion. With rising prices and supply shortages, it seems inevitable to consider alternative energy and protein sources to fully or partially replace the conventional ingredients in chicken feeds. Because traditional feed is becoming expensive for poultry producers, mostly in developing countries, it is important for farmers to consider adopting unconventional feed (insects such as earthworms, grasshoppers, beans, termites, mealworms and others) as substitute feed (Laureati *et al*., 2016; Sebatta *et al*., 2018; Selaledi *et al*., 2021).

Research done by Rouckova *et al*. (2004) revealed that extruded grain amaranthus can be fed to broiler chicks without adversely affecting body weight, feed utilization, or carcass yields. Furthermore, the study discovered that heat-processed amaranthus grain could fully replace meat-and-bone meals in broiler diets. Additional research has also shown that pelleting the amaranthus in diets is beneficial because it improves chicken body weight and feed intake (Peiretti, 2018). This view was supported by (Sebatta *et al*., 2018), who published a study about farmers' acceptance of insects as an alternative protein source in poultry feed. Research conducted by Selaledi *et al*. (2021) concluded that small-scale poultry farmers in Tshwane accepted the use of yellow mealworm as a substitute in poultry feed. There is a large volume of published studies describing alternative energy and protein sources (conventional) in poultry feed which was supported by the society (Biasato *et al*., 2016; Rapatsa and Moyo, 2017; Manyelo *et al*., 2020; Selaledi *et al*., 2021). Laureati *et al*. (2016) however, revealed that there is more potential for the use of insects in livestock farming than in the human diet, even though it could stress the sustainability and nutritional value of insects as a source of food which provides sufficient motivation for the acceptability of insects as food. As energy and protein sources, Amaranthus and sorghum have the potential to be alternative ingredients. However, the commercial industry has not explored the acceptability of the combination of sorghum and amaranthus as sources of energy and protein. Therefore, the acceptability of poultry feeds made from sorghum and amaranthus is unknown.

1.4 RESEARCH AIM AND OBJECTIVES

1.4.1 Aim of the study

The research aimed to assess farmers' acceptability of alternative chicken feeds made from sorghum and amaranthus.

1.4.2 Objectives

This study was premised on the following research objectives about broiler farmers in Gauteng province:

i. To profile broiler farmers' socio-demographic characteristics.
ii. To determine the operation and production characteristics of broiler enterprises.
iii. To determine broiler farmers' willingness to adopt alternative chicken feeds made from amaranthus and sorghum as energy and protein sources, respectively, and the influencing factors.
iv. To identify the challenges experienced by broiler farmers.

1.5 NULL HYPOTHESES

The null hypothesis of the study are as follows:

i. **H_0**: Farmer's age, farming experience, gender, education level, number of production cycles, feed costs, net income, size of poultry structure, number of birds per cycle, mortality rate and weight of live birds do not positively and significantly influence their willingness to adopt alternative feeds made from amaranthus and sorghum.
ii. **H_0:** Type of land ownership, farm/plot size, number of chicken houses, distance travelled, number of feedbags utilised per cycle and price of chicken do not positively and significantly influence farmers' net farm income.

1.6 ORGANISATIONAL STRUCTURE OF THE DISSERTATION

The dissertation is organised into seven (7) chapters; Chapter 1 is the orientation of the study, which provides the background and introduction, significance of the study, research problem and questions, aims and objectives of the study. Chapters 2 and 3 focus on the literature review and research methodology conducted in the study, respectively. Chapters 4 to 6 present the results and discussions of the following: the respondents' socio-demographic characteristics and farmers' willingness to adopt alternative chicken factors influencing adoption willingness, challenges faced by broiler farmers and reasons why farmers rejected the adoption of alternative chicken feeds. Finally, Chapter 7 includes the conclusion and recommendations of the study.

CHAPTER 2

2 LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews on research carried out in disciplines related to the current study. The chapter consists of four (4) main sections (2.2-2.5). Section one provides the background on the socio-demographic characteristics of broiler farmers who choose to adopt alternative chicken feeds. Section two presents the broiler industry in South Africa. Section three explores the feed industry (feed ingredients, cost, feed forms and production efficiency of feed). Section four covers the adoption of innovation (adoption theory, accessibility and affordability).

2.2 SOCIO-DEMOGRAPHIC CHARACTERISTICS OF POULTRY FARMERS

Demographic information is related to social and demographic information hence the word socio-demographic information was used. According to Koukouli *et al*. (2002) and Stone (2018), socio-demographic characteristics involve a combination of sociological and demographic information such as age, gender, race, religion, income, marital status, size of family, employment status, heritage and education. The characteristics are important because they can influence adoption decisions in broiler farming (Verbeke, 2000; Diaz *et al*., 2021). Moreover, socio-demographic characteristics are important because they strongly affect farmers' willingness to adopt innovations. The socio-demographic characteristics of the broiler farmers differ by the size of production and area. The literature in the study will focus on the following socio-demographic characteristics: age group, gender, race, marital status, education, type of land ownership, farming experience, farm plot size, sources of income and farm income.

2.2.1 Age group

Age can be used to measure the experience and productivity of farmers (Tshuma, 2013). According to Esiobu *et al*. (2014), poultry farmers aged between 41 to 50 years are more receptive to innovation and adoption of improved farming technologies in Nigeria. Machethe (2016) found that a majority (51%) of the small-scale broiler farmers were aged between 40-59 years while 30% were between 60-81 years and 19% were between 26-39 years of age.

Furthermore, the aforementioned study indicated that age negatively affects farmer output and technical efficiency in Limpopo province. In contrast, Chia (2020) found that farmers' age had a positive effect on their willingness to pay for insect-based feed because the accumulated experience of older farmers helps them make an early willingness to pay decision in Kenya. On the other hand, Ogolla (2016) in Nairobi reported that the majority (53%) of the poultry farmers are middle-aged adults aged between 31-40 years, followed by young adults (21-30 years) at 17%. Older farmers over 51 years and young adults at below 20 years were somewhat small, representing only 10% and 5%. This implies that poultry farming is common among younger farmers, unlike among those above 51 years. Similarly, Selaledi *et al*. (2021) discovered that in South Africa, the dominant age group of smallholder chicken farmers was 36-45 years (34.6%), whereas 28% were younger than 35 years old. However, age had a negative effect on the adoption of alternative chicken feeds. In North America, the majority (69%) of poultry and egg producers were between 35-64 years of age, compared to 58% of all U.S. producers (USDA, 2017).

2.2.2 Gender

Gender refers to the social roles and relations between women and men. Gender is not strongly determined by differences in biological traits between women and men per se, but in this case, gender refers to sex, as Monde (2012) described. On the other hand, Norton *et al*. (2010) refer to the term gender as non-biological differences between women and men. Roles in farming and household decisions in developing countries differ by gender. The gender of farmers serves as an important factor for resources with specific reference to allocation, utilisation, control and decision-making. In farming, men and women adopt agricultural technologies at different rates and stages (Doss, 2000). Gender results by Adeyonu (2021) revealed that the production of broilers is dominated by males (82.9%) as opposed to females (17.1%). In the United States, more poultry farmers were males (64%) compared to females which stood at 36% (USDA, 2017). The results may be related to the common perception that poultry production is a strenuous work that only males can handle. Similarly, Machete (2016) found that broiler farming in the Mopani District in Limpopo province was dominated by male smallholder broiler farmers (51%), while 49% were females. However, the study conducted by Adeniyi and Oguntunji (2011) found that female farmers in African societies usually dominate poultry production. The study further explained that women mostly kept poultry because it is easily manageable and has lower procurement foundation costs and replacement stocks. The results are consistent with the findings of Green *et al*. (1993), which revealed that female-headed households have less access to improved technologies, land, and extension than male-headed households.

2.2.3 Race

Statistically, South Africa categorises race into five racial population groups: black, white, coloured, Indian and other/unspecified. The majority (98%) of the farmers are Black Africans, while 2% are Coloured (Antwi & Nxumalo, 2014; Rakoena, 2019). This is similar to the finding of Aliber (2011), who reported that the majority (79%) of the population of Dr Kenneth Kaunda District is Black Africans and other groups form 21% of the population. In support, Modibedi (2019) also discovered that 100% of the farmers in Gauteng were Black Africans. The above shows that land reform is advancing in its mission to support previously disadvantaged groups in South Africa, which are predominantly black people (Hendriks, 2016).

2.2.4 Marital Status

Marital status clearly defines a person’s livelihood: for instance, a married person cannot behave as a single person in terms of household responsibilities and commitments (Pote, 2008). Tshuma (2013) reported that widowed females in South Africa often could not access resources that could boost their knowledge and productive capacity because they lacked collateral. In the African context, it is generally perceived that marriage signifies stability. In Gauteng province, Rakoena (2019) found that the majority (78.0%) of the farmers were married, followed by those who were single (9.8%), widowed respondents were 8.3%, with divorced respondents being the least (3.9%). On the contrary, Modibedi (2018) reported that the majority (53.5%) of the respondents were single, followed by those that were married (28.3%), while 18.2% were widowed, divorced, cohabitating and others. In Nigeria, it was reported that the majority (73.3%) of broiler farmers were married and 26.7% were single (Onuk *et al*., 2017). The marital status results imply that married people are more involved in broiler production than single people. Selaledi *et al*. (2021) reported that 47.7% of the broiler farmers were married, 39.3% were single while, 13% were divorced and widowed in Gauteng province of South Africa. In North West province, Selaledi (2017) reported that about 65.7% of poultry farmers were married, and 2.9% were divorced. The above shows that, generally, broiler farmers have spousal support through marriage.

2.2.5 Level of Education

Regarding innovation in agriculture, in as much as innovation is complex, education highly influences the rate at which farmers adopt innovation and the progression of a farmer's quality in the practice of any agricultural activity (Makara, 2010). The findings agree with Phezisa (2016), stating that innovation is characterised by complexity; consequently, the education level influences the adoption rate of agricultural innovations to a greater extent. The results are consistent with Chiputwa *et al*. (2011), who reported a positive association between education and the adoption of crop rotation in Zimbabwe. The results concur with other scholars who found out that farmers with a high education background are more likely to adopt innovation than those without such a background (Ajewole, 2010; Folefack, 2015; Paul *et al*., 2017; Rathod *et al*., 2017; Wahyudi, 2017). On the contrary, a study by Jera & Ajayi (2008) found that education had a negative and insignificant influence on the adoption of tree-based fodder technology in Zimbabwe. Mbuza *et al*. (2016) revealed that level of education can improve broiler production because literacy and numeracy are required for the effective management and production of broiler poultry. In support, Ali and Hossain (2008) found that exposure to more training education and experience improve the capability of a farmer. Tesfamariam *et al*. (2018) found that the majority (64%) of the farmers in South Africa had formal education, while about 36% had no formal education. In support, Selaledi *et al.* (2021) revealed that more than half (60.7%) of small-scale farmers in Tshwane in South Africa had secondary education.

2.2.6 Type of land occupation method

Land is a fixed factor of production and one of the most fundamental resources in farming. In any production process, land is the starting point. For example, in industries, it helps to provide raw materials, and in agriculture, crops are produced on land. The hope and resource optimization levels differ between farmers who own land and those without ownership. In South Africa, three classification categories of land are used: state, private, and other (Land Audit, 2017). Land Audit revealed, among its findings, that land ownership is distributed by race, gender and nationality. Mtshali (2002) emphasises that the type of land ownership occupation is important because it increases control over other resources, such as income earned and access to resources needed for agricultural production, such as capital, credit, infrastructure, and inputs. It is worth noting that most black South African farmers do not raise broilers on a large scale compared to white farmers. However, after land reform, some black farmers had a chance to raise broilers on a large scale as they had access to land (Tlali, 2010).

According to the NAMC (2020) case study of smallholder broiler producers in South Africa, land ownership status results show that 55% of the sampled respondents owned the land privately, which implies a greater likelihood of continuity in farming. In Nigeria, Oduwaiye *et al*. (2017) reported that the majority (63.2%) of the poultry farmers owned their farmland.

2.2.7 Farming experience

A farmer's knowledge is vital in bringing about sustainable innovations in agriculture (Röling & Jiggins, 1998). Once people have farmed for an extended period, mastering the techniques occurs; additionally, the knowledge gained over those years enables them to venture into different agricultural enterprises (Maoba, 2016). Farming experience is an important socio-demographic attribute influencing innovation adoption, decision-making, productivity and profitability. Knowledge gained over time can also help farmers to evaluate the merits of new technology, thereby influencing their decisions on the new product (Simtowe *et al*., 2011). Therefore, farming experience is linked to farmers' willingness to adopt a new technology. In Gauteng province, Maoba (2016) found that about 46.2% of the beneficiaries had 3-5 years of farming experience, while 38.5% had 6-10 years, and 7.69% had 0-2 years of farming experience. However, the farming experience was different in Limpopo province, where Machethe (2016) found that the majority (72.2%) of the smallholder broiler farmers had between one to five years of experience, followed by 21.9% between six and ten years of experience while the smallest group of farmers (5.9%)had experience of 11 years and above. The author further suggested that training should also be provided to less-experienced farmers to empower them to adopt poultry farming practices. In Nigeria, Okoli *et al*. (2004) also indicated that the majority (67.3%) of broiler farmers had one to 10 years of experience, whereas 36.36% had 1-5 years' experience and30.91% had 6-10 years' experience in broiler production while 32.73% had 11 years of experience and above. This seems to concur with what respondents reported about their farming experience in Mafsikaneng (2015) that 60% had less than ten years of farming experience, while 40% had more than ten years of farming experience. These findings contrast those of Annor-Frempong (2013), who indicated that most farmers in South Africa and Lesotho had over ten years of farming experience. USDA (2017) suggested that more (73%) poultry farmers in the United States had 11 or more years of experience, while 27% had ten years of experience or less.

2.2.8 Farm/ plot size

South Africans typically judge a farm's viability based on its land size without necessarily considering other attributes such as specific farming enterprise and managerial ability (Kirsten & van Zyl, 1998). The authors further highlighted that defining the "viable farm" based on size alone had a profoundly negative effect on the relative profitability of farms smaller than the viable size. Farm/plot sizes simply assume the expected yield and returns from production. Farm size socio-demographic information is significant when adopting innovation because the impact of farm size on adoption is in the early stages of the diffusion of innovation and becomes less important when diffusion increases (Fernandez-Cornejo *et al*., 2001). Minai *et al*. (2014) found that farm size had a negative and insignificant impact on the yields of Irish potatoes. The results are consistent with Ekepu and Tirivanhu (2016), who discovered that farm size had an insignificant effect on the adoption of either sorghum-legume rotations or sorghum-legume intercropping. Abara & Singh (1993) acknowledged the differences in technology adoption between large and small farms and highlighted that small farms had been argued to have high fixed costs, thereby hindering technology adoption. Previous studies on technology adoption have found farm size to positively affect adoption of legume-based multiple cropping systems (Ekepu and Tirivanhu, 2016). Khapayi and Celliers (2016) reported that 72% of the farmers produced on land less than 10 hectares, whereas 28% of the farmers produced more than 10 hectares of land in Eastern Cape Province. In Tshwane Metropolitan Municipality, Mafsikaneng (2015) reported that almost half of the respondents (48.3%) had less than 100 ha, while a slight majority (51.7%) had 100 or more hectares of farmland for production.

2.2.9 Sources of income

According to Ahmad *et al*. (2008), broiler production as a business is mainly practised by farmers as a source of income. However, due to the high production costs and little profits, most commercial farmers exit the broiler industry in search of better income-generating activities. The situation explained shows why most farmers have multiple sources of income besides chicken production as their primary source of income. According to Ellis (2006), farming was the primary source of net income for 48% of the farmers in Knoxville. There was no significant difference in the primary source of net income for the two groups (interested and not interested in innovation). Interested respondents indicated that 52% of their primary net income came from off-farm sources, while 49% of their primary net income came from off-farm sources for non-interested respondents**.** It was reported that more than half (52%) of the poultry and egg producers in North America's primary source of income was farming, while 48% was other activities. In contrast, the source of income in the United States from other activities was 58%, while agriculture activities contributed 42% of the income (USDA, 2017).

Chirwa (2005) found a positive relationship between non-farm sources of income and the adoption of inorganic fertilizers in Malawi. In Uganda, Ekepu and Tirivanhu (2016) conversely discovered a negative relationship between off-farm income and the adoption of sorghum-legume rotations. The income sources captured in a study by Akoth (2021) showed that urban farming households got their income from numerous sources, for instance, solely agricultural production or other means of income (wages, self-employment and pension). Akoth (2021) further indicated that the theory holds because diverse income sources were identified among urban farming households.

2.2.10 Net farm income

Foote (2016) refers to net farm income as gross farm income minus farm expenses and taxes, whereas gross farm income is the annual level of income received from farming activities before farm expenses, taxes, and withdrawals have been deducted. In Malaysia, it was reported that higher income significantly influences ruminant farming to employ innovations (Abdullah *et al*., 2020). In South Africa, Selaledi *et al*. (2021) found that less than half (43.0%) of the farmers made between R3 501 and R10000 per annum (U$233 and

U$666 per annum) from broiler enterprises. In North West province, Selaledi (2017) reported that 14.3% of small-scale poultry farmers made a turnover of below R2 000, whereas 18.6% earned above R2 001 and below R4 000 per cycle. On the other hand, 11.4% of farmers generated a net farm income above R10 000.

2.3 BROILER INDUSTRY

The poultry sector, which has an extremely important place in food safety and nutrition, is the fastest-growing agricultural sub-sector, especially in developing countries (Yildiz, 2021). According to data from the Food and Agriculture Organization of the United Nations (FAO), the total poultry presence in the world (chicken, duck, goose, guinea fowl, and turkey) was about 27.9 billion heads in 2019 (FAO, 2021). The largest share of this presence was by chickens, with about 93%. DAFF (2018) reported that within the agricultural sector, the single leading contributor by value is poultry (16.5%), followed by cattle (13.5%) and maize (9.2%). Looking at the world data on chicken meat, the production of chicken meat was 115 million tonnes in 2018 and then reached 118 million tonnes in 2019. The largest share of chicken meat production is in American countries with a production of 47.9 million tonnes in 2019. In the same year, Asia followed with 42.8 million tons, Europe with 19.4 million tonnes, and Africa with 6.2 million tonnes (Yildiz, 2021).

In South Africa, the broiler industry is the biggest sector within the agricultural sector in terms of production value (DALRRD, 2019). Feed, however, remains the major cost to the broiler producers; hence the value chain's efficiency and competitiveness rely on and depend on the efficient operation of other value chains such as maize and soybeans (IDC, 2016). Despite high production costs, chicken production remains the cheapest protein supplier compared to all other animal proteins (Davids, 2013; DAFF, 2018). The broiler industry plays a significant role in the South African economy because it remains one of the largest contributors to the agricultural sector.

2.3.1 Contributions of the broiler industry to the global economy

Globally, the poultry industry is known to contribute significantly to economic development. It creates employment, increases the level of income and reduces poverty (Nushad *et al*., 2021). Poultry provides affordable quality protein, and it also generates up- and downstream investment opportunities for producers; thus, contributing to economic and social sustainability (Rodic *et a*l., 2011). According to Ndiyoi *et al*. (2007), the poultry industry in South Africa consists of both small-scale and commercial farmers. However, Nkukwana (2018) indicated that the poultry industry is dominated by a few fully integrated large-scale commercial producers and a high volume of small-scale producers, either as contract growers or individual producers supplying the informal market. Broiler production occurs throughout South Africa with North West, Western & Northern Cape, Mpumalanga and Free State provinces being the main producers accounting for approximately 74% of total production (DAFF, 2019). The South African gross domestic product (GDP) increased the total, annual growth rate at 1% from 2018 to 2019 (OECD, 2019). GDP from agriculture amounted to R69 690.51 million in the second quarter of 2019 (which decreased from R70 443.35 million in quarter one: 2019). According to Trading Economics (2019), the average GDP from 1993-2019 is R59 779 million. Although the share of the total GDP is relatively small, agriculture plays an important role in the process of economic development and can contribute to household food security (DAFF, 2018). In addition, the sector plays an important role in job creation, especially in the most rural parts of the country. Poultry remains one of the largest contributors in the agricultural sector in South Africa because it contributed about R140 028 million to gross income of animal products in 2018 (DAFF, 2018).

The South African broiler industry continues to attract attention from both local and foreign scholars and policy makers; mainly because the industry is contributing significantly to employment in primary agriculture, manufacturing, and ancillary sectors (SAPA, 2015). With regards to employment, the broiler industry provides direct and indirect employment to over 110 000 people (SAPA, 2019). Again, it supports many peripheral businesses (including the feed industry) and those downstream in the value chain such as packing, packaging, logistics, marketing and trade, food services, hospitality, wholesale and retail. Moreover, DAFF (2019) estimated that broiler, hatchery and rearing industries employed 15 013 people, the processing sector employed a total of 28 578 people, and the broiler distribution industries employed 6 296 people. The grand total of employment within the broiler industry was 49 887. On the other hand, the number of employments in field crops produced specifically for poultry feeds was 18 817 (DAFF, 2019).

2.3.2 Broiler production

The significant growth in poultry (especially broiler chicken) production and consumption in developing countries has important implications for the global trading of all meat products, as well as feeds and related inputs (Taha, 2003; Landes *et al*., 2004). Since the 1960s, the global production of poultry meat has been growing faster than that of any other meat in both developed and developing countries (Chang, 2007). According to FAO estimates, the total production of poultry meat in the world in 2020 increased by 2.6 percent to 137 million tonnes. This amounts to almost half the growth rate in 2019 (Shahbandeh, 2021). Yildiz (2021) reported that the United States had the highest volume of chicken meat production among all countries, producing about 20.5 million tonnes of chicken meat. During the same period, China ranked second with 15 million tonnes, while Brazil ranked third with 13.7 million tonnes of production in 2020.

In the Southern African Development Community (SADC), broiler production makes up most of the poultry industry. Although South Africa produces less than 1.5 per cent of the world's broiler meat, it is a major broiler producer, with almost 80 per cent of total broiler production (Poultry Site, 2010). Approximately 76% of the birds in the poultry industry are used for meat, while the remaining 24% are used in egg production (SAPA, 2017). Poultry production is the largest product sector, ahead of all other animal sectors with beef production (R35.5 billion), milk (R16.6 billion) and eggs (R10.3 billion) and ahead of all field crop and horticultural sectors. According to BFAB (2019), broiler production accounts for 33% of all animal products in Rand value. According to a report by the Department of Agriculture, Forestry and Fisheries (DAFF), there are eight (8) commercial producers responsible for over 70% of the total broiler production, including RCL Foods, Country Bird Holdings and Astral Foods (DAFF, 2018). USDA (2020) reported that RCL Foods and Astral Foods are the African continent's largest two poultry companies, having slaughtered 260 million and 228.3 million broilers annually in 2017. The South African government and the poultry industry 2019 signed a Poultry Sector Master Plan that is proclaimed to increase productivity in the poultry sector and protect the local domestic producers from alleged unfair trade practices and imports (Poultry Industry Master Plan, 2021). Moreover, SAPA (2020) projected an increase in chicken meat production by 4% to reach 1.57 million tonnes, which is an increase from 1.51 million tonnes in 2020.

2.3.3 Consumption

Chicken meat is the highest consumed meat globally with a per capita consumption of 33 kg (USDA, 2020). Based on the comparison of poultry meat consumption per capita in 161 countries, Israel ranked the highest with 71.7 kg followed by Trinidad and Tobago and USA, while Chad with 0.410 kg, Burundi (0.450 kg) and Ethiopia (0.690 kg) consumed the least (Helgi Library, 2019). According to the feed additive report prepared by Yildiz (2021), the countries with the highest poultry consumption in 2019 were China ranking first with 20 million tonnes, followed by the United States with 19 million tonnes, Brazil with 12 million tonnes (representing about 40% of global consumption). These countries were followed by Russia, Mexico, India, Japan, Indonesia, Iran, South Africa, Malaysia, and Myanmar (share of these countries in consumption is around 21%).

South Africa consumes more broiler meat than what is produced locally, meaning the country is not self-sufficient but depends on imports to meet the local demands (DAFF, 2019). Furthermore, the domestic market consists approximately of 265 formal abattoirs. These abattoirs sell meat to five (5) main retailers (Pick n Pay, Shoprite- Checkers, Spar, Woolworths and Mass Mart) and small, medium and micro-enterprises (SMME's) in the retail sector, which buy the biggest share of domestic production (DAFF, 2019). In 2019, SAPA (2019) reported that DALRRD estimated 1.808 million tonnes of the total production of poultry meat (including turkey, ducks, geese and guinea fowl) whereas consumption (including backyard consumption) amounted to 2.328 million tonnes; the per capita consumption of poultry meat for 2019 was 39.30 kg per annum. On the other hand, SAPA's (2019) calculations indicated that poultry consumption amounted to 2.300 million tonnes, whereby poultry meat per capita consumption for 2019 was 39.13 kg.

2.3.4 Tariffs

In Europe and America, the production costs of chicken are largely recovered from the sales of breast meat. The rest of the meat is exported (portions and mechanically-deboned meat), often at very low prices. This causes problems for poultry producers in developing countries, such as South Africa (Willemse, 2021). Dumping, which is the action of cheap exports from Europe and America gains market share in foreign market, drives out competition and obtains a dominant market position by influencing price and quality of chicken meat in African countries. Anti-dumping duties on chicken imports are therefore applied and/or imposed to protect local businesses and markets from unfair competition by foreign imports (Murigi, 2013; Mastara, 2016; Chikomo, 2018). In South Africa, the broiler industry competes in both domestic and international markets (NAMC, 2007). At domestic level, broiler meat competes with other protein sources for market share while there are challenges which prohibit both commercial and small-scale poultry farmers from being named among the best producers in the world. The challenges include low yields (and relative high prices) of grains, high transport costs and low efficiency levels at production levels. As a result of these factors, tariff levels and Sanitary and Phytosanitary Standards (SPS) are very important in maintaining the competitiveness of the industry (BFAB, 2017).

However, SAPA argues that the tariffs set in 2013 have failed to provide more than 5% average protection to the industry and have had no result because 1) they are too low; 2) they do not apply to the EU because of the Trade, Development and Cooperation Agreement (TDCA)/EPA between South Africa and the EU; and 3) dumping of mechanically-deboned meat in the South African market causes far-reaching distortion of the whole value chain (SAPA, 2019). There are unfair trade practices in the importation of chicken to South Africa and other developing counties. As a result, there are job losses as chicken producers scale back due to the massive volumes of imports, also, jobs in the maize and soya industries which supply chicken producers are at risk if the chicken industry collapses and threatens food security. Moreover, the national economy will suffer because the poultry industry is the largest component of the country's agricultural sector contributing 16% of agricultural GDP in 2018 (Nkukwana, 2018). Because of that, the government-imposed tariffs to non-EU countries such as Brazil, US and Argentina of 62% for frozen bone-in chicken portions (up from 37%) and 42% for frozen boneless portions (up from 12%) in 2020 to protect from unfair practices (Banda, 2022).

2.3.5 Imports and exports

Global chicken meat exports for 2022 in the USDA report indicate that chicken meat exports revised up 1% from April to 13.5 million tonnes as an improved outlook in Ukraine and China which reduced EU and UK shipments (USDA, 2022). On the other hand, the chicken meat import price in Africa in 2018 was at US$ 1,038 per tonne, a year in which 1.9 million tonnes (in terms of value, US1.9 billion) of chicken meat was imported (Poultry World, 2020). The major African importers of chicken meat in the same years were Angola with 432,000 tonnes (US$ 465 million), and South Africa with 370,000 tonnes (US$ 372 million), accounting for 23% and 20% of total imports, respectively. Ghana (213,000 tonnes) ranks next in terms of the total imports with a 12% share accounting for 53% of total import (Poultry World, 2020).

According to USDA (2020), about 30% of chicken meat consumed in South Africa was imported from Brazil, European Union and the United States. Furthermore, the country was estimated to import 435,000 tonnes of chicken meat to boost local production, which is a decrease of 10% from 2019 imports. In January 2021, broiler imports were 30% less compared to January 2020 and 15% less from 2017 (USDA, 2020). The Poultry Industry Master Plan (2021) reported that imports have declined since September 2020. According to DALRRD (2020), South Africa imported approximately 510 000 tons of broiler meat in 2019 at R5.5 billion of which 15.4% 7(8 794 tonnes) was from USA, whereas 88.3% of the mechanically-deboned meat (MDM) were imported (168 078 tonnes) from Brazil. For the EU exporters, only Poland (48 679 tonnes), Ireland (30 235 tonnes), Denmark (23 325 tonnes), and Spain (17 623 tonnes) exported significant quantities of broiler products to South Africa in 2019 (SAPA, 2019).

The broiler meat industry is also an earner of foreign exchange through broiler meat export. South Africa experienced a decrease of 1% in exports quantity and an increase of 0.3% in exports value in 2019 compared to 2018 (DALRRD, 2020). Moreover, the export trend is declining because most of the SADC countries known to be the main South African exports market suspended poultry imports from South Africa due to the outbreak of Highly

Pathogenic Avian Influenza (HPAI) in 2017 (SAPA, 2019; DALRRD, 2020). South Africa's major export markets are in the neighbouring countries, namely, Botswana, Lesotho, Malawi, Mozambique, Namibia, Zambia, Swaziland and Zimbabwe. South Africa experienced a decrease of 21% in exports quantity and an increase of 13% in exports value in 2018 compared to 2017 (DALRRD, 2019). According to USDA (2020) report, South Africa exported 68,618 tonnes of chicken meat in 2017 and further took a downturn by 54,529 tonnes in 2019. In conclusion, South Africa imported 460 000 tonnes of poultry and exported almost 52 000 tonnes in 2020 (BFAB, 2020).

2.4 POULTRY INDUSTRY CHALLENGES

Poultry producers worldwide continue to struggle with high production costs for feeding, largely due to volatility in the prices of basic feed ingredients, including maize and soybean meal (Nkukwana, 2018). There is an ever-increasing demand for conventional poultry feed ingredients, which, as a result, greatly increases production costs. As a result, rising conventional feed costs is a global challenge that farmers are facing in the poultry sector (Godfray *et al*., 2010; Banson *et al*., 2015; Huang and Yang, 2017; Selaledi *et al*., 2021). It is therefore important to look for cheaper sources of energy and protein substitutes that have the potential to reduce the high costs of conventional feed. The competition between humans and animals for energy and protein ingredients is another challenge which raises major concerns. For example, maize is increasingly used for human and animal food and other industrial purposes, including biofuel production (Shiferaw *et al*., 2011). However, finding more cost-effective feed ingredients for poultry remains a challenge. Attempts to utilise available and affordable local by-products may benefit the end-users by reducing the feed cost which subsequently can reduce the total cost of production of meat and eggs (Tirumalaisamy *et al*., 2016).

According to Swain *et al*. (2014), traditional sources of vitamins and proteins used in poultry rations such as fish meal, meat and bone meal, soybean meal, groundnut cake and so forth are becoming expensive in developing countries. The availability of these feed ingredients is not adequate because of the rising cost of raw materials and ever-increasing competition with humans for the same food items. Hence, the search for alternative feed sources has become inevitable to reduce the feed cost (Swain *et al*., 2014). Adequate market access to core markets also poses a threat to poultry production. This could be because broiler farmers get little returns on what they sell (low capital), so they never try to improve the quality of chickens (Mojtaba, 2011). Limited access to consistent high quality water supply is also a major constraint which may pose food safety and microbial contamination concerns (Hafez & Attia, 2020; McGahan *et al*., 2021). Regarding climate change, adverse effects of climate change on maize production, which include frequent droughts, heat, increased temperature, and inadequate rainfall during maize's growing season, have affected production yields and prices (Li *et al*., 2019).

The South African feed industry came into practicality a halt after severe droughts and depression that happened during the 1930s (DAFF, 2019). In 2015, the National Agricultural Marketing Council reported that the highest cost faced by poultry producers in South Africa and the rest of the world is feed costs (NAMC, 2015). The main factors determining the composition of animal feed are the prices of raw materials, the nutritional value of the components, the nutritional requirement of the specific animal and rules and regulations of the government (DAFF, 2019). Furthermore, maize is one of the most important ingredients used in animal feed, and nearly 60% of the total maize produced in South Africa is used for food consumption, industrial (other than feed) and seed purposes. SAPA (2017) reported that members of AFMA produced a total of 6.362 million tonnes of animal feed. Moreover, the poultry industry consumed 3.94 million tonnes, of which 2.569 million tonnes were broiler feed, 0.88 million tonnes were layer feed, 0.470 million tonnes were breeder feed, and 0.015 million tonnes were ostrich feed (SAPA, 2019). Even though the poultry industry utilises more animal feed than other sectors, the cost of feed remains high due to the price of energy and protein ingredients.

2.4.1 Feed ingredients and cost

The cost of feed is affecting backward and forward poultry market linkages with higher production costs. Ravindran (2013) indicated that maize (corn) is the most commonly used energy source, and soybean meal is a common plant protein source globally. Furthermore, feed signifies the major cost of poultry production which constitutes up to 70% of the total operational cost, about 95% is used to meet energy and protein requirements, followed by

3 to 4 percent for major mineral, trace mineral and vitamin requirements, and 1 to 2 percent for various feed additives in New Zealand.

In East Africa, the competitiveness of poultry production is largely governed by feed prices (Poultry World, 2018). Furthermore, Wageningen University and Research and the Netherlands Africa Business Council (NABC) looked at the interdependency between countries (Kenya, Uganda, Rwanda and Tanzania) for the development of the poultry sector and the study found that feed prices are lowest in the countries that are able to locally produce the main feed ingredients such as maize. For example, South Africa in the 2015/16 marketing season experienced low production of maize due to drought, which consequently contributed to high feed costs (Nkukwana, 2018).

DAFF (2019) reported that compound feed production requires the use of various agricultural raw materials. The most significant ingredients include oilcake, maize, and fish meal (DAFF, 2017). According to DAFF (2019), soybean is the most frequently used oilseed meal which is commonly used in both cattle and poultry feed. Nkukwana (2018) reported that maize and soybean meal worldwide will remain the major ingredients in poultry diets. However, research on feedstuffs for partial replacement of these two will still be relevant. In South Africa, there is a need to import soybean meal and variable maize yields for the broiler industry because local production is insufficient (NAMC, 2015). In 2015/16, South Africa experienced low maize and soybeans production due to drought, which consequently escalated the cost of feed (Nkukwana, 2018). As a result, plantings increased significantly. With increased crushing capacity, South Africa has become less dependent on imported soybeans and soy meal (AgriSETA, 2021). The maize milling industry utilises around 4.5 million tonnes of white maize annually for the production of maize meal (2.8 million tonnes per annum on average) and hominy chop (a by-product from the maize-milling industry) (1.5 million tonnes per annum on average) which are used for the manufacturing of animal feeds (Agri SETA, 2021).

Protein feed ingredients

The use of alternate protein sources has the potential to reduce the cost of conventional protein ingredients (Thirumalaisamy *et al*., 2016). Soybean, groundnut, cotton, sunflower and canola meals are used as major ingredients in animal feeds (Adeleke *et al*., 2020). According to DAFF (2019), the most significant ingredients are oilcake, maize, as well as fish meal. Furthermore, the inclusion of rape seed meal and sunflower seed meal each at 10% level replacing soya bean meal supported optimum growth and profit margin in broilers. The other promising by-products include guar meal, cotton seed meal, sesame meal, rice gluten meal etc., which could also be used in poultry production (Ravindran & Blair, 1992; 1993). Oilcake offers proteins in animal feed and are relatively used more in most types of animal feed than in others, after maize (DAFF, 2019). In addition, soybean is the most frequently used oilseed meal, followed by sunflower and is commonly used as feed oilcake.

In South Africa, fishmeal is a good source of high-quality protein; hence, its price is usually high. Fishmeal is also rich in minerals (calcium, phosphorus and trace minerals), B vitamins and essential fatty acids, and sometimes, it is the only source of animal protein ingredients in most developing countries (DAFF, 2019). However, in South Africa, a limited amount of fishmeal is used in compound feed formulation. For example, fishmeal usage is determined by availability, product mix and price concerning other available protein sources. Amaranth can also be identified as an alternative good source of protein for animal food because it has high contents of protein when compared to maize and soybean (Peiretti, 2018). According to Longato *et al*. (2017), Amaranth as a broiler diet is known to be more suitable for facilitating better performance characteristics. In support, Venskutonis and Kraujalis (2013) and Peiretti (2018) stated that amaranth grains have a higher protein content than other cereal grains with more lysine than soybean contents.

Energy feed ingredients

Maize is one of the most important energy ingredients used in animal feed and is used extensively in industrial products, including the production of biofuels in developing countries (Shiferaw *et al*., 2011). In India, the availability of maize as main energy sources has been increasing at a slower rate but not at par with the livestock and poultry sector growth (Thirumalaisamy *et al*., 2016). The study further suggested that to meet the demand, the combinations of maize with other cereals especially pearl millet, finger millet and sorghum could be tried. Combinations of these cereals at 25-33% level are encouraged in the development of poultry feed in the UK (Wiseman, 2006). The use of different cereals and oilseed residue has been proved to be good (Thirumalaisamy *et al*., 2019). The cereals can therefore safely be used as part or solely as a dilutor of protein mineral concentrate in the finisher stage of broiler production. Moreover, broken rice, rice polish, de-oiled rice bran, under-sized wheat, dried distillery grain ghee residue and other sources available could be used to replace maize as an energy ingredient (Wiseman, 2006). In addition, the edible oils and fats play a major contribution in replacing maize as energy source (Ravindran and Blair, 1991). In Central and southern Africa, the major sources of energy include maize, maize bran, sorghum and barley. Minerals and vitamins are normally incorporated in the diets as pre-mixes (Sebastian *et al*., 2008). According to DAFF (2019), approximately 60% of total maize produced in South Africa is used for food consumption, industrial (other than feed) and seed purposes. The rest of the feed is used for the production of animal feed. On the other hand, Mabelebele *et al*. (2020) discovered that whole sorghum grains of about 50% of the diet can be included into chicken diets and offered from hatch without any adverse effects on performance. Several studies have discovered that sorghum has the potential to be used as alternative sources of energy in animal feeds (Fernandes *et al*., 2013; Moss *et al*., 2017). This indicate that there are few studies where sorghum was used as an alternative animal feed, the reason for this fact might be due to the misconceptions related to poor growth performance associated with feeding commercial chickens with sorghum-based diets. An attribute that favours the use of sorghum as a whole-grain supplement is its small kernel size, which allows for feeding of young birds without difficulty (Mabelebele *et al*., 2020).

Cost of ingredients

The main factors determining the composition of animal feed is the price of raw material, nutritional value of the components, nutritional requirement of the specific animal as well as rules and regulation of the government (Gizzi & Givens, 2004). In the United States, the demand for maize increased together with the world demands for feed grains due to the diversion of maize for biofuel production which resulted in unprecedented feed prices (Donohue & Cunningham, 2009). Furthermore, the increased costs of feed ingredients have resulted in $9.36 billion in cumulative additional costs to the poultry industry since the year 2006. Approximately 60% of the average US poultry diet is maize, with another 25% of the diet made from soybean meal (Leeson *et al.*, 2005). The cost of maize typically forms about 50-60 percent of the total feed formulation and the industry consumes nearly 30% of all maize produced in Ghana (Kusi *et al*., 2015). The highest cost which is faced by poultry producers is feed costs (Henseler *et al*., 2013; NAMC, 2015; Machethe, 2016; Ncube *et al*., 2017). For example, the cost of feed in South Arica (SA) is very expensive because the country is a net importer of maize (DALRRD, 2020). A considerable amount of literature has been published which estimates that at least 70% of a broiler growers input costs consists of feed costs (Louw *et al*., 2011; NAMC, 2015). Feed costs have however been highly volatile due to the unpredictable nature of the prices of raw materials. This can be regarded as one of the core reasons why South African broiler producers lack competitiveness with their counterparts (SAPA, 2011).

The price of maize and soya bean has a significant influence on feed cost because maize and soya in broiler production constitute majority of the raw materials for broiler feed (Nkukwana, 2018). High maize feed prices directly affect the quantity of meat imports (USDA, 2019). Furthermore, high maize prices have put pressure on broiler production profitability and has lowered farmers' gross margins and farm net income. Because of that, a change in the price of maize will directly affect broiler producers' profit margins. Nkukwana (2018) revealed that broiler feed costs are high, and it is not unusual to find small-scale producers paying an extra R50 to R100 for feed. The cost is higher than what commercial producers pay for a bag of feed because small-scale farmers purchase small quantities of feed. Furthermore, some broiler farmers buy feed only through middlemen since they require small quantities. SAPA (2017) revealed that an increase in feed price had majority (98%) of broiler producers buying feed in bags, while 1% bought in bulk, followed by 1% of farmers who manufactured their own feed because the cost of feed is overwhelmingly high.

2.4.2 Production efficiency of conventional chicken feed

Even though maize is a crop produced throughout the world, there exists competition for maize consumption between humans and the livestock industry. There is strong competition because the energy found in maize is much higher compared to other cereal grains (Mohamed *et al.*, 2015). Findings by Gebeyew *et al*. (2015) discovered that maize is a major source of energy in poultry nutrition. According to Olomu (2002), the Metabolizable Energy (ME) and percent crude protein content of sorghum are 3270 kcal kg-1 and 9.5%, which is comparable with 3319 kcal kg-1 ME and 10.1% CP (crude protein) of maize. Gebeyew *et al*. (2015) also found the energy and protein content of sorghum to be 3986.4 Kcal/kg DM and 11.4%, which is comparable with 11.6% CP and 3800.1 Kcal/kg DM ME (Medegu *et al*., 2010). Furthermore, the results indicated that sorghum is a good feed ingredient to replace maize, although the effect on the performance of the broiler will not be adverse. However, the use of sorghum will result in a better body weight gain of chickens (Olomu, 2002). Gebeyew *et al*. (2015) mentioned that the assessment of maize and soybeans as feed resource for poultry showed that maize has low nutrient value, meaning that maize has nutritional limitation of low protein content and poor protein quality. As a result of this, the nutritional limitation requires the use of expensive high-protein supplements or synthetic amino acids such as lysine in diets containing large proportion of maize. In conclusion, the study further highlighted that the replacement of sorghum with maize by up to 45% appeared to be biologically better, not having adverse effect on broiler performance and economic feasibility. Therefore, it can be concluded that maize is not efficient when compared to sorghum.

2.4.3 Forms of feed

Feed is generally known as food for animals, which may be explained as highly nutritious food components that are predominantly prepared for animals, especially livestock, and fed to them for proper growth and development to enhance animal productivity (DAFF, 2017). According to the Poultry Site (2005), the ability of the birds to achieve daily nutritional requirement will, in part, depend upon the nutrient composition of the diet; however, what chickens actually responds to is the feed intake (which is the amount of feed consumed over a given period of time). Furthermore, feed intake can be significantly affected by the feed because a poor feed form can potentially affect broiler growth rate. For example, feed form is considered to have a very significant impact on broiler growth and feed intake (Dozier *et al*., 2010). Therefore, feed form at the optimum level increases feed intake, which maximises chicken performance (Poultry Site, 2005). Therefore, the type of feed influences the growth performance of chickens.

Chicken feed comes in three forms: crumbles, mash and pellets forms of feed (diets). Each type of feed form has a significant impact on broiler growth and feed intake (Dozier *et al*., 2010). According to (McKinney and Teeter (2004); Amerah *et al*. (2008); Chewning *et al*. (2012)), broilers that are fed pellets have higher body weight than those fed with mash feed. In support, Jahan *et al*. (2006) indicated that pelleting has become a common processing method widely employed by feed manufacturers to improve livestock performance. In addition, pellets enhance bird performance by decreasing feed wastage, alleviating selective feeding, destroying pathogens, improving palatability and increasing nutrient digestibility compared to mash (Lv *et al*., 2015). However, one disadvantage is that pelleting costs about 10% more than the production of mash feed (Jahan *et al*., 2006). Moreover, broilers fed with crumble-pellet diets in the starter stage of production perform better than those fed mash diets. In the grower phase, birds fed with crumble-pellet diets had higher body weight than those fed with mash diets. According to Zang *et al*. (2009), it is commonly accepted that pellet diet increases weight gain and improve feed efficiency. In addition, pellets improve feed conversion and feed intake (Johan *et al*., 2006). Kim *et al*. (1996) on the other hand concluded that crumble-pellet treatment significantly improved feed conversion. However, Mirghelenj and Golian (2009) reported that feeding broilers with crumble-pelleted diets causes a significant increase in feed intake.

2.5 ADOPTION OF INNOVATION

According to the Oxford Dictionary of Business and Management, innovation is "any new methodology to designing, producing, or marketing goods that gives the innovator or his company a benefit over competitors" (Law, 2006). Urabe (1988) states that innovation is the generation of a new idea and its implementation into a new product, process, or service. In the same light, Afuah (2003) states that innovation is the employment of newly attained knowledge which then provides a new product or service what customers want. In some studies, innovation is defined as a product or process that is fairly new to the organisation, not simply to the world or market (Hobday, 2005). For instance, Rogers (2003) describes innovation as the adoption of ideas that are perceived new to the adopting individual or organisation. However, Slappendel (1996) emphasises that the term innovation is employed to indicate both the product and the process of innovating. The author stresses that the term "innovation" is also used to refer to the process, even though in which new ideas are already shaped, developed, or reinvented. In its conceptualisation, the innovation process contains periods of design and development, adoption, implementation, and diffusion. In summary, innovation is generally considered to be related to a product or process. To give an instance, it is when a new product is considered over the old products, or a change is made in farming practices to deal with challenges. Innovation is, therefore, something "new" but not in absolute terms. Some ideas might be innovative in developing countries but would not be regarded as such in developed economies (Khorakian, 2011).

2.5.1 Importance of innovation

Innovation is important because it allows companies to" transform ideas into new or improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace" (Schertlin, 2018). In agriculture, it is important for farmers to adopt innovations because they enable farmers to achieve high yields (Mukasa, 2018; Ntshangase *et al*., 2018). In addition, the expected profit from adoption is greater than that of non-adoption because adopters can diversify their cultivation (Dsouza, 2016). Also, innovation is important because it converts challenges into opportunities (Lazzaron, 2010). For instance, farmers are facing a challenge with the rising cost of conventional feed (Selaledi *et al*., 2021). The availability of these feed ingredients is not adequate because of the increasing cost of raw materials competition with humans for the same food items. Hence, the search for alternative feed sources has become inevitable to reduce feed cost (Swain *et al*., 2014).

2.5.2 The Adoption of innovation - Diffusion Theory

The study of innovation has a long past which has a historical divider between research that sought to understand patterns of diffusion (often through the use of methods such as logistic modelling), set against attempts to understand the structure and process of decision-making that influenced the adoption of innovations (Montalvo, 2008). Adoption and diffusion of innovation theory has been extensively used to identify factors that influence an individual's decision to adopt or reject an innovation (Rogers, 1995). Rogers developed adopter categories to 'measure' innovativeness of farmers to produce a statistical model (normal distribution curve) to show the distribution rate of the five adopter categories over the average time of adoption (See **Figure 2.1**). The author further defined adopter categories as “the classifications of members of a social system on the basis of innovativeness” (Rogers, 2003). This classification includes innovators, early adopters, early majority, late majority, and laggards. In each adopter category, individuals are similar in terms of their innovativeness: “Innovativeness is the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system” (Sahin, 2006). Moreover, Rogers categorises the adopters based on innovativeness which is an individual’s willingness to change familiar practises.

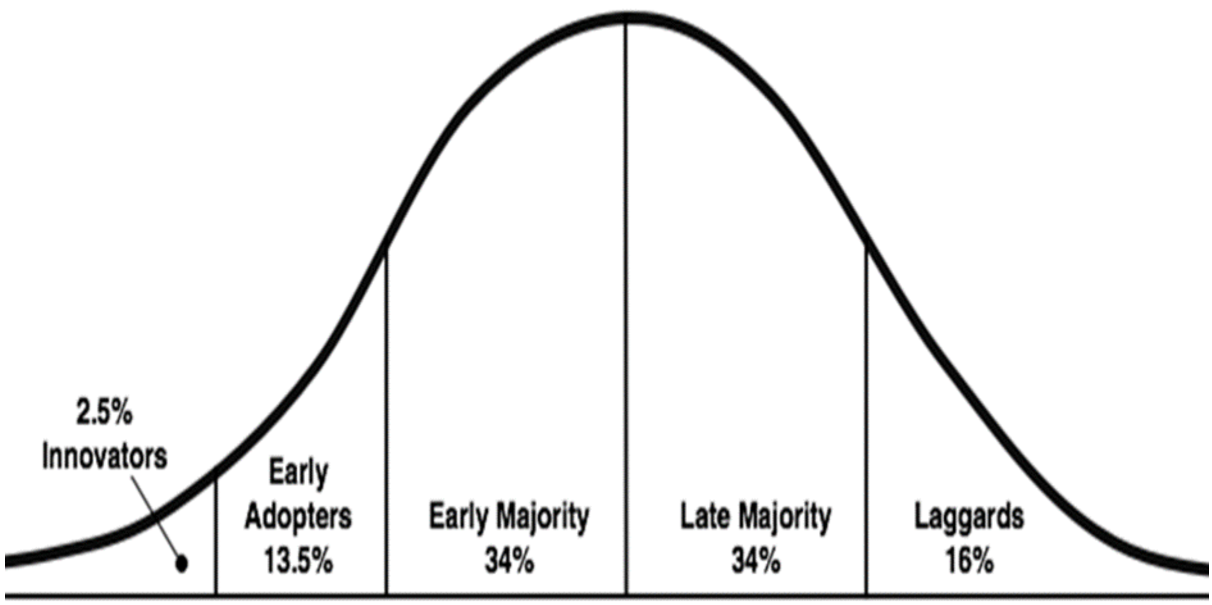

Figure 2.1: Adopters’ categories
Source: Rogers (2003)

Rogers (2003) distinguished that incomplete adoption and non-adoption do not form this adopter classification. Only adopters of successful innovations generate this curve over time. In the normal distribution, each category is defined using a standardized percentage of respondents. These are innovators, early adopters, early majority, late majority and laggards. In addition to these five categories of adopters, Rogers (2003) further described his five categories of adopters in two main groups: earlier adopters and later adopters. Earlier adopters consist of innovators, early adopters, and early majority, while late majority and laggards comprise later adopters. The author identifies the differences between these two groups in terms of socioeconomic status, personality variables, and communication behaviours, which usually are positively related to innovativeness. For instance, "the individuals or other units in a system who most need the benefits of a new idea (the less educated, less wealthy, and the like) are generally the last to adopt an innovation" (Rogers, 2003; Sahin, 2006).

Rogers in the adoption-diffusion theory also identified five (5) characteristics of an innovation that affect an individual's adoption decision or determine how an innovation will be responded to by a potential farmer or end-user (Ellis, 2006). The characteristics are (a) relative advantage, which is the degree to which an innovation is observed as being better than the idea it succeeds; (b) compatibility, or the degree to which an innovation is perceived as consistent with the existing values and beliefs, past experiences, and the needs of potential adopters; (c) complexity, which is the degree to which an innovation is perceived as relatively difficult to understand and use; (d) trialability, or the degree to which an innovation may be used experimentally on a limited basis; and (e) observability, which is the degree to which the results of an innovation are visible to others (Hippie & Duffy, 2002; Rodgers, 2003; Boz & Akbay, 2004). The adoption-diffusion theory has however been criticized to be "pro-innovation bias, individual-blame bias, and issues of equality" (Ellis, 2006). In the beginning, adoption-diffusion researchers identified characteristics of adopters, such as socio-economic status, personality, communication behaviour, and risk tolerance that determine the likelihood of adoption (Rogers, 2003). It is of supreme importance to note that the point at which a new idea is adopted depends on its characteristics (Selaledi *et al*., 2021).

2.5.3 Acceptability of innovation by farmers

For innovation to have a high adoption rate of new agricultural practices and be successful, it has to be accepted. According to Rumpold *et al*. (2013), the successful introduction of a new product in the market depends on the product's marketplace acceptance by the target users, which ultimately will affect the willingness to pay for the product. On the other hand, Adesina and Baidu-Forson (1995); Mbaka *et al*. (2008) indicated that farmers' perceptions of technology characteristics significantly affect their adoption decisions. Early adopters of new technology may realise increased profits, at least in the short-run. As more farmers adopt the technology, the increase in aggregate supply causes agricultural prices to fall, which can reduce farmer profits (Ellis, 2006). There is positive correlation between acceptability of innovations and adoption rate (Rogers, 1995). Meaning, for innovation to achieve a high adoption rate, it must be accepted by farmers. The issue of acceptability influences social, environmental and economic sustainability (Specht *et al*., 2019). Moreover, if there is a chance whereby innovation is not accepted, it could be due to impending adoption factors such as production methods and applied technologies, uncertain impacts, food products and consumers, related target groups, ethical factors and factors related to (non-supportive) framework conditions. Akudugu *et al*. (2012) found that the factors that influence technology adoption can generally be "categorised into economic factors, social factors (age, level of education and gender) and institutional factors (access to information and access to extension services)" respectively.

Technical change in the form of adoption of improved agricultural production technologies has been reported to have positive impacts on agricultural productivity in the developing world (Nin *et al.,* 2003). Curry *et al*. (2021) reported that adoption levels of technologies and the pace of adoption remains slow among small-scale farmers in developing countries. Akudugu *et al.* (2012) in Ghana also identified low adoption of modern agricultural production technologies amongst farmers as one of the main reasons for the low agricultural productivity. Additional literature has shown that the acceptability of yellow maize product in Zimbabwe was positively influenced by gender, price and income (Muzhingi *et al*., 2008). However, relative price and household income had a negative and statistically significant correlation with the adoption of yellow maize. Christoph *et al*. (2008) on the acceptability of genetically modified (GM) technology, found that gender and age had a significant and positive effect on the adoption decision. In contrast, age and gender had a negative and significant influence on the respondents' willingness to use mealworm to feed their chickens (Selaledi *et al*., 2021). The literature presented has shown that the important factors to be considered when one accepts the adoption of innovations are perceptions, accessibility of production inputs, socio demographic, socio-economic status, personality, communication behaviour, risk tolerance, market factors, cultural values, environmental factors and economic factors and technology perceptions, social factors, institutional factors and attitude (Rogers 2003; Mbaka *et al*., 2008; Christoph *et al*., 2008; Akudugu *et al*., 2012; Specht *et al*., 2019; Selaledi *et al*., 2021). In summary, adoption is affected by relative advantage, compatibility, complexity, trialability and observability (Selaledi *et al*., 2021). Ellis (2006) argued that advances in agricultural technology have often been associated with productivity, growth and lower agricultural commodity prices.

2.5.3.1 *Product Characteristics*

When a new product or service is introduced in the market, the product's related characteristics may increase consumer acceptability (Lysak *et al*., 2019). For instance, for consumers to adopt a new product, they consider product characteristics that affect adoption among consumers such as product expensiveness, product purchase frequency and product intangibility (Jain & Jain, 2011). According to Flight *et al*. (2011), for customers to adopt a new product, they consider characteristics such as compatibility, relative advantage and risk of the product. This means that customers adopt the innovation of a new product if it is compatible with their lifestyle, has benefits and feel less apprehensive about a potential negative consequence. Adoption therefore becomes more probable under the aforementioned conditions (Flight *et al*., 2011).

In broiler production, for farmers to consider alternative use of animal feed, there are certain factors such as (feed composition and quality (nutritional content), energy requirement, feed intake, feed availability, feed efficiency ,feed costs, improved weight gain and low mortality rate). Manyelo *et al*. (2020) found that feed composition and quality is an important attribute because providing the right nutrition is important for the growth, production, and health of poultry. Furthermore, there is evidence that the productivity of broiler chickens can be improved by the manipulation of their diets. With feed efficiency, several studies have been conducted to improve the productivity of local chickens through efficient feeding (Manyelo *et al*., 2020). Feed efficiency is defined as the ratio between feed intake and weight gain (Yi *et al*., 2018). Kingori *et al*. (2007) discovered that feed intake is an important characteristic to consider when adopting innovation because increased energy and protein levels optimise feed intake and growth. In essence, Astral Foods (2019) discovered that feeding has a direct impact on the growth rate, live weight, production capacity and health status of chickens. Thus, improved feed efficiency and chicken live weight are important attributes that farmers consider before deciding to adopt new feeds.

On the other hand, increasing dietary energy to protein ratio level decreased growth rate, thus, negatively affecting live weight of the chickens at six weeks of age (Mbajiorgu, 2010). Furthermore, correlation analysis indicated that optimal feed intake, feed conversion ratio and metabolisable energy level were positively correlated with dietary energy to protein ratio levels. However, optimal live weight was negatively correlated with dietary energy to protein ratio levels (Mbajiorgu, 2010). In respect of body weight, Assan (2013) reported that body weight has a direct relation to the production and profitability of any livestock enterprise. Razzaque *et al*. (2009) discovered that a reduction in mortality rates for livestock farms has a minimal effect on farm cash flows. Because of that, farmers prefer feeds that will reduce mortality weight. As a result, enterprises would increase their technical and economic efficiency by decreasing the mortality rate (Dogan *et al*., 2018). This means that for farmers to adopt alternative chicken feeds, the aforementioned variables should be considered.

2.5.3.2 *Product acceptability*

When farmers make decisions on adopting new technologies, they must take into consideration the time and cost required to access the product. Generally, producers or consumers consider distance travelled to access a new product or innovation. In farming, Hagos *et al*. (2018) discovered that distance was the most important variable in the adoption of rice technology. Furthermore, distance was found to be negatively and statistically correlated with the adoption decision of farmers. It implied that farmers who are distant from the input and output markets have less likelihood to adopt the improved technology. Studies by Solomon *et al*. (2011), Yemane (2014); Olalekan and Simeon (2015) were consistent and showed that distance was negatively and statistically correlated with adoption of improved agricultural technology.

Production input suppliers’ operating times and accessibility of the supplier location are additional factors that influence farmers’ decision to adopt innovation. For example, the supplier location and their times of work are limiting factors that prevent farmers from accessing inputs for their farming operations. Accessibility of agricultural inputs is an essential element of the agricultural value chain which enable farmers to effectively produce (Mtombeni *et al.*, 2019). The studies cited above describe agricultural inputs as animal feed, compost and fertilizers, seeds, plant protection products (chemicals, cleaning agents and additives) used in food production.

2.5.3.3 *Cost of product*

Jain and Jain (2011) found that the price of a product is a major factor affecting consumers' decision to purchase the product. Ideally, a potential adopter (individual or company) weighs the fixed costs of adoption against the expected benefits (Hall & Khan, 2003). In a farming setup, the cost effectiveness of the new technology is a clear factor in a farmer's decision to adopt a new technology (Katiha *et al*., 2005). According to Kumar *et al*. (2018), new technologies affect costs and cost effectiveness in numerous ways, depending on the amount of capital investment required and whether the new technology primarily affects annual fixed or variable costs. The scale of production and farm size could influence the cost of the product when adoption is considered. By way of illustration, some yield-increasing innovations may also be more rapidly adopted by very large-scale farms, which may be able to attain information or other inputs at lower costs or receive higher prices for their products than smaller farms would (Ellis, 2006). In contrast, others have suggested that smaller organizations are more likely to be innovative because of the flexibility afforded by their smaller size and fewer levels of bureaucracy (Patterson *et al*., 2003). Additionally, previous research, regardless of the measures used to evaluate size and adoption, has consistently indicated that organizational size positively correlates with technology adoption (Rogers, 1990; Germain, 1993; Dawe, 1994). When output prices are raised, or prices of inputs such as fertilizer are lowered, the profitability of a new technology relative to an old technology may be increased, thus increasing the rate of adoption (Miller & Tolley, 1989). Farmers however abandon technologies if the cost is greater than the benefits (Dsouza, 2016). Therefore, farmers' acceptability of innovations is influenced by the cost of purchasing an innovation.

2.5.3.4 *Cultural values and norms*

According to Schertlin (2018), the concept of culture being present in almost every part of an individual's life has been researched and defined by various scholars. The study further denotes that culture "seems to distinguish one group from another based on: a certain set of values, beliefs, behaviours and attitudes. Looking at the research investigating the effect of culture and religion on the decision to participate in projects, Lee (2011) and Lekhanya (2013) observed that regardless of the area, technology adoption diffusion is influenced by ethnic and clan members. In support Pai and Tu (2011) discovered that peoples' decision to adopt a technology is influenced by external impressions such as cultural values and norms that people are subjected to. Thus, cultural beliefs and values are prioritised when accepting innovations. For example, the introduction of a new project could be ignored for not satisfying societal norms even though it could yield optimal profit (Lekhanya, 2013). Tanko (2020) also indicated that cultural and religious values affect the adoption of agricultural technology.

2.6 THE THEORETICAL FRAMEWORK OF THE STUDY

Figure 2.2 illustrate the theoretical framework of the adoption of innovation whereby innovation adoption underpins the analysis of the study. This is because the main objective of the study is to determine the willingness of broiler farmers to adopt alternative chicken feeds as it fits well into the theory of adoption. The adoption and diffusion of innovation theory has been extensively used to identify factors that influence an individual's decision to adopt or reject an innovation (Rogers, 1995). There are characteristics of an innovation that affect an individual's adoption decision or determine how innovation will be responded to by a potential farmer or end-user (Ellis, 2006).

Figure 2.2 shows that firstly, sufficient knowledge about the innovation is required (Hippie & Duffy, 2002). Persuasion factors such as the characteristics of innovation, attributes of the product and affordability have a significant influence on farmers' adoption decisions. Furthermore, the decision to either adopt or reject innovation could be influenced by the socio-demographic characteristics of farmers (age, gender, farming experience, level of education etc.) which also influence the decision to adopt or reject based on their socio-economic characteristics. The framework depicts that adoption of new technology in the poultry industry, due to intense chicken feed challenges, could attract cost-effective alternative sources of chicken feed, a situation which will eventually translate into having adopters and non-adopters of innovation based on the knowledge, characteristics and attributes of the product (new innovation).

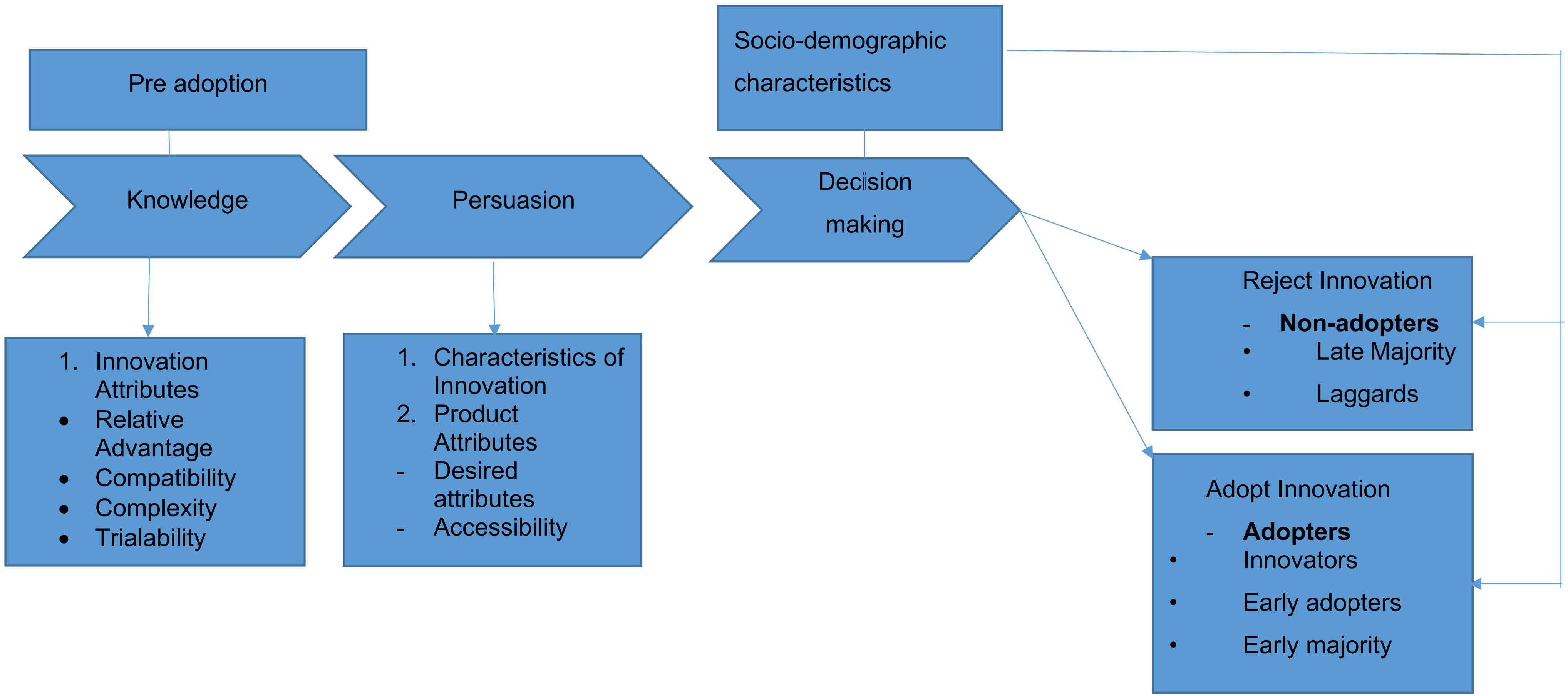

Figure 2.2: Theoretical framework of the study (Adopted from Rogers, 1995)

CHAPTER 3

3 STUDY AREA AND RESEARCH METHODOLOGY

3.1 INTRODUCTION

This section will focus on the research methodology employed to in the current study. The chapter starts by describing the area where the study was conducted, followed by the research approach and design, sampling, data collection, data analysis, validity and reliability of the study, ethical considerations, limitations of the study and the chapter summary.

3.2 STUDY AREA DESCRIPTION

The study was conducted in the Gauteng province of South Africa. Gauteng is the smallest province in South Africa, occupying an area of about 16 936 square kilometres (1.4% of the land area in RSA); however, it is the richest province (Stats SA, 2019). Gauteng province has the highest population share of about 15.2 million people (25.8%), which accounts for 23.7% of the total South African population (Stats SA, 2019). Gauteng Province is located in the northeast part of the country, surrounded by four provinces, namely Limpopo, Mpumalanga, Free State and North West. According to Statistics South Africa (Stats SA, 2019), the most common ethnic groups in Gauteng are Black African (76.4%), Coloured (5.6%), White (12.3%) and Indian/Asian (4.9%). In addition, about one-third of the population speaks Nguni languages (IsiZulu, SiSwati, Ndebele and IsiXhosa), 25% speak Sotho languages (Sepedi Sesotho and Setswana), 18% speak English, 7% speak Afrikaans, and 6% speak Tshivenda (Stats SA, 2019). Gauteng is divided into three metropolitan municipalities, the City of Ekurhuleni, the City of Johannesburg and the City of Tshwane Metropolitan Municipalities, as well as two district municipalities (Sedibeng and West Rand District), which are further subdivided into six local municipalities (Sedibeng District is divided into Emfuleni Local, Lesedi Local and Midvaal Local while West Rand District is divided into Merafong City Local, Mogale City Local and Rand West City Local).

According to Census 2011, Gauteng's three metropolitan areas (the City of Johannesburg, the City of Tshwane and Ekurhuleni) contain the greater part of Gauteng residents, with the

City of Johannesburg being occupied by approximately 36.1% of Gauteng's population. On the other hand, West Rand District Municipality has the smallest percentage of the population at 6.7% (Stats SA, 2019). **Figure 3.1** illustrate Gauteng Province Metropolitan Municipalities, District Municipalities, and Local Municipality.

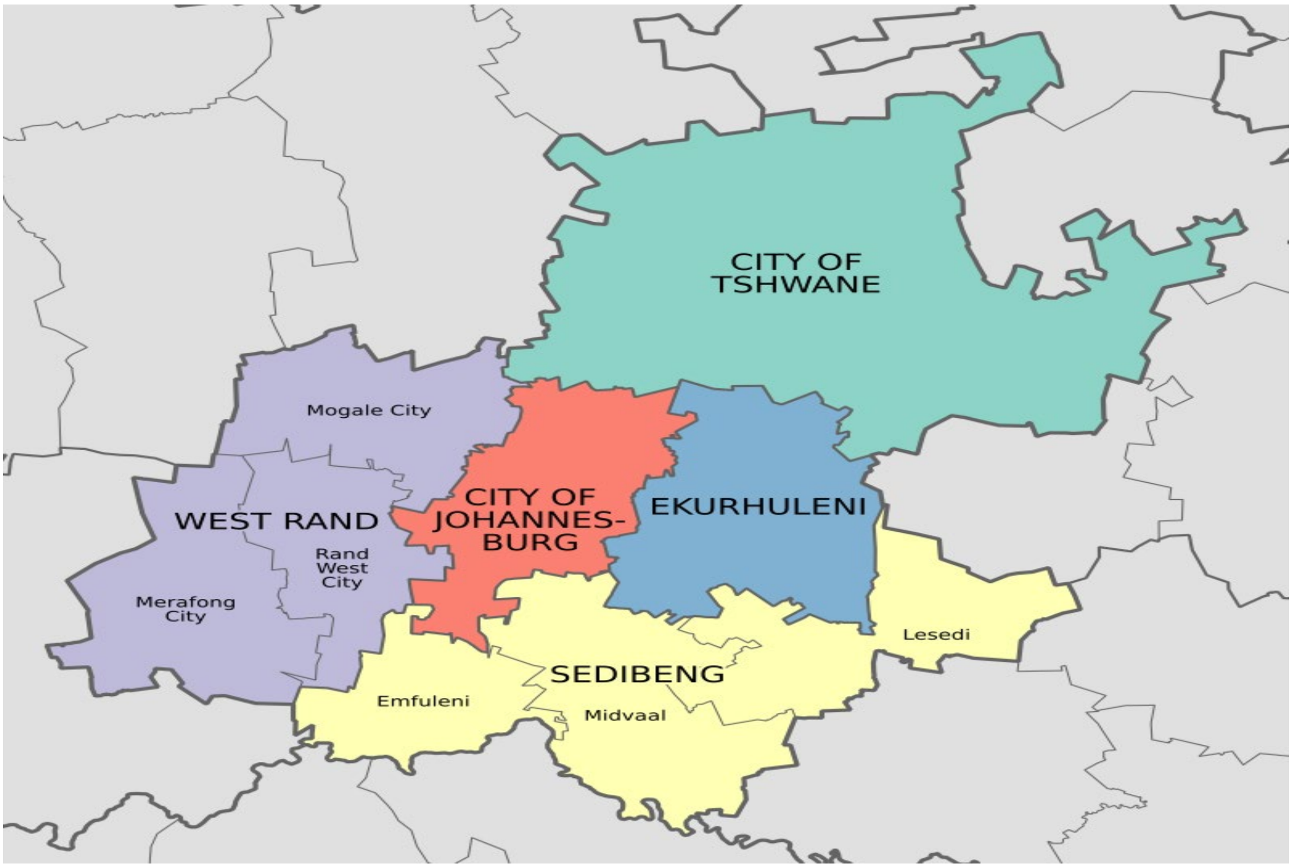

Figure 3.1:Gauteng Metropolitan and District Municipalities (Source: https://upload.wikimedia.org/wikipedia/commons/thumb/8/8f/Map_of_Gauteng_with_municipalities_named_and_districts_shaded_%282016%29.svg/800px-Map_of_Gauteng_with_municipalities_named_and_districts_shaded_%282016%29.svg.png)

The Gauteng Department of Agriculture and Rural Development (GDARD) stated that the contribution of primary agriculture to Gauteng's GDP was 0.5% (GDARD, 2017). In addition, the contribution of the total agricultural value chain, including secondary and tertiary agriculture to GDP was 2.3%. According to Stats SA, 2020), Gauteng has about 3% of the country’s arable land. The Census of Commercial Agriculture (2017) showed that Gauteng is at the bottom when it comes to the number of farms (5.7%), commercial agricultural land (0.8%) and commercial agriculture employees (4.8%). Gauteng province is rich in different farming activities such as poultry, livestock, piggery, vegetables, citrus field and grain crops in all the district municipalities and metropolitans. However, maize (5%) and soybeans (6%) are the major crops produced in Gauteng (DALRRD, 2021). Maize is the most important grain crop cultivated in the province because it is used as food for both human and animal consumption. In 2017, maize was cultivated on 105 000 ha of the 315 000 ha of arable land available in Gauteng (GDARD, 2017). Furthermore, about 63 000 ha (60%) of maize produced in Gauteng was white and 42 000 ha (40%) was yellow maize.

Regarding livestock production, SAPA (2019) indicated that almost a quarter of the country’s egg production and 10% of broiler production is from Gauteng. In addition, the province has 10% of the country’s pigs (DALRRD, 2021). The Gauteng Department of Agriculture and Rural Development farmer’s registry indicated that there was 29% of poultry commodities in Ekurhuleni metropolitan, 7% in City of Tshwane, 28% in Sedibeng and 14% in West Rand (GDARD, 2019). SAPA (2018) recorded 11 173 187 broiler birds (9.8%) and 7 199 553 (25.1%) of layer birds which contributes to a total of 18 372 740 (12.8%) of birds in South Africa. Furthermore, GDARD (2019) estimated that there were 22% of poultry farmers in Gauteng province.

3.3 STUDY APPROACH AND DESIGN

The study adopted the quantitative research approach and survey design. The quantitative research approach was used because it focuses on gathering quantifiable data and performing statistical, mathematical, or computational techniques (Creswell, 2003). Survey research is "the collection of information from a sample of individuals through their responses to questions" (Check & Schutt, 2012). This type of research allows for a variety of methods to recruit participants, collect data, and utilise various methods of instrumentation. Survey research can use quantitative research strategies (e.g., using questionnaires with numerically rated items), qualitative research strategies (e.g., using open-ended questions), or both strategies (i.e., mixed methods) (Ponto, 2015). A survey design was chosen because it could obtain more information from the large sample of the population (De Leeuw, 2008).

3.4 POPULATION OF STUDY AND SAMPLING PROCEDURE

Poultry farmers in all districts and metropolitan municipalities of Gauteng Province were the unit of analysis (study population). The list of all (active and non-active) poultry farmers was acquired from the Gauteng Department of Agriculture and Rural Development (GDARD). According to the GDARD list, the number of poultry farmers was 397. Out of the 397 poultry farmers in Gauteng province, about 180 produced broilers and some were involved in mixed farming (vegetables, cattle production, layers and broilers) while 217 were rearing layers. Nonetheless, for the purpose of the study, the target population was broiler enterprises (180) only. During data collection, it was however discovered that some of the farmers were duplicated on the list, as a result, the actual population size of the broiler farmers was reduced to 125.

Thereafter, a formula by Yamane (1967) was used to calculate the sample size. The formula is: $\mathbf{n} = \frac{\mathbf{N}}{\mathbf{1}+\boldsymbol{Ne^2}}$

Where;

n = required sample size

N = Total population

e = margin of error at 5% (0.05)

Solution:

$$\mathrm{n} = \frac{125}{1 + 125\ (0.05)^2}$$

$$= \frac{125}{1+0.3125}$$

$$= \frac{125}{1.3125}$$

=95

Therefore, n= 95

According to the above calculations, the appropriate sample size for this study was 95. However, during the survey, only 70 broiler farmers were interviewed because some of the farmers were not willing to participate in the study. The sample of the active participants from each regional office was selected using a probability sampling technique, namely, stratified sampling. Stratified sampling is a basic probability sampling technique that allows a researcher to randomly choose a subgroup of participants. The participants are from the list of poultry farmers receiving extension services from GDARD. The stratified sampling was used to select participants from Tshwane, Germiston and West Rand regions under the Gauteng Department of Agriculture and Rural Development (GDARD). Crossman (2020) describes stratified sampling as a sample that ensures that the subgroups of a given population are satisfactorily represented in a sample population. For example, this involved further grouping and refining of the list of broiler farmers into three areas to allow for a fair representation and participation from each region. In the study area, the Tshwane region included the City of Tshwane Metropolitan Municipality whereas Germiston region included Ekurhuleni Metropolitan Municipality and Sedibeng District Municipality. Again, the West rand region included participants from West Rand District Municipality and the City of Johannesburg Metropolitan Municipality. The sample size from three different regions was calculated using the following formula adopted from Research Advisors (2006):

Nj = Nj/N × n

Solution:

Gauteng province regional area's population sizes of the broiler farmers in operation was:

Tshwane Region: 28

Germiston Region: 39

West Rand Region: 58

Total: 125

Where nj is the sample size for the stratum, n is the total sample size, Nj is the population size for stratum j, N is the total population for all the poultry farmers in the three regional areas. The application of the formula was as follows:

Tshwane region: nj = Nj/N x n = 28/125 * 95 = 21
Germiston region: nj = Nj/N x n = 39/125 * 95= 30
West Rand region: nj = Nj/N x n = 58/125* 95 = 44
Total = 95

Simple random sampling technique was used to select participants from three regions. The advantage of random sampling is that it is simple and easy to apply when a small population is involved (Teddlie & Yu, 2007). Furthermore, each region in the accessible population, has an equal chance of being included in the sample, because selection is made independently. In addition, the researcher does not need to know the true composition of the population beforehand. **Table 3.1** represents the distribution of the study population, target sample size and achieved sample size of the study.

Table 3.1 The distribution of the study population, target sample size and achieved sample size.

Name of region	Number of farmers	Target sample size (n)	Achieved sample size (n)
Tshwane Region	28	21	23
Germiston Region	39	30	20
West Rand	58	44	27
Total	**125**	**95**	**70**

3.5 VALIDITY AND RELIABILITY

A pilot study was conducted to determine the validity and reliability of the survey instrument (questionnaire). About ten (10) participants were included in the pilot study. The survey instrument or questionnaire was adjusted accordingly based on the results of the pilot study. The revised questionnaire enabled the researcher to collect relevant data required to attain the objectives of the study with maximum reliability and validity. The questions were structured in such a way that all the information required to achieve the research objectives were collected. The following were measured to determine validity and reliability:

- The relevancy of the types of questions asked;
- Time required to conduct telephonic interviews and/complete survey instrument; and
- The willingness of the targeted study population to participate in the study.

3.6 SURVEY INSTRUMENT

The survey instrument (questionnaire) enabled the research to collect socio-demographic information such as age, race, marital status, educational background, type of land occupation method, farming experience, farm/plot size, main source of income and net farm income. Other information collected include the number of chicken houses, carrying capacity of chicken house, number of employees, distance to the nearest feed store, access to agricultural services, receipt of government subsided feed and access to formal market and net farm income. The production characteristics covered in the questionnaire were the number of production cycles per year, number of feedbags per cycle, average live weight of chickens, anticipated live weight from proposed feed and preferred feed form during different phases of production. In addition, the questionnaire collected information about the willingness of broiler farmers to adopt alternative chicken feeds made from amaranthus and sorghum. The willingness to adopt questions was scored on three-point Likert scale ranging from 1=would not consider; 2=Might consider to 3= Will consider. General questions were asked in an open-ended format to determine the challenges faced by the broiler farmers.

3.7 DATA COLLECTION

A semi-structured survey questionnaire was used to interview broiler farmers in Gauteng province. Data was collected through telephonic and online surveys however Covid 19 regulations were a limitation particularly with regards to movement from one point to another (which was restricted when the country was in level 5). Because of that, the researcher was not able to visit the farmers for data collection. However, the researcher sought permission from the Gauteng Department of Agriculture and Rural Development (GDARD) for their provincial poultry registry to conduct telephonic and virtual interviews because movement was not permitted. The researcher explained everything concerning the questionnaire virtually and over the phone and made telephonic appointments through GDARD Extension Officers before collecting data. The researcher is of the view that all clarity was given during the telephonic interviews and completion of questionnaires. During the interviews, the researcher discovered that language was a challenge particularly IsiZulu (which is part of the Nguni group). An interpreter was employed since the researcher was not fluent in the language of the respondents. However, the respondents understood IsiZulu, Setswana and Sesotho because they are the predominant languages in the study area. Where the respondents sought clarity, the researcher clarified in their home language. The researcher is of the view that no meaning was misunderstood during the interview and completion of questionnaires.

3.8 DATA ANALYSIS

The quantitative data was captured on Microsoft Excel and transferred to Statistical Package for the Social Sciences (SPSS) version 27 for analysis. The analysis included both descriptive (means, frequency, percentage, standard deviation, standard error of mean and mode) and inferential statistics. Inferential statistics involved the use of Ordered Logistic Regression (OLR) model, Correlation and Non-parametric tests (Friedman's test and Wilcoxon signed rank test). Data from open-ended questions was analysed using codes, themes, frequencies and percentages. In inferential statistical analysis, the level of significance was determined using $p \leq 0.05$ (5% significance level). **Table 3.2** presents the summary of data analysis methods that were used to achieve each research objective.

Table 3.2: Data analysis methods used in the study to achieve each research objective.

Research objective	Data analysis method
To profile broiler famers' socio-demographic characteristics	Descriptive statistics, Binomial test and Kendall's tau-b Correlation
To determine the operations of broiler enterprises	Descriptive statistics, Pearson Correlation and Ordered Logistic Regression (OLR) model
To identify challenges experienced by broiler farmers	Codes, Themes, Frequencies and Percentages
To determine the willingness of broiler farmers to adopt alternative feeds made from amaranthus and sorghum as energy and protein sources, respectively; and influencing factors	Descriptive statistics, Friedman's Test, Wilcoxon signed rank test and Ordered Logistic Regression (OLR) model

Descriptive statistics

Descriptive statistics included mean, minimum, maximum, mode, media, variance, standard deviation and standard error of mean. A mean score of 1-1.5 was considered as 1(Would not consider), 1.6-2.4 will be considered as 2 (Might consider), whereas 2.5-2.9 was considered as 3 (Will consider).

Correlation

To achieve objectives 1 and 2, data was analysed using Kendall's tau-b and Pearson correlation to measure the relationship that exist between the variables. Gogtay and Thatte (2017) define correlation analysis as the association or relationship between two (or more) quantitative variables. In this study, Kendall's tau-b correlation (τ) was performed to assess the statistical relationship between socio-demographic characteristics (age group, gender, and level of education, land occupation, farming experience and farm/plot size (ha)). Khamis (2008) reported that Kendall's tau-b is used if one variable is continuous and the other is ordinal. On the other hand, Pearson correlation (r) was used to measure the strength of the linear relationship between operational and production variables (number of chicken houses, number of chickens (carrying capacity), number of employees, production cycles per year, number of feedbags used per cycle, average live weight (kg), mortality rate (%) and price of chicken) with no influence from any extraneous variables. The value of *r* lies between –1 and +1. Pearson correlation considers two continuous variables (Khamis, 2008). According to Webster's Online Dictionary, correlation is a reciprocal relation between two or more things; a statistic representing how closely two variables co-vary; it can vary from −1 (perfect negative correlation) through 0 (no correlation) to +1 (perfect positive correlation) (Parker, 2010). The variables that seemed to interact with each other were selected and analysed at 0.05 and 0.01 levels of significance.

Ordered Logistic Regression model

In the Ordered Logistic Regression, the willingness of chicken farmers to adopt alternative feeds made from sorghum and amaranthus was categorised as 1=Would not consider; 2=Might consider; 3=Will consider. Ordered Logistic Regression can predict a polychotomous ranked dependent variables as a function of explanatory variables that describe the characteristics of a unit, individual or economic agent (Gujarati & Porter, 2009). To determine factors influencing the adoption willingness of broiler farmers in Gauteng Province to adopt alternative chicken feeds made from amaranthus and sorghum as energy and protein substitutes, "Will not consider", "Might consider" or "Will consider", the following OLR model defined regression equation was used:

$$Y^{*} = X'\beta + \varepsilon \qquad (1)$$

Where *Y**, the latent variable in equation (1), is not observable. What is observable is the polychotomous Y, defined by the following:

$Y=1$ (Would not consider) if $Y^* \leq 1$,
$=2$ (Might consider) if $1 < Y^* \leq \mu_2$,
$=3$ (Will definitely consider) if $\mu_2 < Y^* \leq \mu_3$,
The μs are unknown parameters that will be estimated with β. The ε in equation (1) is normally distributed across observations. With a constant mean and zero variance. The probabilities derived from equation (1) are:

$\text{Prob}\ (y=1 \mid x) = \phi\ (-x\ \beta)$
$\text{Prob}\ (y=2 \mid x) = \phi\ (\mu_2 - x\ \beta) - \phi\ (\mu_1 - x\ \beta)$
$\text{Prob}\ (y=3 \mid x) = \phi\ (\mu_3 - x\ \beta) - \phi\ (\mu_2 - x\ \beta)$

Marginal effects indicate the change in probability of being a certain category when the explanatory variable increases by one unit. They are approximations of how much the dependent variable is expected to increase or decrease for a unit change in an explanatory variable. For continuous variables, this represents the instantaneous change given for a unit increase and for dichotomous variables, the change is from zero to one. On the probabilities, the marginal effects of the regressors (X_s) are not equal to the coefficients. For the three probabilities, the marginal effects of alterations in the explanatory variables are:

$$\frac{\delta \text{Prob}(y=1 \mid x)}{\delta x} = -\phi\ (x\ \beta)\ \beta$$

$$\frac{\delta \text{Prob}(y=2 \mid x)}{\delta x} = [\phi\ (-x\ \beta) - \phi\ (\mu - x\ \beta)]\ \beta$$

$$\frac{\delta \text{Prob}(y=3 \mid x)}{\delta x} = \phi\ (\mu - x\ \beta)\ \beta$$

The base group is the "Would not consider" category. The higher categories are "Might consider" and "Will definitely consider".

The above Ordered Logistics Regression will be projected as follows:

$Y = f(x_1, x_2, x_3, x_4, x_5, x_6, x_7, - x_8 \ldots \mu) \ldots\ldots (xx)$

Table 3.3: List of dependent and independent variables used OLR model for farmers' willingness to adopt alternative chicken feed.

Dependent variable	**Variable description and value**
Y=Willingness to adopt alternative animal feeds made of sorghum and amaranthus	1=Would not consider; 2= Might consider; 3= Will consider
Independent variables	**Variable description and value**
X_1 = Age of participant	1= 18-35;2= 36-45;3= 46-55;4= 56-65; 5= >65 and above
X_2= Gender	0= Male; 1= Female
X_3 = Level of education	1=Never been to school;2=No formal Education, 3=Primary Education; 4=Secondary Education; 5=College Education; 6=University Education; 7=Other (Specify)
X_4 = Type of land ownership	1=Inherited, 2=Communal tenure; 3=Rented/Leased. 4=Purchased 5=Other (Specify)
X_5 =Farm Size/plot size	Hectares (Ha)
X_6 =Source of income	1 =Employed; 2 = Self-employed. 3 =Social grant; 4 =No income;5 =Farming; 6 =Other (Specify)
X_7 = Number of production cycles per annum	Number
X_8 =Price of chicken	Rands (R)
X_9 = Net annual income	Rand (R)
X_{10} = Farming experience	Years
X_{11} = Mortality rate	Percentage
X_{12} = Weight of live birds	Kg
X_{13} = Carrying capacity of broiler houses	Number
X_{14} = Distance travelled to nearest feed store	Km

OLR was also used to determine factors influencing farmers' annual net income. In the Ordered Logistic Regression, farmers annual net income was categorised as 1=<R10 000, 2=R10 001-R30 000, 3=R30 001-R90 000, 4=R90 001-R120 000 and 5=>R120 000. Table 3.4 shows the description of independent and dependent variables used in OLR.

Table 3.4: List of dependent and independent variables used OLR model for factors influencing farmers' annual net income.

Dependent variable	Variable description and value
Y=Annual net farm income	1=<R10 000; 2=R10 001-R30 000; 3=R30 001-R90 000; 4=R90 001-R120 000; 5=>R120 000.
Independent variables	**Variable description and value**
X_1 = Age of participant	1= 18-35;2= 36-45;3= 46-55;4= 56-65; 5= >65 and above
X_2= Gender	0= Male; 1= Female
X_3 = Type of land ownership	1=Inherited, 2=Communal tenure; 3=Rented/Leased. 4=Purchased 5=Other (Specify)
X_4=Farm Size/plot size	Hectares (Ha)
X_5 =Number of chicken houses	Number
X_6 =Carrying capacity of chicken houses	Number
X_7 = Distance travelled to nearest feed store	Km
X_8 = Receiving government subsidised feed	No=0; Yes=1
X_9 = Number of production cycles per annum	Number
X_{10} = Number of feedbags utilised per cycle	Number
X_{11} = Average live weight (Kg)	Kg
X_{12} = Mortality rate	Percentage
X_{13} =Price of chicken	Rands (R)

Binomial test

Binomial test was used to analyse the socio – demographic characteristics of the broiler farmers. Binomial test is a non-parametric test used to determine the probability that an outcome will occur where the population being investigated must have exactly two possible outcomes (Mann, 2013). According to Norušis (2006), the Binomial test compares the observed frequency in each category of a dichotomous variable (two possible values: Yes or No, 0 or 1, and so on) with expected frequencies from the binomial distribution with a specified probability parameter, the tested variables should be numeric. In the study, Binomial test was used to determine means, percentages and statistical significance between Yes and No responses. The level of significance used in the Binomial test was 5% ($p \leq 0.05$).

Non- parametric Test

The types of non-parametric tests employed in the study were Friedman's test and Wilcoxon signed-rank test. Friedman's test is a widely used rank-based (low to high) alternative to the analysis of variance (ANOVA) used to test and identify differences between groups when the dependent variable being measured is ordinal (Pereira *et al*., 2015). Friedman's test only discloses whether or not there is a significant statistical difference ($p \leq 0.05$) among the attributes but does not exactly show where the difference occurs. To determine where the difference is, the Wilcoxon signed rank test will be used.

A post-hoc test (Wilcoxon signed rank test) was performed to further determine where exactly the difference was between the groups. Rosner *et al*. (2006), describes Wilcoxon signed rank test as two non-parametric test procedures that are applicable to a single data set or data collected as pairs, such as before and after treatment. In addition, the Wilcoxon signed-ranks test is regarded as a greater statistical power because it is used to determine where exactly the statistically significant difference lies between paired observations/related samples. On the other hand, the Wilcoxon signed rank test model is used to compare data on the basis of before and after (Antwi and Nkwe, 2013). The level of significance used in the Wilcoxon signed ranks test was 5% ($p \leq 0.05$). The key results for Wilcoxon signed rank test are Z-score value, Mean Ranks, Sum of Ranks and significance value (Oladele & Ward, 2017).

3.9 ETHICAL CONSIDERATIONS

An application for permission was sought from the Gauteng Department of Agriculture and Rural Development (GDARD). After receiving permission from GDARD, the researcher applied for ethics approval from the Research Ethics Review Committee of the College of Agriculture and Environmental Science at UNISA before data collection commenced. The research ethics clearance number allocated to the student was **2019/CAES_HREC/170**. Data collection commenced after the researcher acquired ethical clearance from both organisations. Prior to data collection, the researcher thoroughly explained the aims and purpose of the research to all the participants. Participants were informed that their participation was solely voluntary as they had the right not to participate (Paratoo, 2006). The respondents were informed about their rights and that they could withdraw from the study at any given during the study (Strydom, 2011). Details regarding the entire study were fully disclosed to all participants to enable them to make informed decisions on whether to participate or not. An assurance was made to ensure anonymity when the results of the study were reported. This implied that the names of the respondents were not disclosed in the results used for the dissertation, reports, journal articles or other formal publications. Concerning informed consent, the researcher communicated the nature, procedure, potential benefits and anticipated inconvenience of participation of the study before the interview. Thereafter, the researcher made interview appointments with the farmers that consented to participate in the study.

3.10 LIMITATIONS THE STUDY

Limitations of the study were Covid 19 regulations which restricted the researcher from visiting the farmers. The researcher however collected data telephonically and also used internet/e-based technology (email). As a result, the researcher could not see the farmers' faces and the chicken structures which were at the broiler farms meaning that the researcher relied on the farmers' answers. There was the challenge of inability to access telephone numbers and problems with network or limited network coverage. In addition, the farmers were unwilling to participate and respond to questions that required records of finances (sources of income and net farm income). Some respondents were sceptical about revealing accurate information relating to net income and source of income especially via telephone interviews; this was remedied by guaranteeing the confidentiality of the information provided during the interview. In spite of the challenges, the emerging data collection approach based on internet/e- based technologies (e.g., online platforms and email), is a relatively cost effective and reliable survey alternative (Regmi *et al*., 2016). The advantages of telephone and email surveys include rapid data collection, lower costs as you can have higher response rate, anonymity and large-scale accessibility (Moore, 2001).

3.11 CHAPTER SUMMARY

In summary, the study was conducted in Gauteng province; using quantitative research approach and survey design whereby 70 (achieved sample size) broiler farmers were interviewed telephonically as part of data collection. Semi-structured survey instrument (questionnaire) was utilised for data collection. The quantitative (numeric) data was analysed using descriptive statistics, Ordered Logistic Regression (OLR) model, Friedman's test, post hoc test, Wilcoxon signed ranks test and Binomial test in the SPSS version 27. Qualitative data was captured using open-ended questions. The open-ended questions asked participants to provide responses in their own words. Ethical clearance and permission to conduct the study were granted by UNISA and GDARD, respectively.

CHAPTER 4

4 SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE RESPONDENTS

4.1 INTRODUCTION

This chapter presents the results of the socio-demographic characteristics of the respondents. The chapter is based on the following objective: to determine the socio-demographic characteristics of poultry farmers in Gauteng province. The chapter starts by presenting the results of the demographic and socio-economic characteristics of poultry farmers in the study area, followed by the discussion of the results and summary and conclusion at the end.

4.2 RESULTS

The results section is divided into four sections namely, demographic and socio-economic characteristics, correlation of the socio-demographic characteristics and access to support services and markets.

4.2.1 Demographic characteristics of broiler farmers in the study area.

In surveys, demographic information of the respondents is essential because it shows whether the selected participants are a fair representative sample of the target population for generalisation purposes. Because of that, demographic data was collected from the respondents whereby the information that formed part of the research was age group, gender, race, marital status, and education of the respondents. The results of the demographic characteristics of the respondents are presented between sections 4.2.1.1 and 4.2.1.5.

4.2.1.1 *Age group*

Data about age of the respondents was categorised, meaning the respondents were not required to reveal their exact ages. **Figure 4.1** presents the results of the ages of the respondents.

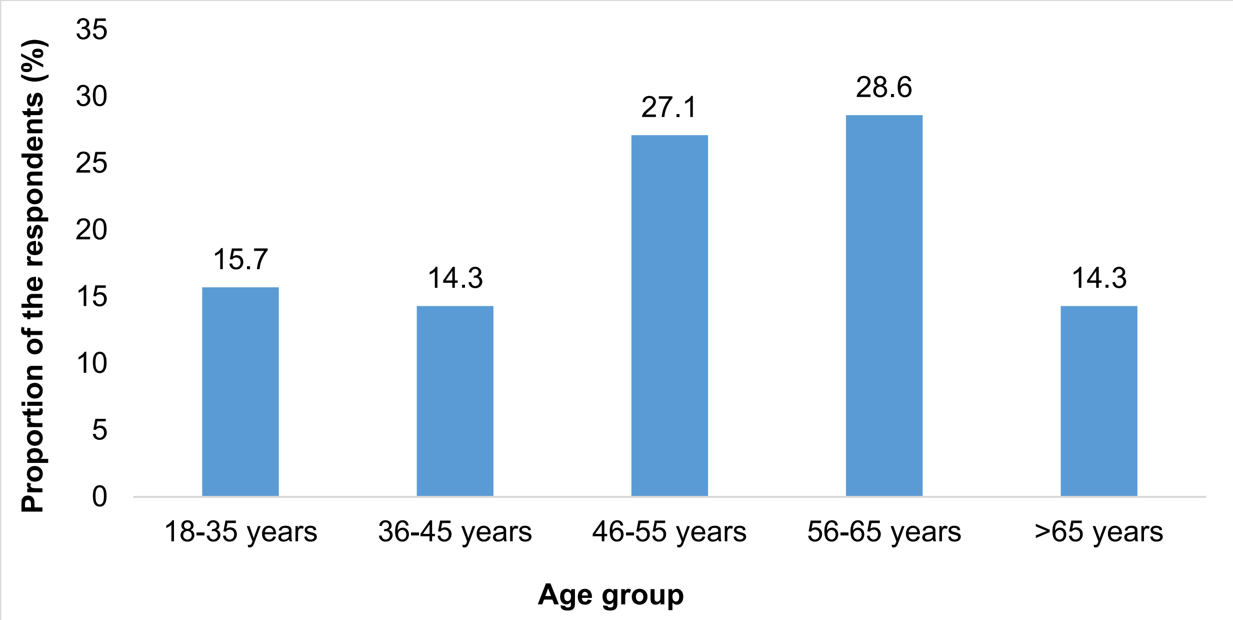

Figure 4.1: Age group of the respondents (n=70).

The results in **Figure 4.1** shows that 42.9% of the respondents were above 55 years of age, followed by 41.4% who were between 36 to 55 years. Less than one-fifth (15.70%) were between 18 and 35 years. The findings indicate that more than one-third (42.9%) of poultry farmers in the study area were either retired or approaching retirement. This is because in South Africa, the retirement age is 55 years, depending on the profession and the employment sector. Furthermore, the results illustrated that youths' participation in poultry farming was low because 15.7% of the respondents were classified as youths (18-35 years old).

4.2.1.2 *Race*

The study examines the way in which racial affiliation plays a role in Agriculture. In South Africa, majority of smallholder farmers are black while most large-scale farmers are white because of the apartheid system that allocated land according to racial affiliation. The main types of racial groups in South Africa are Black African, Coloured, White, and Indian/Asian. Race information was collected in the study area to determine which group had more access to land for farming and their participation in broiler farming. The results of the racial affiliation of the respondents are presented in **Figure 4.2**.

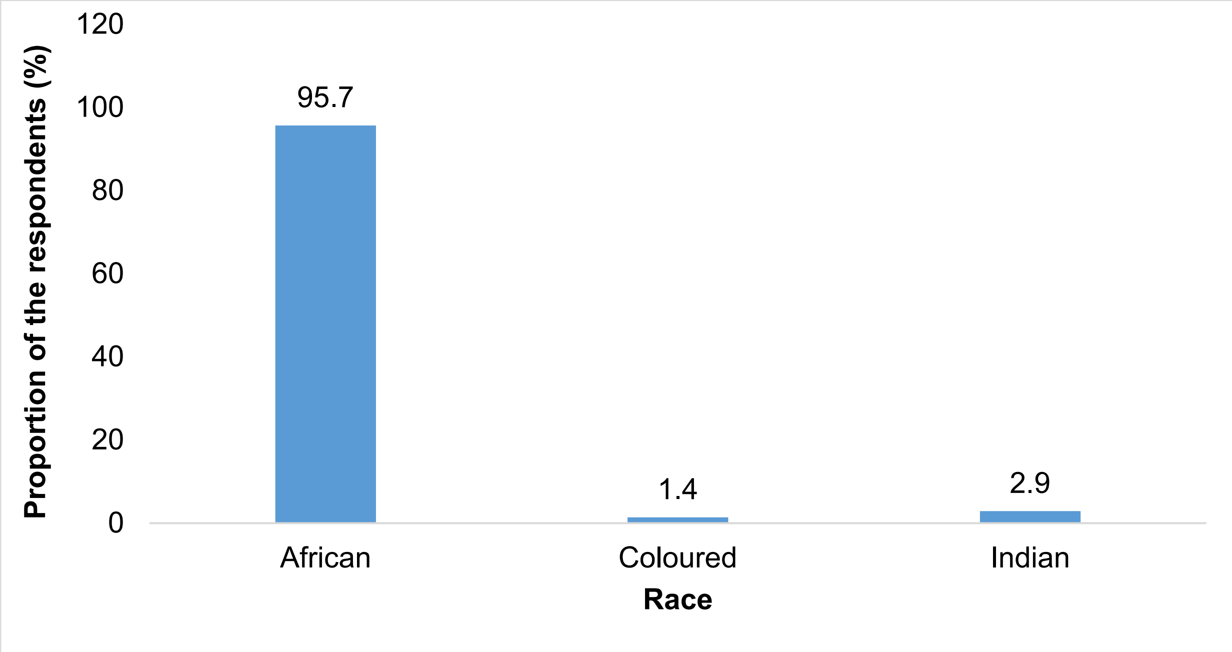

Figure 4.2: Racial affiliation of the respondents in the study area (n=70).

From race standpoint, **Figure 4.2** depicts that about 95.7% of the respondents in the study were Africans while less than 4.3% were Indians and Coloureds combined. It is notable that majority of the African broiler farmers were actively participating in farming activities after the land reform processes which was aimed at empowering and ensuring that more African farmers own agricultural land. It implies that the broiler sector in Gauteng province is highly transformed since it is dominated by a previously disadvantaged group of people.

4.2.1.3 *Gender*

In Agriculture, research has shown that it is important to document farmers' gender in survey studies because it influences activities such as technology adoption, selection of livestock to breed and crop cultivars, decision making, access to resources and others (Aregu *et al*., 2010). In the current study, it was therefore important to profile gender participation in poultry farming and how it influences the adoption of alternative chicken feeds. The results of the respondents' gender are presented in **Figure 4.3.**

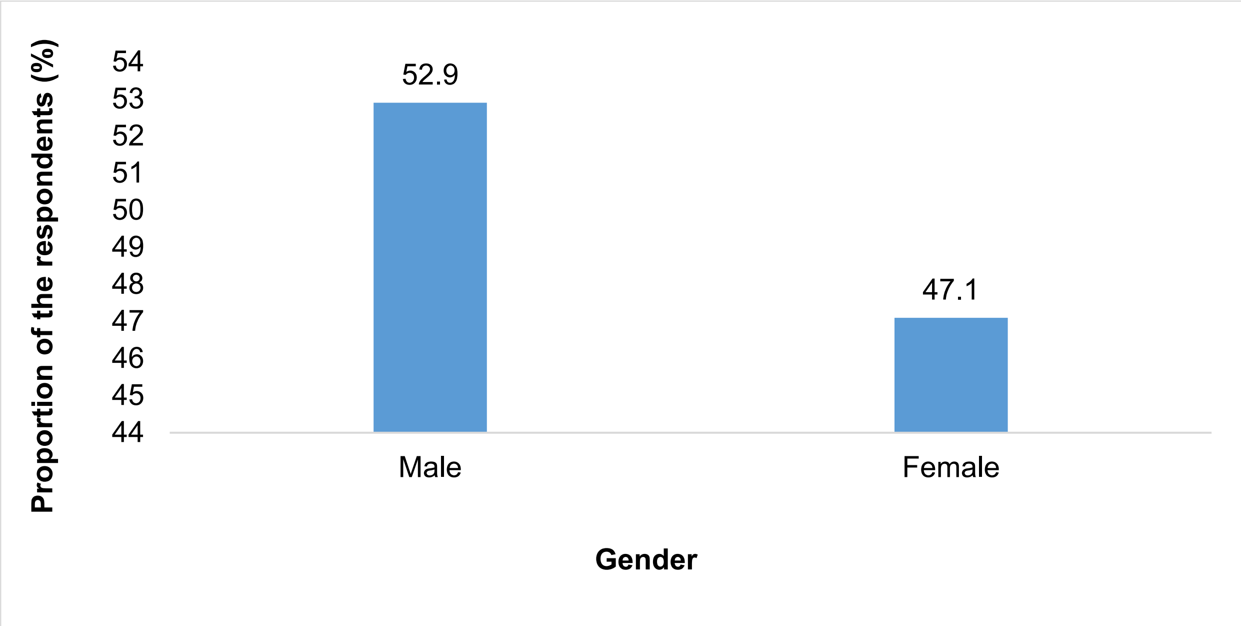

Figure 4.3: Gender of the respondents in the study area (n=70)

In **Figure 4.3**, the demographic information reveals an interesting proportion between male and female broiler farmers in the study area. Majority (52.9%) of the respondents who participated in broiler production were males and 47.1% were females. There is less than 6% (5.8% actual) difference between both genders even though men dominated. However, the results of the binomial test revealed that there was no statistical significance (p=0.72) between the proportion of male and female farmers although majority were men. The mean score achieved from females (categorised as 0) and males (categorised as 1) was 0.47. However, the mean score in the dichotomous data does not have much meaning; hence no further interpretation is provided.

4.2.1.4 ***Marital Status***

Information about the marital status of the respondents was collected to establish the courtship behaviour of broiler farmers in Gauteng province. Understanding the relationship status of the farmers is necessary because it creates specific opportunities and obligations in running a business. Options used to describe the marital status of the respondents were married, single, divorced, cohabitation, widowed and others. The results of the marital status of the respondents are presented in **Figure 4.4**.

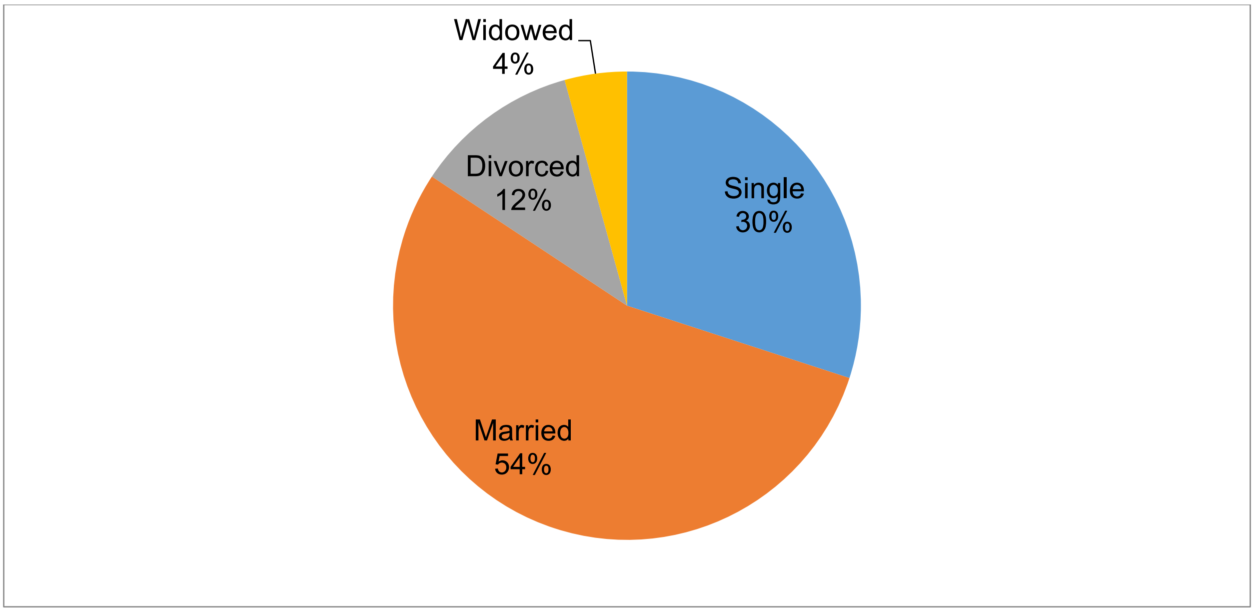

Figure 4.4: Marital status of the respondents (n=70)

The findings on the marital status of the farmers as shown in **Figure 4.4** indicate that more than half (54%) of the respondents were married while 46% were not (single, divorced and widowed). The results imply that a large proportion of the respondents running chicken production units were in formal relationships because a majority of them were married. The assumption is that married couples are likely to have complementary skills from their spouses. Such skills will be helpful in their production activities and sharing financial burden.

4.2.1.5 *Level of education*

Educational background includes formal and informal education received in their lifetime. Research has shown that highly educated people are exposed to better information and opportunities. Furthermore, highly educated farmers are more likely to adopt innovation, generate more income and achieve high productivity. In the current study, information on educational level attained by broiler farmers in the study area was gathered and analysed. The levels of education are categorised as university, college, secondary, primary education, no formal education and never been to school. The results of the educational level of the respondents are presented in **Figure 4.5**.

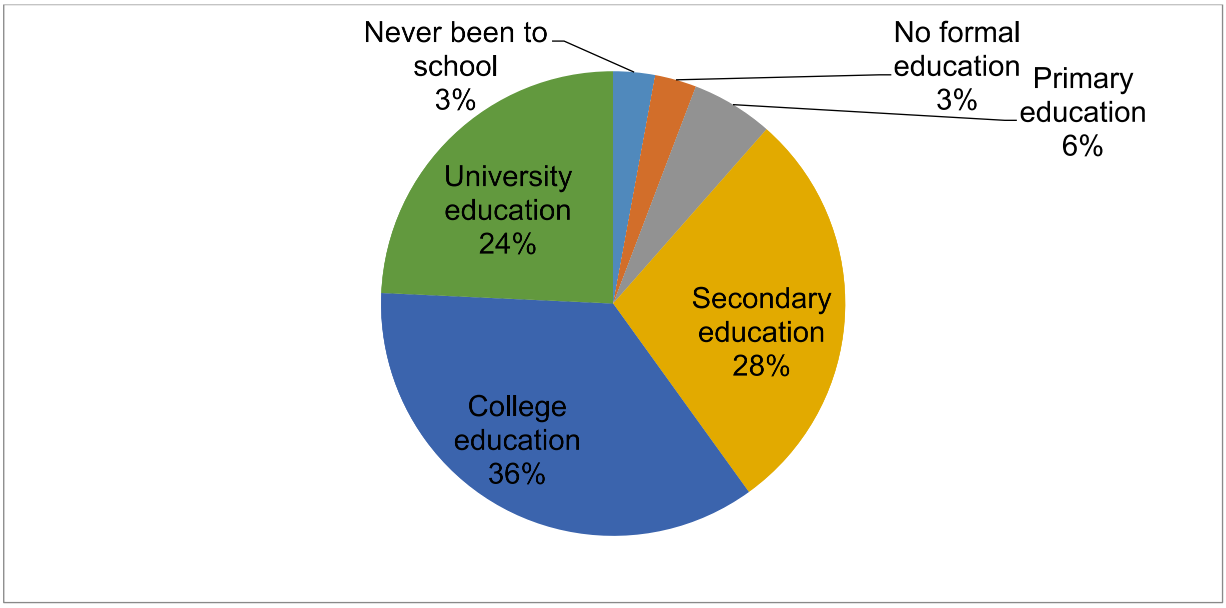

Figure 4.5: Educational level of the respondents (n=70).

Concerning level of education amongst the respondents, the results indicate that 94.3% had formal education while 5.7% neither had formal education nor attended school. The formal education acquired by the respondents include primary, secondary, college and university education. In formal education, 60% of the farmers were tertiary (college and university) graduates. Therefore, more than half of the farmers had access to higher education in their lifetime. The results show that majority of the respondents can access necessary information to improve their production activities, decision-making, access to market and marketing of their produce.

4.2.2 Socio-economic characteristics of the respondents

In the current study, the socio-economic characteristics of the farmers were important to measure because the farming sector in South Africa is diversified. Socio-economic characteristics information was collected to highlight the various ways through which the characteristics influence decisions to adopt agricultural technologies. To achieve the goal of adoption of new innovation, the following information about socio-economic characteristics of broiler farmers in Gauteng province was collected and analysed: type of land occupation method, land size, farming experience, sources of income, and annual net farm income. The results of the socio-economic characteristics of the respondents are presented from sections **4.2.2.1 to 4.2.2.4.**

4.2.2.1 *Type of land occupation method*

Land is an important asset in South Africa because of the Native Land Act of 1913 that prevented black people from owning land. For that reason, farmers in South Africa occupy land through different land tenure methods. Owning land in the study area (Gauteng province) is expensive and perceived as a lifetime investment that is not easy to acquire. This is mainly because the value of land in Gauteng is higher compared to other provinces. As a result, most farmers opt for other land occupation methods such as renting due to lack of capital to purchase land. For the purpose of this study, land occupation methods were grouped into four categories namely, purchased land (privately owned), communal or commonage land, rented or leased land and inherited land. The findings of land occupation methods used by poultry farmers in the study area are shown in **Figure 4.6.**

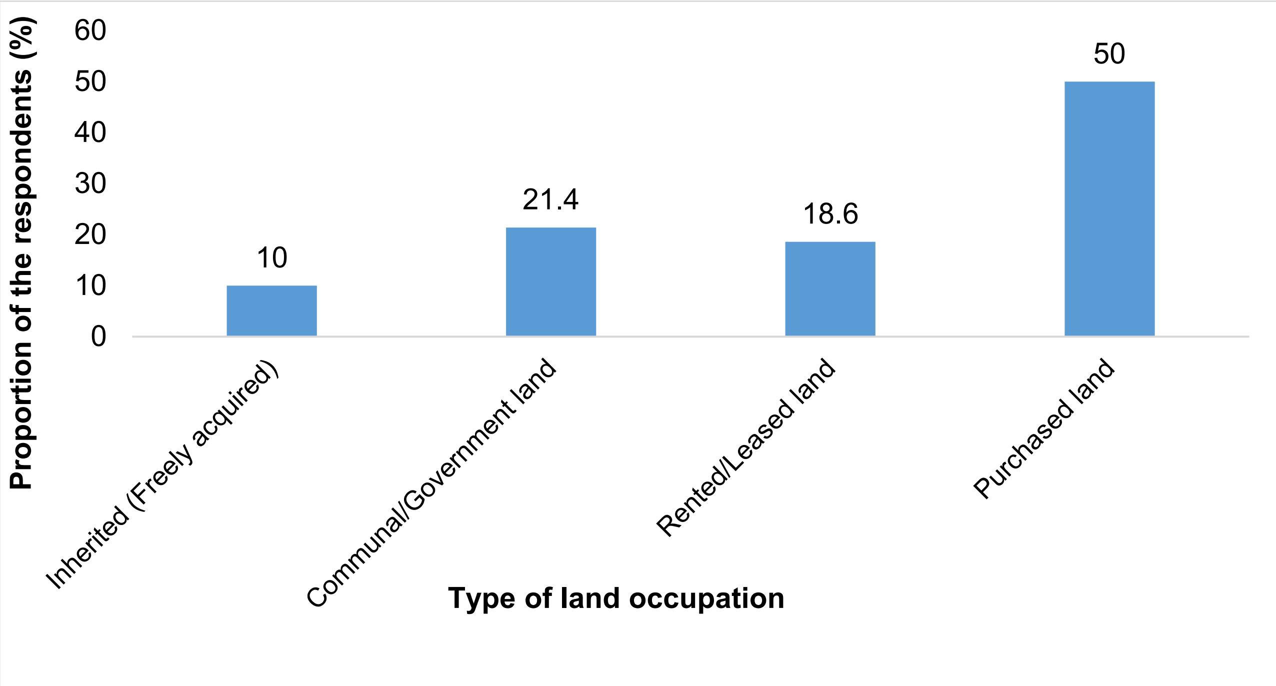

Figure 4.6: Land occupation methods of the respondents (n=70).

The results in **Figure 4.6** shows that half (50%) of the respondents privately owned their farmland which they purchased, while the other half did not. The respondents who did not purchase their farmland used communal/government land freely, rented and inherited land freely from the previous owners. Amongst the respondents who did not purchase their farmland, majority (21.4%) occupied government land acquired through communal land tenure system and/ commonage system (municipal land). This implies that majority (60%) of the farmers have collateral because they have full ownership of their farmland which they acquired through inheritance and freehold tenure (purchase). Furthermore, the aforementioned group of farmers are more likely to have access to credit from financial institutions because they have land as a collateral for borrowing money.

4.2.2.2 *Farming experience*

Farming experience measures how long an individual has been involved in farming (agricultural activities) at the time of data collection. In South Africa, the farming sector consists of old and young people. Because of that, some of the farmers are highly experienced while others are not. The farming experience of the respondents was measured to determine variation in the number of years in which the broiler farmers have been involved in farming. The results of farming experience showed that on average, the broiler farmers have been involved in farming for 9 years (actual is 9.2) years ranging between 1 and 30 years. The variation in farming experience was not high because the value of standard deviation obtained was 6.16. Furthermore, a low (0.737) value of standard error of mean was also achieved. The average farming experience of approximately nine (9) years implies that the farmers were knowledgeable about broiler production. In addition to the above results of farming experience of the respondents, grouping was done and analysed in percentages. The grouping of farming experience was <5 years, 5-10 years, 11-15 years, 16-20 years, 21-25 years and 26-30 years as presented in **Figure 4.7**.

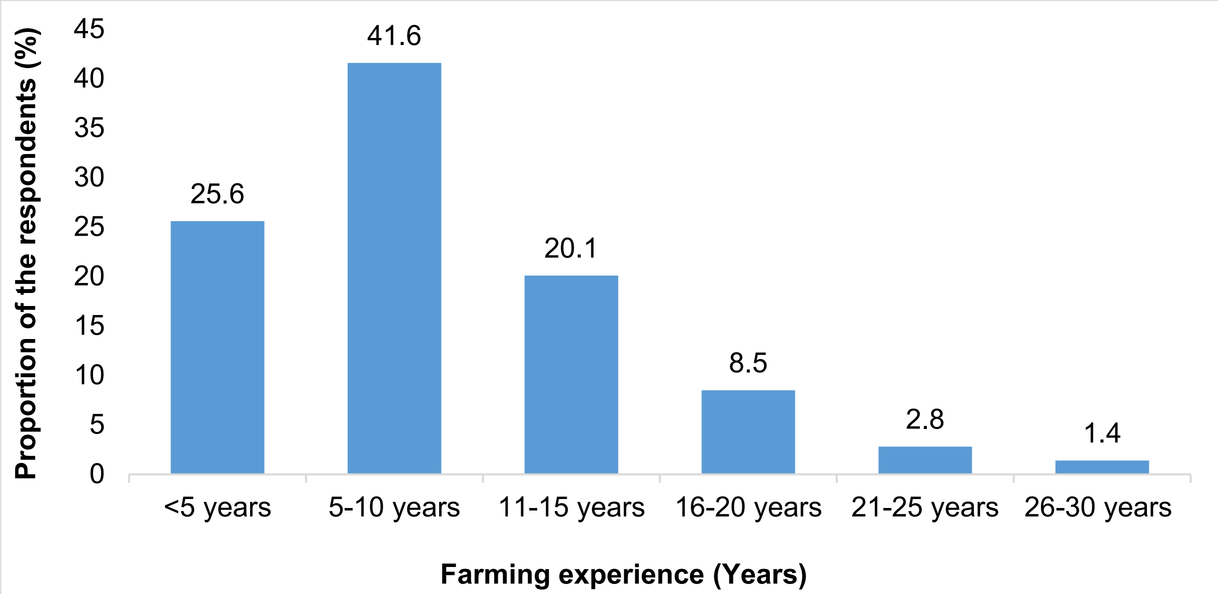

Figure 4.7: Category of farming experience of the respondents in the study area (n=70)

The results in **Figure 4.7** show that 41.6% of the farmers had 5-10 years of experience followed by about a quarter (25.6%) with less than five years. It means that more than two-thirds (67.2%) of broiler farmers in the study area have not been farming for more than 10 years. Only 32.8% had farming experience more than 10 years of which 4.2% had more than 20years of experience. The results imply that broiler farming in Gauteng province is dominated by farmers with a decade of farming experience and less.

4.2.2.3 *Farm/plot size*

Farm/plot size plays an important role in the performance of chicken farming. The size of the farm determines the scale of production and informs the operational status and capacity of the farm. In the study, it was found that the average farmland (farm/plot size) of the respondents was 11.17 ha with a minimum and maximum of 1 ha and 138 ha, respectively. Standard error of mean achieved was 2.66 whereas the standard deviation was 22.33. The value of standard deviation means that the variation in the farm/plot size was slightly higher. It meant that some farmers had access to more land whereas others did not. Moreover, the results of the farm size of the respondents were categorised into different sizes (<10 ha, 10-20 ha, 21-30 ha, 31-40 ha and >41 ha). **Figure 4.8** presents the results of the categories of farm/plot size occupied by the respondents.

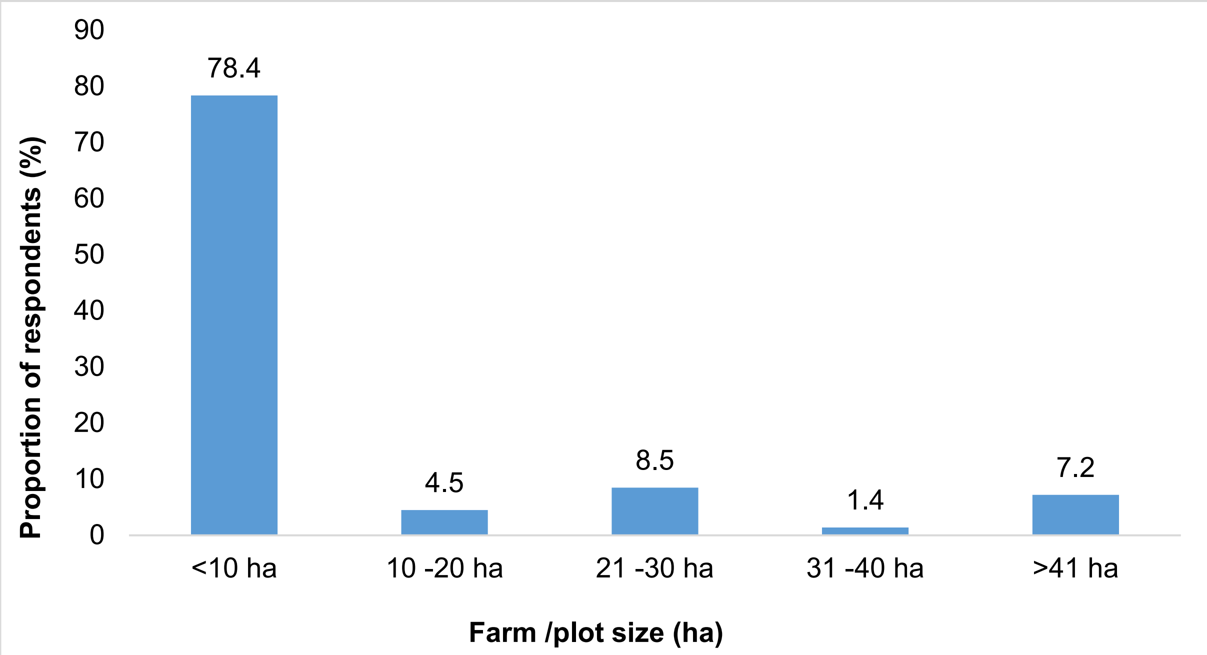

Figure 4.8: Categories of the farm/plot size of the respondents (n=70)

The results in **Figure 4.8** depict that more than three-quarter (78.4%) of the respondents had less than 10 ha of farmland, followed by 8.5% and 7.2% who occupied 21-30 ha farms and >41 ha, respectively. It means that less than one-fifth of the respondents had farms/plots above (ten) 10 hectares (10 ha). Some of the respondents who occupied big farmland were involved in additional farming activities that required more space for farming than broilers.

4.2.2.4 *Annual net farm income of the respondents*

Net farm income is important because it determines how much a farmer makes after sales and farm profitability and sustainability. Information about annual net farm income of the respondents was categorised because it was found that some of the farmers were reluctant to provide their actual income during the pilot study. The scale for measuring net farm income ranged from < less than R10 000 and above R120 000 per annum. The descriptive statistics results on annual net farm income of broiler farmers in the study are illustrated in **Figure 4.9**.

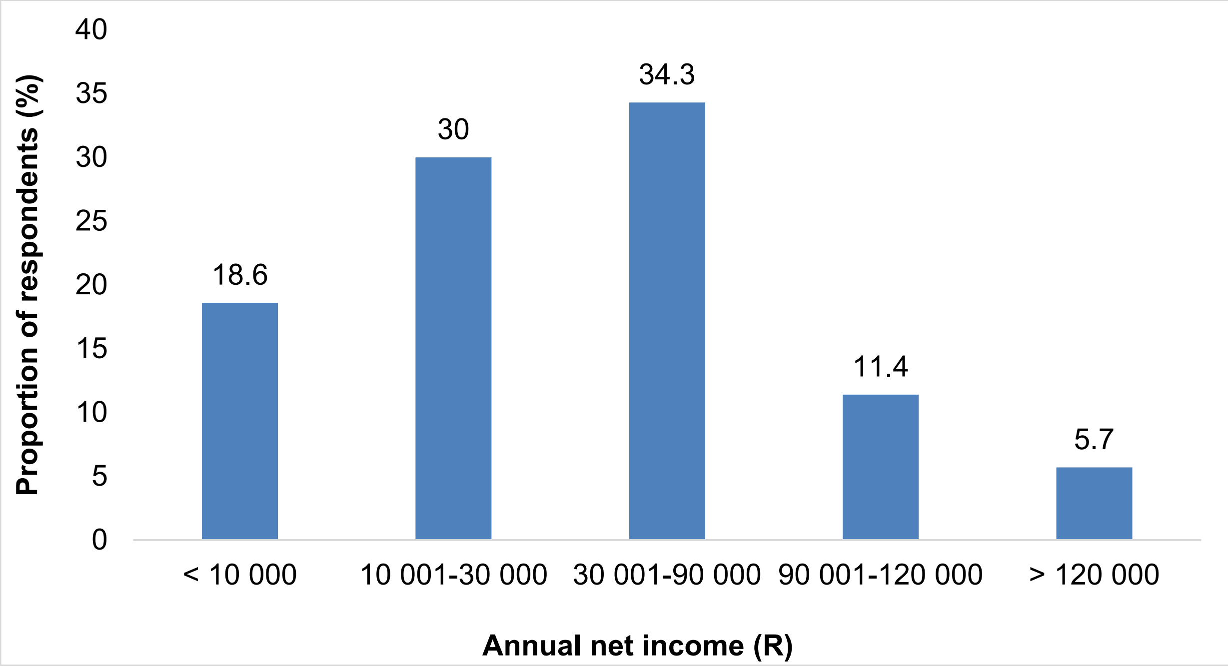

Figure 4.9: Annual net income of respondents (n=70)

The results in **Figure 4.9** indicate that a large percentage (64.3%) of the respondents earned net farm income between R10 001 and R90 000 per annum while 17.1% earned more than R90 000. It implies that most farmers in the study area did not earn more than R10 000 per month from their farming activities. This is because 82.9% of the respondents earned ≤R90 000 per annum from their broiler enterprises per annum. The low levels of income were a clear indication that broiler enterprise did not enable farmers to earn high-income from their farming activities. Because net farm income is important in farming, it was therefore necessary to determine factors influencing the annual net farm income of the respondents using Ordered Logistic Regression (OLR). **Table 4.1** presents the model fitting information results.

Table 4.1: Model-Fitting Information (n=70)

Model	-2 Log Likelihood	Chi-Square	df
Intercept	203.323		
Final	178.259	25.064	14

Source: field data (2021)

The results of the model fitting information presented in **Table 4.1** show the p-value of 0.0034, which is statistically significant at 5% significance level. Therefore, the results suggest a good model fit and that the model can significantly predict the threshold. Table 4.2 presents the results of the Goodness-of-fit.

Table 4.2: Goodness of fit (n=70)

	Chi-Square	df	Sig.
Pearson	258.934	262	0.542
Deviance	178.259	262	1.000

Source: field data (2021)

Table 4.2 reveals that a p-value of 0.054 and 1.000 was achieved for Pearson chi-square test and Deviance chi-square test at 5% significance level; the test results implies that the values were not statistically significant. Therefore, the model used to analyse the data fits well (good model fit). It is worthy to note that both tests used may not yield same results (do not always agree). **Table 4.3** depicts Pseudo R- Square.

Table 4.3: Pseudo R-Square (n=70)

Cox and Snell	0.301
Nagelkerke	0.318
McFadden	0.123

Source: field data (2021)

There is no strong guidance in literature on how Pseudo R-Square results should be used or interpreted. The results of the Pseudo R-Square show that there is no equivalence on logistic regression to the R squared values in Ordinary Least Squares (OLS) regression, the values of R-squared have a different meaning in OLS regression, therefore their analysis is of less importance. **Table 4.4** presents the results of the parameter estimates of the Ordered Logistic Model (OLM) of the factors influencing the net farm income of the respondents.

Table 4.4: Parameter estimates of the Ordered Logistic Model (OLM) of the factors Influencing net farm income of the respondents (n=70).

	Variable	**Estimate**	**Std. Error**	**Wald**	**df**	**Sig.**	**95% Confidence Interval**	
							Lower Bound	**Upper Bound**
Threshold	[<R10 000 = 1]	0.997	1.965	0.257	1	0.612	-2.855	4.849
	[R10 001-R30 000 = 2]	2.750	1.988	1.914	1	0.167	-1.146	6.647
	[R30 001-R90 000 = 3]	4.828	2.046	5.570	1	0.018	0.819	8.838
	[R90 001-R120 000 = 4]	6.282	2.105	8.909	1	0.003	2.157	10.407
Location	Age group	-0.276	0.213	1.679	1	0.195	-0.695	0.142
	Gender	1.090	0.499	4.759	1	**0.029**	0.111	2.069
	Type of land occupation	0.299	0.242	1.534	1	0.216	-0.174	0.773
	Farming experience (years)	-0.007	0.042	0.026	1	0.871	-0.089	0.075
	Farm/plot size (ha)	2.370E-5	0.011	0.000	1	0.998	-0.021	0.021
	Number of chicken houses	0.250	0.213	1.378	1	0.240	-0.168	0.668
	Carrying capacity per house	0.000	0.000	4.130	1	**0.042**	1.397E-5	0.001
	Distance to feed store (km)	0.011	0.012	0.911	1	0.340	-0.012	0.034
	Government subsidised feed	-0.079	0.653	0.015	1	0.904	-1.359	1.201
	Number of production cycles per year	0.293	0.118	6.149	1	**0.013**	0.062	0.525
	Number of feedbags utilised per cycle	0.001	0.001	0.994	1	0.319	-0.001	0.004
	Average live weight (Kg)	-0.890	0.835	1.135	1	0.287	-2.526	0.747
	Mortality rate (%)	-0.011	0.056	0.036	1	0.849	-0.120	0.099
	Chicken price (R)	0.017	0.025	0.473	1	0.491	-0.031	0.065

4.2.3 The correlation of socio-demographic characteristics

A correlation of the socio-demographic characteristics of the respondents was also determined to measure the relationship that exist between the aforementioned characteristics in the study area. The variables that were selected for correlation analysis are age group, gender, level of education, type of land occupation method, farming experience and land size. **Table 4.5** below presents the correlation of demographic and socio-economic characteristics results.

Table 4.5: Correlation of socio-demographic characteristics of the respondents

Variables	1	2	3	4	5	6
1. Age group	1.000	0.001	-0.055	**0.239***	**0.322****	-0.018
2. Gender	0.001	1.000	0.023	0.096	-0.027	-0.134
3. Level of education	-0.055	0.023	1.000	-0.090	-0.161	**0.212***
4. Land occupation	**0.239***	0.096	-0.090	1.000	0.087	-0.100
5. Farming experience	**0.322****	-0.027	-0.161	0.087	1.000	0.133
6. Farm/Plot size (ha)	**-0.018**	-0.134	**0.212***	-0.100	0.133	1.000

*. Correlation is significant at the 0.05 level.

**. Correlation is significant at the 0.01 level.

Table 4.5 depicts that there is a positive and statistically significant correlation between age group and the two (2) variables, namely type of land occupation method and farming experience. The significant difference was at 1% and 5% significance level. It means that older farmers who occupied rented or purchased land were highly experienced. This may be because older farmers have been involved in broiler farming for a longer period, thus they prefer renting or purchasing land because they know the benefits of such land occupation methods. The level of education had a positive and statistically significant relationship with farm/plot size at 5% significance level. It implies that highly educated broiler farmers in the study area occupied bigger farms/plots. This may be because the educated farmers were well informed about the type of land tenure systems that exist in the country. As a result, they preferred land tenure methods that enabled them to access bigger farmland.

4.2.4 Access to government services and market

In farming, access to services from different institutions is important because it enable farmers to succeed in their agricultural activities. Rural farmers farming on small hectares of land can face lack of adequate credit, lack of access to product market, lack of adequate extension contacts and so forth. Among these constraints, inadequate extension services have been identified as one of the main limiting factors to the growth of the agricultural sector and rural community development at large. Consequently, access to government agricultural services and the market were some of the factors measured in the study that influence the productivity and sustainability of a farm. The results of the respondents' access to subsidised feed, extension services and market are presented in **Table 4.6**.

Table 4.6: The respondents' access to subsidised feed, extension services and market access (n=70).

Variables	Response (%)		Mean	Significance (Binomial test)
	No	Yes		
Access to government subsidised feed	81	19	0.19	<0.001
Access to extension services	54	46	0.46	0.550
Access to reliable market	84	16	0.16	<0.001

Table 4.6 indicates that a large proportion (81%) of the respondents did not receive subsidised chicken feed from government while 19% did. This is supported by a mean score of 0.19, which shows that only 19% said yes to the question because zero (0) and one (1) represented No and Yes, respectively in the responses. The significant value of <0.001 ($p<0.01$) was achieved from the results of the Binomial test that compared the variation in the No and Yes responses. It means that there is a statistically significant difference between the proportions of farmers who received subsidised chicken feed and those who did not. Therefore, the proportion of respondents who did not receive government subsidised feed is significantly higher. Access to extension services refers to whether the farmers received agricultural extension and advisory services from government extension officers (agricultural advisors) or not. **Table 4.6** illustrates that more than half (54%) of the respondents had no adequate access to government extension services whereas 46% had access. The results

were supported by a mean score of 0.46 which shows that less than half (46%) of the farmers agreed that they had access to extension services. The variation between "No and Yes" responses were not statistically significant (p=0.550) as shown by the results of the binomial test. It means that there is no statistical significance between the number of farmers who had access to extension services and those without access even though majority did not have access. With regards to reliable market access, 84% of the respondents answered 'Yes' to the question of having access to reliable markets while 16% did not (Answered with No).

A mean score of 0.16 supports the notion that more than four-fifths (84%) had access to a reliable market to sell their broilers (chickens). There is a statistically significant (p<0.01) relationship between the number of respondents who had access to markets and those without access to reliable markets as revealed by the binomial test results in **Table 4.3** above. It implies that the proportion of the respondents who had reliable market access is significantly higher. Thus, broiler farmers in the study area had adequate access to market.

4.3 DISCUSSIONS

4.3.1 Socio-demographic characteristics

The findings of the study showed that more than four-fifth (95.7%) of broiler farmers in the study area were Black African of which the majority (52.9%) were males. The broiler farming sector is therefore highly transformed since the previously-disadvantaged group of people (Black people) in South Africa dominated it. The results aligns with the population of South Africa because majority of the people in the country are Black Africans. In support, National Agricultural Marketing Council (NAMC) (2020) discovered that Black African broiler farmers are the most dominant (92%) in South Africa. In addition, more than half (54%) of the farmers were married, meaning most of the broiler farmers had spousal support. The results are in accordance with the common assumption that says married people are more involved in farming than the single people (Onuk *et al*., 2017). In agreement to this, Selaledi (2017) discovered that majority of broiler farmers (65.7%) in the Tshwane region of South Africa were married and mostly men (51.4%). However, in another study by Selaledi *et al.* (2021), found that less than half (47.7%) of the farmers were married while others were divorced (5.6%), single (39.3%) and widowed (7.4%). Moreover, the study revealed that there is no statistical significance difference (p=0.72) between the proportion of male and female broiler farmers in the study area even though majority were men. Therefore, there is gender equity in the group of farmers involved in broiler production in Gauteng province. Several scholars have reported that men (males) are more involved in farming activities as opposed to women (females) in South Africa (Machethe, 2016; Selaledi *et al*., 2021); Rwanda (Mbuza *et al*., 2017) and Uganda (Sebatta *et al*., 2018). In contrast, studies conducted in Nigeria and Uganda by Adeniyi and Oguntunji (2011) and Ekepu and Tirivanhu (2016) discovered that poultry production was dominated by female farmers in African societies. The fact that females are the majority of broiler farmers shows that there are changing perceptions about the participation of women in agricultural activities. The change is positive because female farmers are still marginalised in some African countries. Further analysis of factors influencing net farm income indicated a positive and statistically significant (sig=0.029) correlation between gender and annual net farm income at a 5% level of significance. This shows that the domination of men in poultry farming in the study area makes them earn more income than female farmers do. This may be because men are given more income negating farming opportunities since they are the majority and are less marginalised compared to women. The other reason could be that women are not empowered to manage broiler production activities that generate high income. In Northern Nigeria, Yasuf *et al*. (2018) had similar findings where it was found that gender had a positive and significant relationship with net revenue.

Moreover, most of the farmers in the study were males. However, this is in contrast with what Rakoena (2019) discovered in the Gauteng province. Gender had a positive and insignificant impact on the net farm income of the farmers, even though female farmers were the majority (51%). The results in the study area imply that gender disparity in farming is likely to continue. Men will continue to dominate broiler farming, have ownership and control over resources, cultivate larger farms and, as a result, expand more agricultural activities when they earn more income than female farmers. In addition, male farmers are enjoying benefits such as increased production and marginal returns (net profit or net income). Therefore, men will acquire more assets, increase farm sales and generate more potential profits.

The current study discovered that most farmers (64.3%) earned net farm income between R10 001 and R90 000 in the previous year, while 18.6% had less than R10 000 annual net income from broiler enterprises. The fact that most farmers earned less than R100 000 from farming enterprises per annum indicates that a large proportion of broiler farmers in the Gauteng province of South Africa are struggling to create wealth from chicken sales. This is supported by the fact that more than two-thirds (67.2%) of the broiler farmers earned income from non-farming activities (employed, self-employed, social grants and other sources of income), while 32.8% were from farming activities. The results differ from NAMC (2020), which discovered that a large proportion (77%) of small-scale broiler farmers in South Africa rely on agricultural activities, non-agricultural activities (21%) and others (2%) as the sources of income. Likewise, Sharmin *et al*. (2012) reported that most farmers (86%) had farming as their primary occupation; only 8% of the respondents owned their own businesses, and the other 6% were employed in salaried jobs in Bangladesh. The findings imply that income from farming alone was not sufficient to sustain farmers' livelihoods; hence, there were multiple sources of income to generate income.

From annual net farm income perspective, the results are however not consistent with Selaledi *et al*. (2021) and Selaledi (2017) who indicated that more than half (>50%) of the broiler farmers in the City of Tshwane Metro and North West province earned annual net farm income of ≤R10 000. This implies that most farmers cannot fully depend on broiler farming to sustain their livelihoods because their annual net income is low. Annual net farm income was positively and significantly influenced by gender, carrying capacity of poultry house and number of production cycles. In support, findings from several studies showed that farm income has positive and significant correlation with farmers' socio-economic characteristics such as gender (Jerry & Williams, 2000; Safa, 2005; Mpawenimana, 2005; Mabe *et al*., 2010; Ibekwe, 2010; Parvin & Aktezuzzaman, 2013). However, Ibekwe *et al*. (2015) discovered that in Nigeria, age has a significant impact on broiler net farm income. Therefore, it can be deduced that men earn more income from broiler farming enterprises than women (female farmers). This can be due to the fact that male farmers in general are perceived to have more working capacity and energy (strength) to do more work than women, especially in farming. As a result, male famers are deemed to achieve higher outputs and earn more net farm income from sales as opposed to female farmers.

Regarding age perspective, it was found that more than one-third (42.9%) of the respondents were above 55 years of age while one-fifth (15.70%) were youths (18-35 years). The results show that broiler farming is dominated by older people (≥ 55 years old). It depicts that most of the farmers were either retired or approaching retirement (≤55 years) compared to young farmers (≤35 years). Younger people may be denied opportunities to access land because they are considered to be too young and do not have collateral. Moreover, young people in Gauteng province may have less interest in farming because the province is highly industrialised. Therefore, there are more lucrative economic opportunities in the manufacturing, banking, services and other sectors compared to farming in the province. The findings are somewhat inconsistent with the findings of Selaledi *et al*. (2021) who discovered that less than one-fifth (14.9%) of broiler farmers were above 55 years old. In support, Selaledi *et al*. (2021) found that less than one-third of broiler farmers were younger than 35 years old. Also, in support, Ogolla (2016) found that farming is dominated by older people (≥36 years) compared to youths (17%) even though the participation of farmers above 55 years was lower than the results in the current study area. In support, Machete (2016) indicated that the average age of small-holder broiler farmers in Limpopo province was 53 years old. The high proportion of older farmers in broiler production may be because, generally, when people plan to retire, they opt for farming as an income-generating activity that will keep them busy.

Furthermore, there was a positive and significant correlation between age and farming experience, meaning older farmers were highly experienced. The results of farming experience showed that farmers had 1 to 30 years of experience, with an average of 9 years (actual is 9.2). Further analysis indicated that a majority (67.2%) of the farmers had between 1-10 years of experience, while a prime proportion (32.8%) of the farmers had more than 11 years and above. This means that some farmers were involved in agriculture for less than two years, while others started broiler farming about 30 years ago. The findings corroborate that of Okoli *et al*. (2004), in Nigeria and also Machete (2016), in Limpopo province, discovered that two-thirds of the farmers had one (1) to 10 years of experience in farming. Also, in support, in Ekurhuleni Metropolitan Municipality and Sedibeng District Municipality, Maoba (2016) found that that a majority (84.7%) of the beneficiaries had 1-10 years of farming experience. In addition, age had a positive and statistically significant correlation with the type of land occupation method and farming experience. This means that older farmers have been involved in broiler farming for a longer period; thus, through experience, they prefer renting or purchasing land because they know the benefits of such land occupation methods. Moreover, the land occupation method results showed that more than half (60%) of the broiler farmers privately owned their farmland. The private land was either purchased (50%) or inherited (10%) from close family members. In support to the study findings, the status of land ownership in South Africa indicated that a majority (55%) of broiler farmers own their farmland privately, whereas 45% do not own land (NAMC, 2020). On the contrary, in North West province, Matsane and Oyekale (2014) found that more than half (53.2%) of the small-scale farmers acquired their land through communal tenure, while 42.6% were privately owned land and 4.2% was rented. In another study, South African Institute of Race Relations (SAIRR) (2018) reported that White people owned about 72% of the land, while Black Africans owned 4%. Even though most farmers in the study area had private ownership of their farmland, the average farm/plot size of the respondents was 11.17 ha ranging between 1 and 138 ha, respectively. Furthermore, additional results indicated that a large proportion (78.4%) of the respondents acquired less than 10 ha of farmland, while 21.6% had farm sizes above 10 ha.

It shows that majority of the farmers who occupied their farmland through private tenure were farming on small-scale settings. It means that agricultural land reform amongst black farmers in the study area is high when it comes to the proportion of farmers who own land privately. However, the proportion of agricultural land occupied by black farmers is still low. Therefore, the land redistribution amongst black farmers in the study area is low. Farm/plot size in the study area had positive and significant relationship with education at 5% significance level. Thus, highly educated farmers occupied bigger farms. This implies that educated farmers may earn more income that enable them to afford to rent or purchase their own land. The valuable knowledge they acquired serves as an advantage to access information about land occupation methods and innovative farming methods. Education levels amongst the farmers indicated that majority (94%) attained formal education (basic education and tertiary education) while 6% had no formal education. In support, Tesfamariam *et al*. (2018) also found that majority (64%) of the farmers in South Africa had formal education, while about 36% were without formal education. This shows that a large proportion of the farmers in the study area went to school and have gained valuable knowledge that can be used to augment agricultural productivity. As a result, majority of broiler farmers in the study area are more likely to adopt agricultural innovations because they have valuable knowledge about how this could positively influence their production. For example, Ajewole (2010); Folefack (2015); Paul *et al*. (2017); Rathod *et al*. (2017) and Wahyudi (2017) reported that farmers with high level of education are more likely to adopt innovation compared to those who are not educated or have no formal education.

4.3.2 Access to agricultural services

A significant proportion of the respondents (81%) indicated that they were not receiving subsidised chicken feed from government. The disparity in the percentage of farmers who received feed subsidy and those who did not, shows that some farmers received livestock feed subsidies while other farmers relied on their own feed. In support, Khapayi and Celliers (2016) reported that majority (64%) of the farmers in the Eastern Cape province of South Africa received support services (production inputs) for their enterprises while (36%) claimed not to be receiving any support service but had to rely on their own resources. Acquiring access to production input subsidies, extension services, market access and information in farming especially in rural small-scale spaces are the major constraints that the farmers raised. Having subsidised feed is important because it grants low-income farmers access to feed; thus, lowering the overall price of the animal feed and keeps farmers in business instead of driving them out of business. However, in the current study, a large proportion of farmers will have to increase the prices of live chickens sold in the market because of high feed cost incurred due to lack of subsidised chicken feed. Thus, most farmers may be forced to abandon their farming activities if they fail to sell their chickens at the desired price. This will occur if farmers do not earn sufficient income to sustain their broiler enterprises. This could therefore have a significant impact on national broiler production (decreasing agricultural growth) and thus, limit subsistence farmers to graduate to commercial farming. Inadequate feed subsidy contributes to farmers acquiring high production costs and low profitability of enterprise (Khapayi & Celliers, 2016).

Findings on access to agricultural extension services revealed that more than half (54%) of the respondents had inadequate access whereas 46% had access to extension services from government (p=0.550). In support, Makapela (2015) indicated that most farmers (51%) found it difficult to access extension services in Amathole District Municipality in the Eastern Cape Province. The results are in contrast with the study conducted by Selaledi (2017) and Phatudi-Mphahlele (2016) which found that majority (>85%) of farmers had access to extension services. According to Mbise (2016), extension services can significantly increase crop yields and production. The fact that most farmers did not have adequate access to extension services implies that they may not have access to innovation and information communicated through extension officers. Thus, farm productivity and net farm income may decline if farmers do not have adequate access to extension services. For example, findings on the impact of extension services on agricultural production: a case study of maize conducted by Mbise (2016) revealed that farmers with access to extension service produced more and achieved high yields/outputs in Tanzania. The results also indicated that maize yield achieved by farmers who extension agents visited frequently was significantly higher than the yield of farmers with less visits. Therefore, improving access to extension services amongst broiler farmers in the study area is important to enable them to achieve higher outputs. Poor access to extension services affects information flow due to unavailable links between research, extension and farmers.

More than four-fifth (84%) of the respondents indicated that they had access to reliable markets in the study area. This means that a significant number of broiler farmers in the study area had adequate access to market access, as shown by the significant value (p<0.01). Machete (2016) had contradicting results whereby less than half (44%) of the farmers in Limpopo province had access to the market for their chickens. Moreover, Baloyi (2010) also discovered that smallholder farmers in Limpopo province have little access to formal markets. According to Khapayi and Celliers (2015), some factors affecting emerging farmers in the Eastern Cape include insufficient marketing information, insufficient marketing facilities, cheap imports from other countries, and high transactional costs. As a result, emerging farmers were most likely to sell their produce to informal markets (Barrett *et al.*, 2011). The results imply that many broiler farmers in the study area have access to reliable markets to sell their chickens. Therefore, most farmers will not incur additional operational costs for chicken feeds, water, medication, labour and others because they will not keep chickens longer than six weeks after maturity. Furthermore, access to a reliable market will enable farmers to expand their production activities. For example, Kamara (2004) found that improved market access increased productivity and reduced poverty. Again, market access will increase the profit of broiler enterprises and enable farmers to have a reliable income to sustain their livelihoods. Mmbando (2014) stated that improved market access plays an important role in improving the rural income of smallholder farmers in sub-Saharan African countries.

4.4 CHAPTER SUMMARY

This chapter assessed the socio-demographic characteristics of broiler farmers and farmers' access to support services and markets. The outcome of the socio-demographic characteristics showed that majority of the broiler farmers in the study area were married Black African men above 55 years of age. The respondents acquired basic education, mostly college education and have been involved in farming for about nine years of which less than half (41.6%) had 5 to 10 years' experience. In addition, farming experience positively and statistically correlated with gender. Majority of the farmers privately occupied their farmland with an average of 11.17 ha. Moreover, more than one-third depended on self-employment as their main source of income whereas less than a quarter relied on farming. About 82.9% of the respondents earned annual net farm income of ≤ R90 000; of which majority (54.3%) had annual net farm income between R10 0001 and R90 000. Annual net farm income had a positive and significant correlation with gender, carrying capacity of poultry house and number of production cycles per annum. The other variables, type of land ownership, farm/plot size, number of chicken houses, distance travelled, and number of feedbags utilised per cycle and price of chicken had positive and insignificant relationship with net farm income. On the other hand, net income was negatively and insignificantly influenced by age group, farming experience (years) government subsidised feed, average live weight and mortality rate. Moreover, a significant proportion of the respondents (>80%) had access to market and received subsidised chicken feed from government. However, the proportion of farmers who had adequate to extension services was low (46%) and not statistically significant.

CHAPTER 5

5 THE OPERATION AND PRODUCTION CHARACTERISTICS OF THE BROILER ENTERPRISE IN GAUTENG PROVINCE

5.1 INTRODUCTION

The purpose of this chapter is to present the research results and discuss the operational status and the production characteristics of the broiler enterprise. It is based on the research objective of assessing the operations of a broiler enterprise that influence chicken production.

5.2 RESULTS

The results section is subdivided into two sections: operation of broiler enterprise, production characteristics and correlation of selected operational and production factors.

5.2.1 Operation of the broiler enterprise

Operational status refers to the practice or techniques that help to maximise the efficiency of broiler production. In the study area, the operational status consists of the following variables: number of employees, number of chicken houses per farm, carrying capacity of the chicken structures, pricing of chickens, and distance travelled to the nearest feed store. These variables are important because they can be used to make financial assumptions concerning the farm and help to optimise an enterprise's production. The results of the operational status of the respondents are presented in sections 5.2.1.1 to 5.2.1.6.

5.2.1.1 *Number of employees*

Labour is one of the four (4) factors of production that serves as the human effort that can be applied to the production of goods and services. People who are permanently employed or seasonal employees are considered part of labour making them the most important resource and staff in a business or enterprise. In Agriculture, "the poultry industry is one of the biggest in South Africa, employing over 100,000 people throughout the value chain," RCL Foods reports. Therefore, collecting information in the study about employees in the chicken farming industry was important because labour is a factor of production; it is essential to assess the effort labour contributes toward production. The number of employees hired in Gauteng chicken operations is presented in **Table 5.1.**

Table 5.1: Number of employees in the operation of the broiler enterprise (n=70)

Variable	Total number of employees	Full-time employees	Part-time employees
Mean	2.31	1.49	0.83
Std. Error of Mean	0.152	0.113	0.108
Std. Deviation	1.269	0.944	0.900
Minimum	1	0	0
Maximum	6	4	3

Table 5.1 shows that the average total number of employees hired was two (2) (Actual was 2.31), with a minimum of one (1) and a maximum of six (6) employees per chicken farm. However, the variation was low and was supported by a standard deviation of 1.26. Standard error of mean of 0.15 was achieved, which was practically low. This means that the number of employees working at broiler farms was low. On the other hand, the standard error of mean of full-time and part-time employees was low, ranging between 0.10 and 0.152. The standard deviation figures were 0.94 and 0.90, respectively. The minimum number of full-time and part-time employees was zero, while the maximum were four (4) and three (3). The variation indicates that the smaller the number of employees, the lower the scale of production.

Regarding full-time workers, the average number of employees was 1.49 whereas that of part-time employees was 0.83. The results show that some farmers do not have part-time employees while others have managed to hire extra help. In addition to the above results of the number of employees, further analysis was done to determine the categories of the number of employees grouped from one (1) to six (6), as presented in **Figure 5.1.**

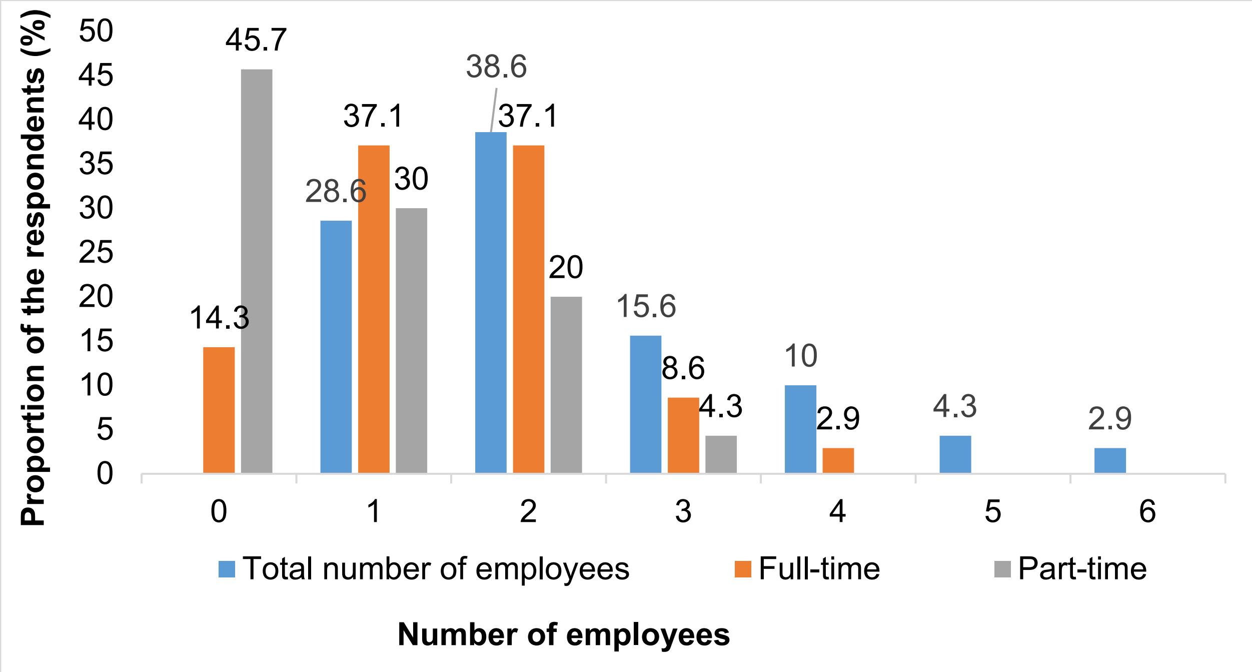

Figure 5.1: Categories of the number of employees (n=70)

Figure 5.1 depicts that the majority (82.8%) of farms have between one (1) to three (3) workers, while 17.2% of the respondents had four (4) to six (6) employees. This implies that employment is not easy to come up, especially when the farm is small however, some chicken farmers hire employees who will manage the day-to-day running of the business on a full-time and also part-time arrangement. The results of full-time employment presented in **Figure 5.1** shows that majority (74.2%) of the farmers have either one (1) or two (2) full-time employees while more than one-tenth (11.5%) have between three (3) to four (4) employees. On the other hand, 14.3% of the farmers do not have employees because the farms are small. **Figure 5.1** illustrates that less than half (45.7%) of the respondents do not have part-time employees on the farm whereas 54.3% of farmers have between one (1) and (3) part-time workers. This implies that having part-time employees is an effective way to cut costs for farmers in areas where farmers do not need full-time employees. Again, it also helps to reduce the workload of full-time employees during peak seasons. Another point of view suggests however, that farmers are not hiring part-time employees because of lack of financial capacity to compensate the employees.

5.2.1.2 *Number of chicken houses of the respondents*

The size of the scale of production in farming is important because it puts chicken producers who are exploiting economies of scale at an advantage. Farmers with a higher number of chicken houses have an advantage over farmers with small number of chickens because they are consistently in production. Information on the number of chicken houses was collected to establish different farm sizes, the scope of production, and the value of the chicken farm's production. In the study area, the average number of chicken houses were found to be two (2) (Actual=2.34) ranging between one (1) and six (6) chicken houses. The standard deviation (1.27) and error (0.152) of the mean achieved were low. This implies that the farmers with more chicken houses have more space to increase the capacity of chicken houses and they also have an advantage over other farmers to produce constantly. **Figure 5.2** presents the category of the number of chicken houses of the respondents.

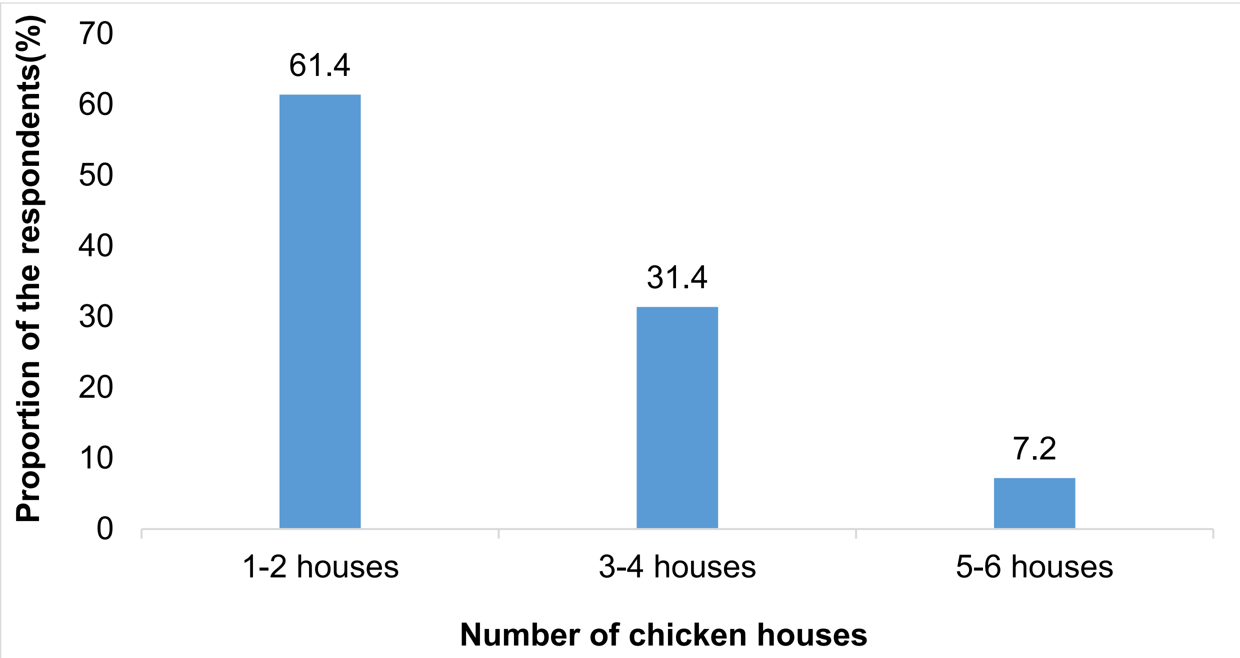

Figure 5.2: Category of the number of chicken houses of the respondents (n=70)

The results presented in **Figure 5.2** illustrate that a large proportion (61.4%) of the respondents have between one (1) to two (2) chicken houses in production, followed by 31.4% of farmers with three (3) to four (4) and the least was 7.2% having five (5) to six (6) chicken houses. This implies that the farmers with more chicken houses are bigger in size and produce more chickens per cycle to keep up with consumer demands.

5.2.1.3 *Number of chickens (Carrying capacity) of the farms*

In broiler production, the size of chicken houses or structures on the farm determines how many chickens to keep in the chicken house. In this study, carrying capacity is the maximum number of chickens that a chicken farm can sustain. The carrying capacity of a farm is the most important housing principle. Broiler farming is one of the most profitable farming businesses and the profitability depends on the number of chickens sold. Therefore, the bigger the carrying capacity of a chicken farm, the higher the amount of profit which can, however, not be guaranteed. It is also imperative to determine the carrying capacity for feeding and management structures. According to the results, the average carrying capacity per farm was 1 804.0 with a minimum of 100 and maximum of 6 000 chickens. The standard deviation of 1 433.62 was obtained, meaning that the carrying capacity of most of the farmers was not close to the mean. Standard error mean of 171.35 was achieved, which was low. This implied that there were farmers who had a higher scale of production whereas others did not. **Figure 5.3** shows the percentage distribution in categories of the aforementioned results.

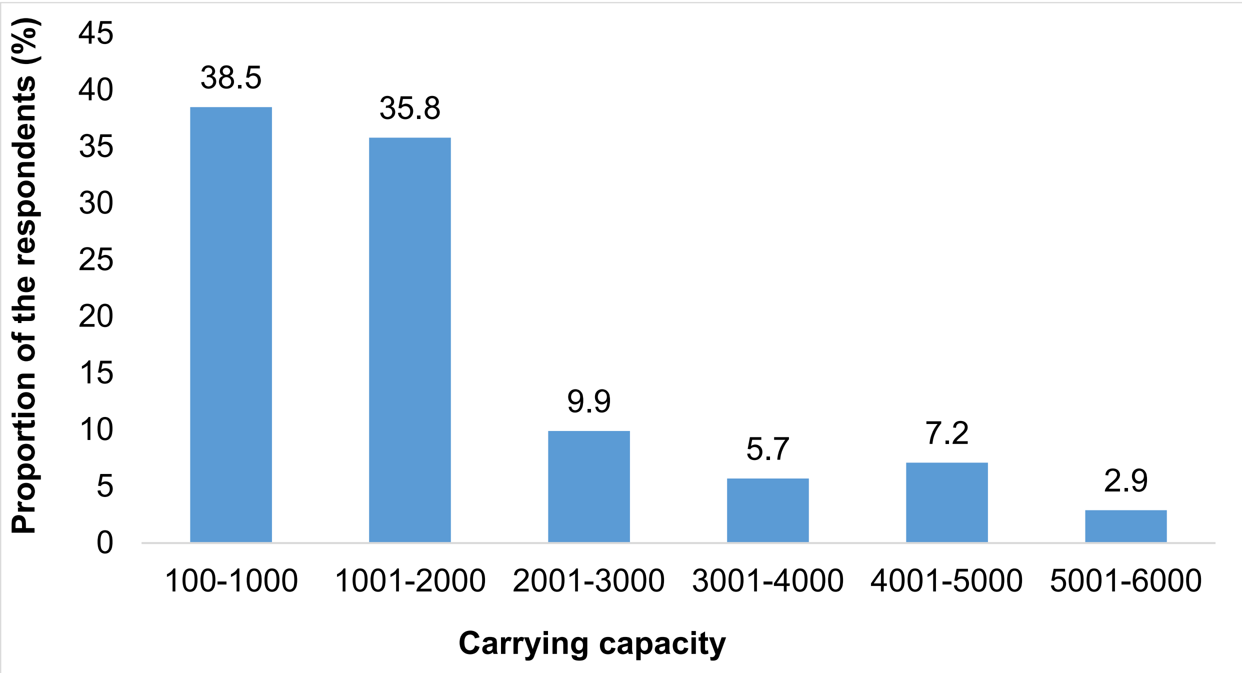

Figure 5.3: Category of the carrying capacity of the operations of the broiler enterprise (n=70)

The results indicated that majority (74.3%) of the respondents in **Figure 5.3** were accommodating between 100-1 000 and 1 001-2 000 chickens at most while 25.6% had ≥ 2 001 chicken capacity. That means farmers who were rearing more than 2 000 chickens per cycle got a good amount of profit compared to the rest of the farmers with few chickens. Another point of view suggests that farmers with a higher carrying capacity have access to more production space.

5.2.1.4 *Pricing of chicken*

Pricing of chickens is important because it determines profitability. There are many factors that influence the price of chickens. The price of live chickens at the farm is determined by the cost of production inputs. The average price of a chicken was R56.24 in the study area with the minimum being R30.00 while the maximum was R80.00. The standard deviation and error mean were 11.04 and 1.32, respectively, which were low. This means that pricing of chickens was volatile amongst the respondents, however, there are factors that affect the pricing strategy. Additionally, further analysis was done to classify chicken price into categories and the results are presented in **Figure 5.4.**

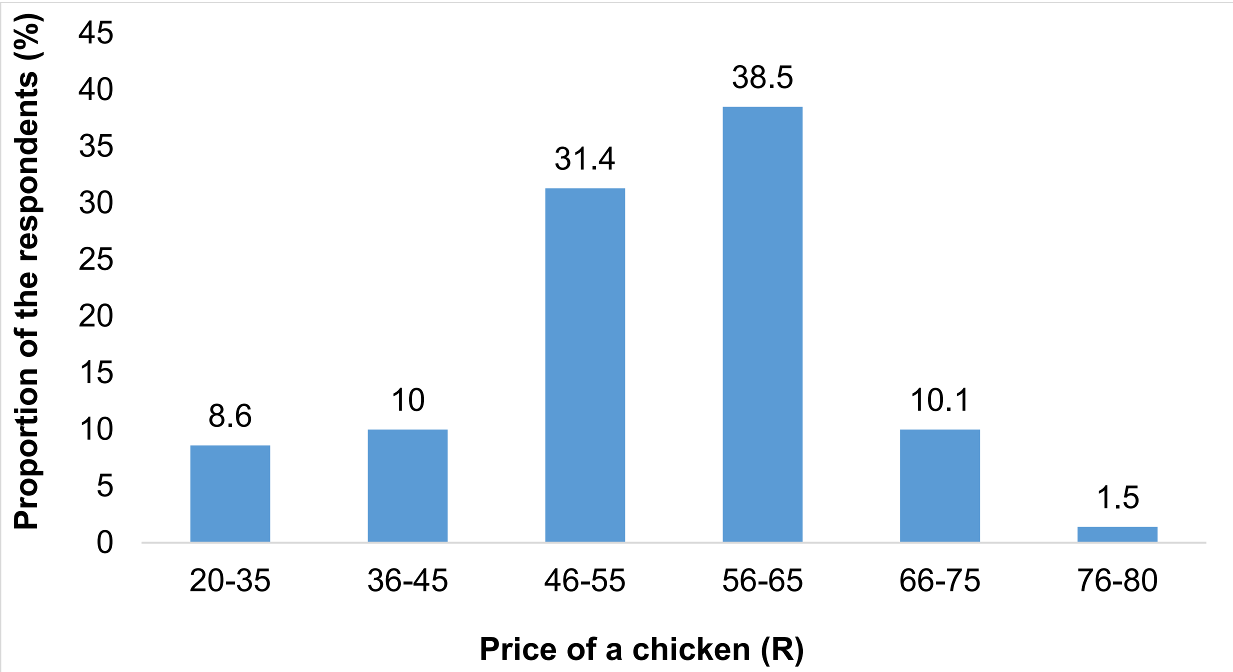

Figure 5.4: Categories of the prices of chickens of the respondents (n=70)

Figure 5.4 shows that less than three-quarter (69.9%) of the respondents' prices were between R46.00 and R65.00. A percentage of 18.6% was between R30.00 and R45.00 while 11.5% of the price of chickens was between R66.00 and R80.00. This means that some chickens were sold at less than six (6) weeks old to avoid buying feed because feed is expensive. On the other hand, some chickens were sold at lower prices because of their weight (under-weight or oversized chickens).

5.2.1.5 *Distance travelled to the nearest feed store*

Distance is a factor which determines the participation of the farmers in various farming activities and programmes, and also influences purchasing decisions. The number of kilometres travelled to access feed is of crucial significance as this affects the operation and production growth of chickens with regards to feed availability. In the study, the average distance travelled by broiler farmers to buy chicken feed is about 20 km per hour which ranges from minimum of one (1) km to maximum of 142 km. There is a high variation supported by the standard deviation of 21.02. The results imply that distance is one of the major challenges faced by farmers in production because feed availability is significant, and some farmers travel longer distances to get feed while others travel less which means that farmers who travel longer use more money. The results were further categorised into less than five (5), 5-15 km, 16-25 km, 26-35 km,36-45 km and >45 km as presented in **Figure 5.5**.

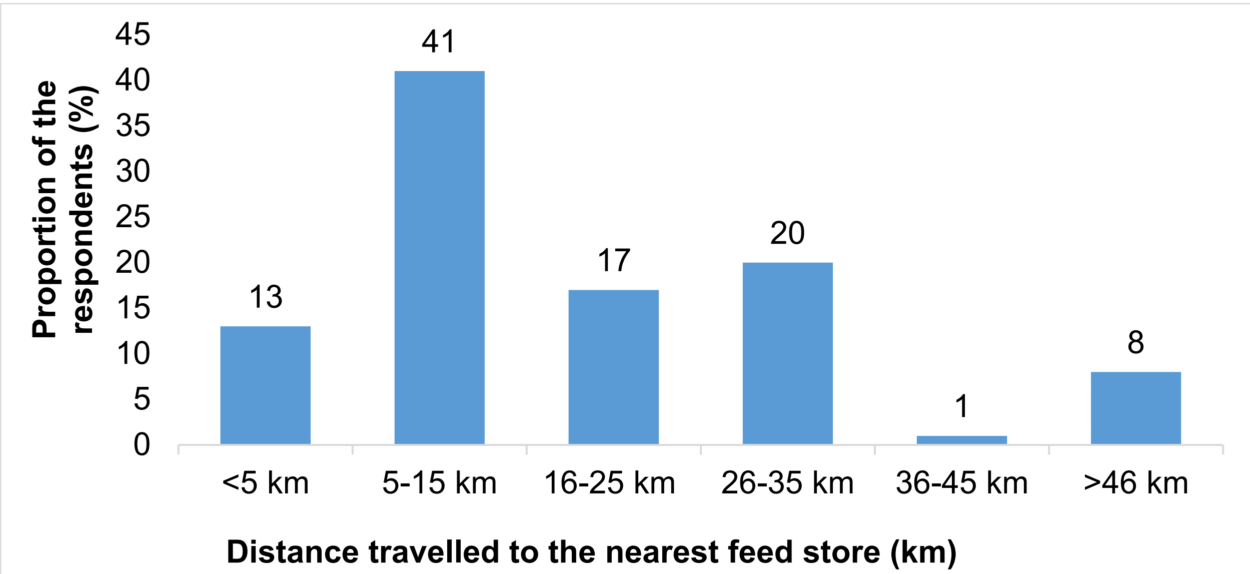

Figure 5.5: Categories of the distance travelled by respondents (n=70)

The results in **Figure 5.5** indicate that only 13% of the farmers travelled <5 km to the nearest feed store, while 41% and 17% were subjected to travel more than 5-15 km and 16-25 km to purchase feed. The variation in kilometres travelled to purchase feed indicates that most of the farmers struggle to access feed stores nearby. This implies that some farmers in the study area do not travel far to access feed stores while other farmers travel more and spend more money on transport as compared to others.

5.2.2 Production characteristics

Production of meat is the main focus of the broiler industry which also focuses on growing meat in the fastest and most efficient possible method. In the study, the production characteristics that most influence the performance of broilers will be evaluated. The production characteristics are number of production cycles, preferred form of feed, and number of feedbags utilised, mortality rate (%), average live weight and anticipated average live weight gained from alternative chicken feed. The results of the respondents are presented between sections **5.2.2.1 – 5.2.2.5**.

5.2.2.1 *Production cycles*

The length of broiler production cycle is also an important factor especially when profitability is measured. In this study, the length of production period is six to seven weeks, and it is divided into three (3) stages of production namely: starters (0-2 weeks), grower (3-4 weeks) and finisher (5-6/7 weeks), respectively. Information on broiler production length was recorded because the length is an important factor when profitability is measured. It was found in the study that the average number of production cycles was 5 (Actual=5.24) with minimum and maximum of 1 and 12, respectively. Standard error of mean achieved was 0.26 while standard deviation was 2.23 which was higher. It suggests that some farmers had more production cycles whereas others had less and shorter cycles.

5.2.2.2 *Preferred forms of feed*

In general, proper feeding promotes good health in livestock, which results in higher productivity. In broiler production, a well-fed chicken will produce good quality meat and does not only increase the yield, but also enhances the quality of broilers. What chickens eat has a major impact on performance, profitability and quality of the end product (meat).

Feeding comes in a lot of forms and it is the responsibility of the farmer to identify the most convenient feed for best health and products. Chicken feed comes in three forms: crumbles, pellets and mash. The type of feed depends on the age of the bird and type of chicken (broiler or layer) production. On the contrary, some farmers mix their own feed to cut costs. **Figure 5.6** shows the preferred forms of feed.

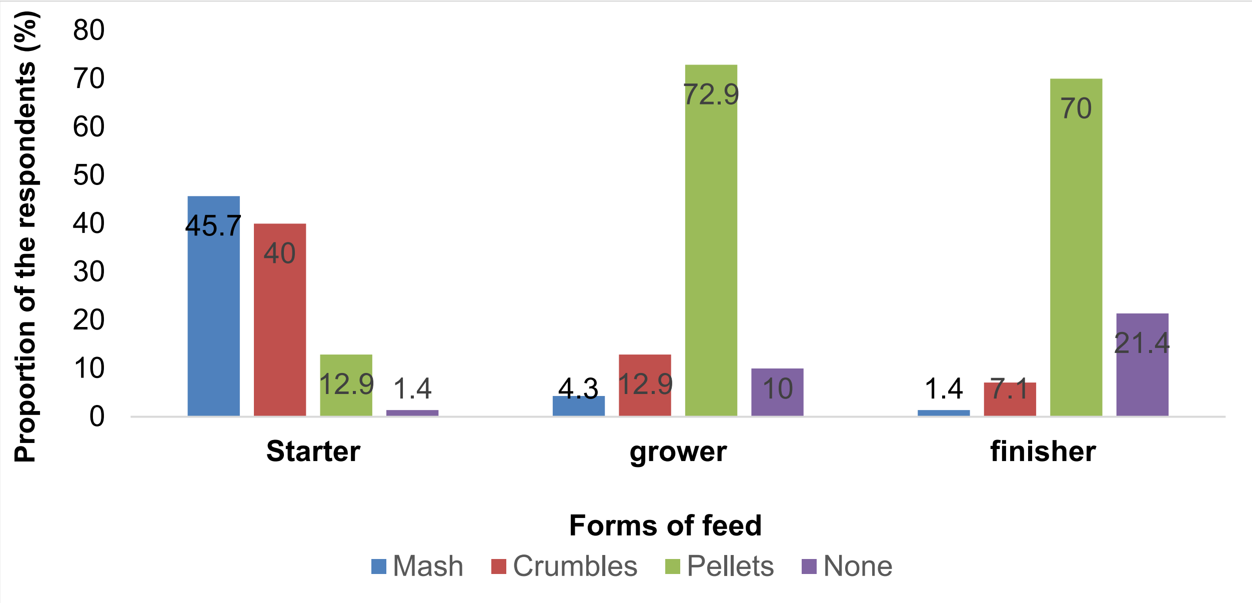

Figure 5.6: Forms of feed preferred by the respondents (n=70)

Figure 5.6 illustrates that less than half (45.7%) of the farmers prefer mash over crumbles and pellets while 1.4% of the respondents had no interest or did not prefer any of the three (3) forms of feed during the starter phase. This implies that almost half of the respondents prefer mash because it is easily digestible and has good nutritional components for development that are needed by small chicks. **Figure 5.6** also shows that 72.9% of the respondents indicated that the chickens prefer pellets in the grower stage. However, crumbles were preferred by 12.9% while mash was not considered; 4.3% of farmers indicated that they would rather use mash for growers because it is cheaper compared to other forms of feed. In the finisher stage, majority (70%) of the chickens are fed pellets, followed by 7.1% of the farmers who prefer crumbles. Surprisingly, there were few farmers (1.4%) who feed finishers mash because the chickens were rejecting other forms of feed due to a strong smell and palatability of the feed. This means that the age of chickens influences feed selection and the form of feed preferred changes due to various factors which includes affordability and quality while other factors may be palatability and digestibility of formulated chicken diets.

5.2.2.3 *Number of feedbags utilised*

It is critical in the earliest stages to accurately estimate feed expense and or feed utilisation because chickens demand different amounts of food and nutritional composition at different ages. Therefore, it is important for farmers to know how much feed is required. Information on the number of feedbags utilised is important in planning a good feeding strategy. **Table 5.2** presents the number of feedbags utilised.

Table 5.2: Number of feedbags utilised per cycle (n=70)

Variable	Number of feedbags utilised per cycle	Number of starter feedbags utilised per cycle	Number of grower feedbags utilised per cycle	Number of finisher feedbags utilised per cycle
Mean	112.19	36.60	45.59	27.63
Std. Error of Mean	21.256	7.102	10.527	4.653
Std. Deviation	177.839	59.423	88.079	38.927
Minimum	7	1	0	0
Maximum	1060	400	635	200

The results in **Table 5.2** reveal that on average, the farmers utilise more than one hundred (Actual =112) bags of feed per cycle. This implies that a farmer with an average of five (5) cycles buys 560 bags of feed. The minimum number of bags of feed utilised was seven (7) while maximum was 1060 bags. The standard deviation was 177.83, which was high. Standard error of mean of 21.25 was achieved, which is also reasonably low. This means that some farmers have more chickens than others. The average number of bags of feed purchased for starters was 37 in comparison to 46 bags for growers and 28 bags of feed for finishers. The standard deviation for growers was 88.07 while starters achieved a standard deviation of 59.42. On the other hand, finishers achieved the lowest standard deviation of 38.92. The results imply that majority of the feed purchased is utilised during the grower stage because the nutrient requirements is higher as opposed to other stages. Growers are capable of using higher digestible protein in their 3-4 weeks of development. Moreover, the results of the number of feedbags utilised were categorised into three (3) stages of production which are: starter, grower and finisher stages. The results of the categories are presented in **Figure 5.7**.

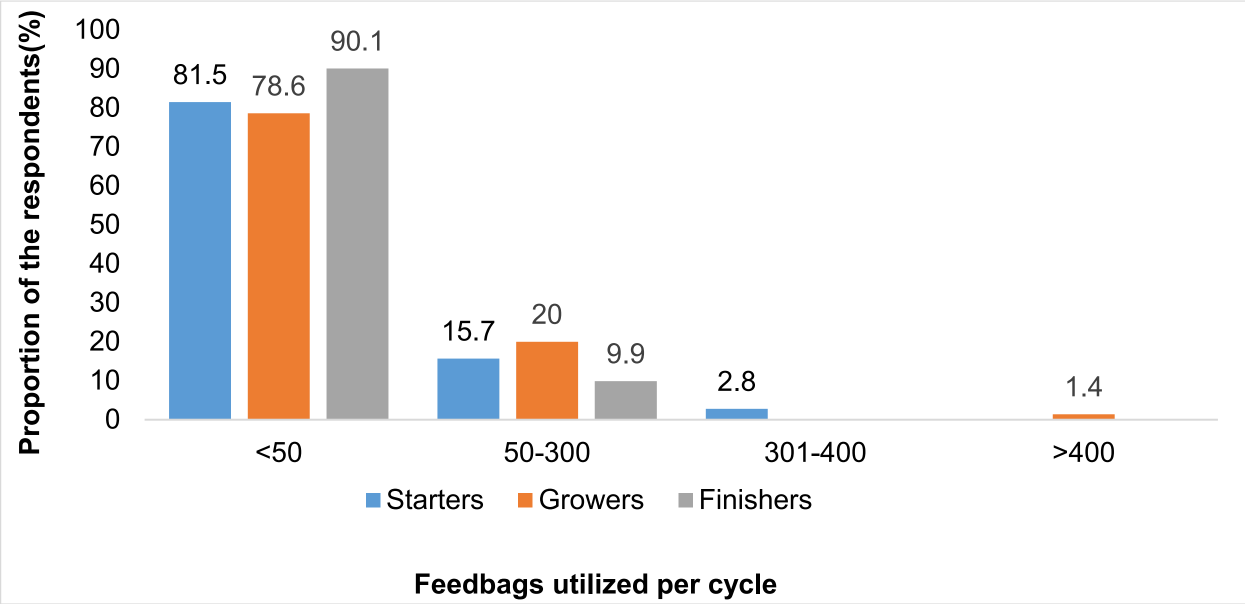

Figure 5.7: Category of the number of feedbags utilised (n=70)

The results in **Figure 5.7** indicate that at the starter stage, more than three-quarter (81.5%) of the respondents used less than 50 bags of feed while 18.5 % of the farmers used50 or more feedbags. That means most of the farmers in the study area used not more than 50 bags of feed at the starter stage of production. Concerning growers, **Figure 5.7** also shows that 78.6% of the farmers used less than 50 bags, followed by 20% who used between 50 and 300 bags of feed. On the other hand, 1.4% of the farmers in the study area used 401 or more bags of feed. The results in **Figure 5.7** depict that 90.1% of the respondents at the finisher stage use less than 50 bags of feed while 9.9% used feed between 50 and 300 bags per cycle. The results imply that chickens in the finisher stage utilise more feedbags than the other stages of production because at this stage, chickens are mature and consume more feed.

5.2.2.4 *Mortality rate (%)*

In poultry production, mortality can be used as a tool to detect early signs of problems in the chicken structure. It is more useful to know the death rate than the number of chickens that die. The results on the mortality rate of chickens fed conventional feed showed that the average mortality rate was 7.6% with minimum of 2% and maximum of 20%. However, the standard deviation of 4.25 was achieved, which was low, and the standard error of mean was 0.50. This means that the mortality rate in some farms was higher than what obtained in other farms. Further analysis was done by splitting the mortality rates into 0-5%, 6-10%, 11-15% and 16-20% categories. **Figure 5.8** presents the aforementioned categories of mortality rates.

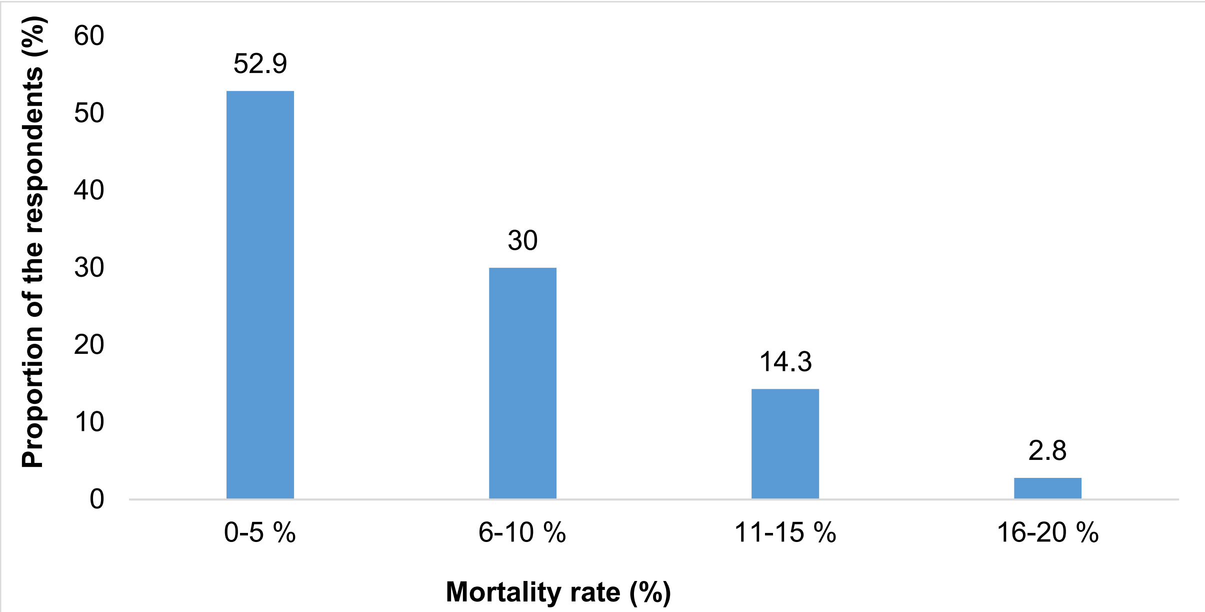

Figure 5.8: Mortality rate of the chickens as given by the respondents (n=70)

Figure 5.8 depicts that more than half (52.9%) of the farmers experienced at most 5% mortality rate whereas 44.3% of the respondents experienced mortality rates between 6% and 15%. On the other hand, 2.3% of the participants had the highest mortality rates between 16% and 20%. The results mean that the relative frequency of chicken deaths was low.

5.2.2.5 *Live weight (kg) of the chickens*

Weight in broiler farming is consequential because it determines price, performance, growth, profitability and so forth. Chickens are weighed using a scale and should be weighed on the same day, once a week from 21 days. It is critical for farmers to monitor the weight of chickens throughout the cycle because it can tell if there is something wrong in the production. Data was collected to identify the average weight between weight gained from consuming conventional diets and the anticipated weight from alternative chicken feeds. The average live weight gained using conventional feed was 1.9 kg with minimum of 1.1 kg and maximum of 2.8 kg. The standard error of mean was 0.03 while the standard deviation of 0.329 was achieved, which was low. This means that some farmers have bigger chickens than other farmers. On the other hand, the average anticipated weight from unconventional alternative feed was 2.0 kg. Minimum of 1.0 kg and maximum of 3.0 kg was reached. A standard deviation of 0.33 was obtained which implied a low variation. The standard error of the mean was 0.03, which was also low. The results indicate that farmers are anticipating bigger chickens from amaranthus and sorghum feed. Furthermore, weight was grouped into two (2) categories, the categories are 1.1-2 kg and 2.1-3 kg as presented in **Figure 5.9.**

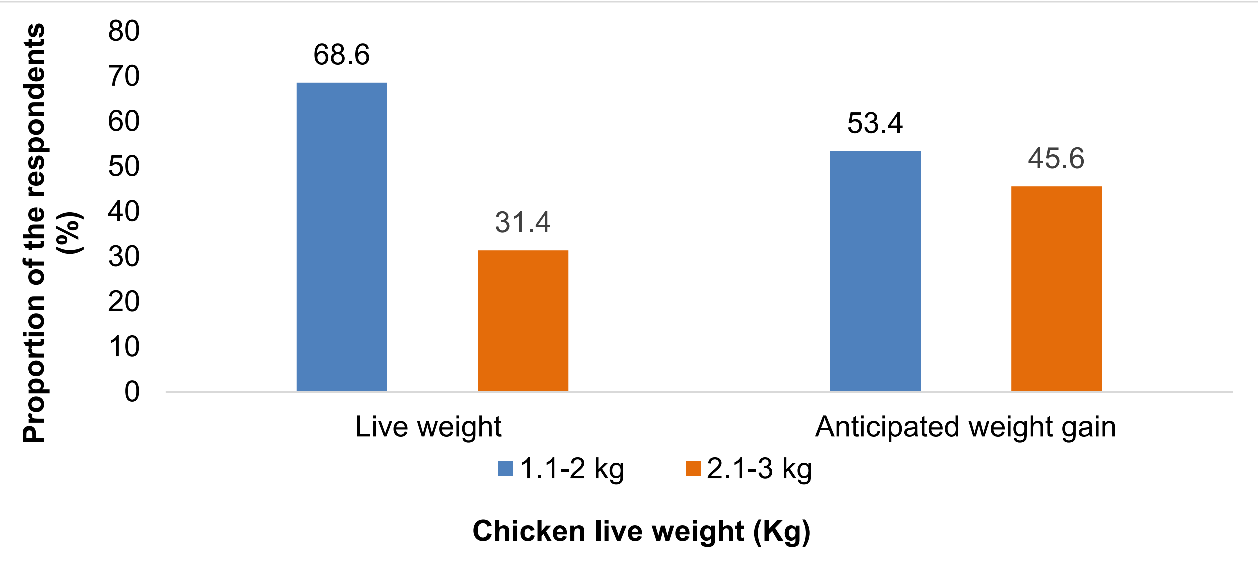

Figure 5.9: Categories of the weight of chickens of the respondents (n=70)

There are three (3) categories established to determine live weight and the results show that majority (68.6%) of the chickens' weight was between 1-2 kg while almost one third of the weight was between 2.1-3 kg. This means that most farmers prefer chickens that are at least 2 kg as it meets market demands. The results in **Figure 5.9** show that the respondents would like to see an increase in the weight of chickens from the proposed alternative feeds. This is supported by the 14.2% increase of chicken weight at 1-2 kg shown in **Figure 5.9**. Almost half (45.6%) of the farmers are anticipating weight between 2.1-3 kg as opposed to 31.4% of the actual weight gained from consumption of conventional feed. The results indicate that some farmers would like bigger chickens while other farmers prefer to maintain the same weight even after using amaranthus and sorghum as the alternative chicken feeds.

5.2.3 Correlation of selected operation and production characteristics of the broiler enterprise.

A correlation of the operational status and production characteristics of the respondents was determined to measure the possible relationship that exist between the aforesaid characteristics in the study area. The selected variables were number of chicken houses, carrying capacity of the farm, and number of employees, production cycles per year, number of bags of feed used per cycle, average live weight (kg), mortality rate (%) and price of chicken. The independent variables explaining the Pearson correlation of operational status and production characteristics of the respondents were found to be significant at 5% (*) and 1% (**), respectively as presented in **Table 5.3**.

Table 5.3: Correlation of selected operation of broiler enterprise variables (n=70)

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1. Number of chicken houses	1	**0.374****	**0.264***	**0.240***	**0.290***	0.172	**-0.247***	0.019
2. Number of chickens (carrying capacity)	**0.374****	1	**0.298***	**0.301***	**0.315****	**0.284***	-0.110	0.119
3. Number of employees	**0.264***	**0.298***	1	0.203	0.225	0.200	0.175	0.028
4. Production cycles per year	**0.240***	**0.301***	0.203	1	0.130	0.121	-0.022	0.009
5. Number of feedbags used per cycle	**0.290***	**0.315****	0.225	0.130	1	0.113	-0.005	0.112
6. Average live weight (kg)	0.172	**0.284***	0.200	0.121	0.113	1	0.033	**0.457****
7. Mortality rate (%)	**-0.247***	-0.110	0.175	-0.022	-0.005	0.033	1	0.186
8. Price of chicken	0.019	0.119	0.028	0.009	0.112	**0.457****	0.186	1

*. Correlation is significant at the 0.05 level

**. Correlation is significant at the 0.01 level

Table 5.3 shows that there exists a statistically significant and positive correlation between the number of chicken houses and the four (4) variables namely, carrying capacity of the chicken houses, number of employees, production cycles per year and the number of bags of feed purchased per cycle at 5% and 1% significance levels, respectively. This means that farmers with more chicken houses have a higher carrying capacity (number of chickens), employed more people, had more production cycles per annum and utilised extra feedbags per cycle. On the other hand, mortality rate had negative and statistically significant relationship with the number of chicken houses. This means that when mortality rate increases, the number of chickens decreases which decreases profit margins.

There is a positive and statistically significant relationship between carrying capacity and preferred form of feed, live weight and chicken price at 1% and 5% significance levels. The results imply that when the carrying capacity of chicken farms increases, the quantity of feed preferred will rise. Alternatively, the live weight of chickens will increase. Improved live weight is important because slaughtering or selling chickens at a lower weight places a farmer at a disadvantage in certain markets. Therefore, those who achieved high live weight will have bigger chickens and better markets, bigger chickens mean that the prices will increase which will in turn, increase the profitability of the farm.

5.3 DISCUSSIONS

The study found that broiler farmers in Gauteng province had two (2) chicken houses with an average carrying capacity of 1 804 chickens (birds). The results somewhat supports what Muchadeyi *et al*. (2005) found in Zimbabwe that small-scale broiler farmers had less than five chicken houses (actual was 3). In contrast, a study done in Free State province found that broiler farmers had more than five (actual was 8) chicken houses per farm with a capacity of 1 000 birds (Hadebe, 2015). The results imply that broiler farmers in the study area were involved in small-scale broiler production. In South Africa, farmers who produce between 1 500 - 40 000 broiler chickens per cycle are categorised as small commercial producers (SAPA, 2018). Moreover, the study found that farmers who had more chicken houses kept large number of chickens. As a result, they purchased more feedbags because they had more production cycles per annum. Such group of farmers were able to create more employment opportunities (average number of employees was two). In contrast, the

National Agricultural Marketing Council (NAMC) (2020) found that the average number of employees in the South African broiler farming sector was four. This shows that the average number of employment opportunities (jobs) created by broiler enterprises in Gauteng province is below the average employment discovered by NAMC in South Africa. Furthermore, the study found that when broiler production (number of chickens) increased, a significant number of jobs were created. In the same light, Ogolla (2016) also discovered that labour positively and significantly influenced poultry production. Therefore, the number of employees serves as an important factor in broiler operation because the number of employees on a farm has the potential to increase farm production. As a result, profit margins are likely to increase. Hyde *et al*. (2008), found that in the United Kingdom, it is reasonable to expect the number of employees to impact the profitability of the farming enterprise positively.

The study discovered that broiler farmers had five (5) production cycles (batches) per annum. Moreover, farmers who had more production cycles per annum achieved higher production (number of chickens). In support, Badubi (2001) found that small-scale broiler farmers in Botswana had an average of 4-5 production cycles per annum. Again, the results are somewhat consistent with what was discovered in Bangladesh where farmers who kept a large number of birds had more production cycles per annum (Ismal *et al*., 2010). In the aforementioned study, it was reported that producers who kept 1 000-3 000 birds had five (5) production cycles per annum on average while those with more than 3 000 chickens had six (6) production cycles. Subsequently, farmers with more production cycles per annum required more feedbags to feed the chickens. On average, the respondents purchased 112 feedbags per cycle (1 cycle = 6 weeks). In contrast, SAPA (2018) indicated that the average number of feedbags purchased per cycle in South Africa was about 68. This shows that the average number chicken feedbags utilised by broiler enterprises in Gauteng province is above the average number of feedbags purchased by SAPA members in South Africa. From chicken mortality point of view, the average mortality rate experienced by broiler farmers was 7.6%. In support of the current findings, Badubi (2001) found that the mortality rate per batch was more than 6% (actual was 9.2%). Thus, chicken mortality rate in the study area is more than the mortality rate (6%) experienced by the broiler industry in South Africa. According to SAPA (2016), the mortality rate of broilers in South Africa is between 4 to 6%.

Moreover, The Poultry Hub (2018) discovered that the standard mortality rate for the broiler industry is between 3% and 5%. This could be due to the fact that on average, the broiler farmers have been involved in farming for nine years; meaning they have acquired enough experience to avoid production activities that could result in a high mortality rate. For example, lower mortality rates are associated with farming experience (Martin *et al*., 1975). Meaning that farmers who have many years of experience in farming often record less mortality rates.

The results of chicken weight showed that on average, respondents achieved a live weight of 1.9 kg through conventional chicken feed. The aforementioned average chicken live weight is above and below what other scholars have recommended as a standard weight for broilers. According to Livestocking (2020), a mature broiler should have an average weight of 2.5 kg. However, in South Africa, the average live weight of chickens is 1.8 kg (Phillip, 2014). In contrast to the current findings, a broiler live weight of 1.7 kg in Bangladesh was recorded (Hanif *et al*., 2017). Also, in contrary, Badubi (2001) found that the average chicken live weight in Botswana was about 1.5 kg. However, farmers indicated that their anticipated chicken live weight from amaranthus and sorghum diet was 2.0 kg. This is not surprising because body weight has a positive relationship with livestock production and profitability (Assan, 2013). According to Tuffour and Oppong (2014), the price of chickens increased profit in their study in the Greater Accra Region of Ghana. The results showed that farmers involved in broiler farming strive for big chickens because they can achieve higher prices in the market and make more profit. Farmers can make more profit if they sell chickens at the prime market weight (Wang *et al*., 2012). Moreover, the average cost of one live chicken was R56.00; thus, the estimated cost per kg was R29.47. In contrast, SAPA (2019) found that the average retail price of chicken per kg was about R49.00. The price of live chickens at the farm gate is different from the price of chicken per kg at retail because the price at the farm gate is determined by adding the cost of day-old chicks, the amount of feed needed to raise a bird and the farmer's profit margin. And it could also be due to the fact that food regulation controls the sale of chicken meat at retail which is priced per kg while farmers sell whole live chickens.

Concerning forms of feed, the results of the current study found that a large proportion (73%) of broiler farmers preferred the pelleted feed form (diets). In support, a study conducted in Bangladesh by Mohamed and Anwarul Haq Beg (2006) revealed that 79% of farmers used crumble or pellet feed form while a small proportion (21%) of farmers used mash diets. This is not surprising because several scholars have discovered that broilers that are fed with pellet feed types have higher body weight than those fed with mash feeds (McKinney & Teeter, 2004; Amerah *et al*., 2008; Chewning *et al*., 2012). According to Dozier *et al*. (2010), the form of feed is significantly influenced by the impact the feed has on the chicken with regards to the chickens' feed intake and growth. For example, Amera *et al*. (2007) found that chickens consuming pellets significantly had a good performance, gained more weight, consumed more food and utilised food more efficiently than chickens that were fed with mash diets. This shows that broiler farmers in the study area were well informed about the advantages of using various forms of feed. Moreover, the response of chickens to the low-fat serving of feed in the form of ground pellets indicated that the pelleting process per se caused a change in the allocation of ingredients that improved weight gain, feed intake and feed efficiency in broilers regardless of the grain source (Jensen, 2000; Nir & Ptichi, 2001). However, the disadvantage of using pellet feed form is that pelleting costs about 10% more than producing mash feed (Jahan *et al*., 2006). Moreover, on average, the distance travelled by respondents to the nearest feed store was about 20 km of which 54% travelled 1-15 km to buy feed. In support, Selaledi (2017) in North West discovered that a large proportion (91.4%) of the farmers travelled 1-15 km to nearest markets. On the contrary, Sebatta *et al*. (2018) found that on average, farmers travelled about 3 km to the nearest feed sources in Uganda. The results show that most farmers travel shorter distances (≤ 15 km to the nearest feed stores). Thus, most famers are more likely to adopt alternative chicken feed made from amaranthus and sorghum if the feed stores will be located within 50 km radius from their farms and be at an accessible destination. According to Rathod *et al*. (2017), farmers are unlikely to adopt innovation if the distance travelled is further from nearest input stores. Therefore, apart from live weight, mortality rate, and others factors that influence adoption, distance plays a major role in the farming industry and agriculture as a whole; in order to produce food, farmers need certain resources, such as feed, seed, fertilizers, packaging materials, and many others. Precisely because of that, transport is an essential part of livestock and crop production that enables delivery of agricultural resources to a farmer.

5.4 CHAPTER SUMMARY

This chapter assessed the operation and production characteristics of broiler enterprises in the study area. The results of the operations of broiler enterprises indicated that on average, farmers had two chicken houses which accommodated about 1 804 birds with less than 10% (actual was 7.3%) mortality rate per cycle. The mean number of hired employees to take care of the chickens were about two. On average, the respondents in the study area had five production cycles per annum of which 112 feedbags were utilised. Majority (73%) of the broiler farmers preferred pellet diets which required farmers to travel 20 km on average to the nearest feed stores. Moreover, the average chicken live (achieved) weight and anticipated live weight were 1.9 kg and 2.0 kg which is sold at R56.00 per live chicken. On the other hand, the number of chicken houses had a positive and significant correlation with carrying capacity, number of employees, number of production cycles and number of feedbags purchased per cycle. Carrying capacity was positive and significantly correlated with number of employees, production cycles, number of feedbags purchased and average live weight of chickens at six weeks of age while the average live weight positively correlated with price of chicken. In contrast, mortality rate was negative and also statistically correlated with the number of chicken houses.

CHAPTER 6

6 FARMERS' WILLINGNESS TO ADOPT ALTERNATIVE CHICKEN FEEDS

6.1 INTRODUCTION

In South Africa, maize and soya bean are commonly used as the main conventional ingredients for animal feed, mostly consumed by broilers and layers in the animal industry. However, the same protein ingredients used in the feed are creating competition between animals and human consumption which as a result, affects feed cost. This has resulted in an increase in total feeding and production costs respectively in chicken production (Ukochukwu, 2005). Consequently, the need for alternative chicken feeds is important because there could be a comparative advantage in terms of feed price and availability which can ultimately reduce broiler production costs. In support, (Anyanwu *et al*., 2011) wrote on "The growth performance and haematological characteristics of broiler finisher chickens fed palm kernel cake as partial replacement for maize and soya bean" and suggested that the use of unconventional chicken feed could potentially be used as a replacement to sustain broiler production. This chapter will look at the willingness of broiler farmers to adopt alternative chicken feeds made from amaranthus and sorghum as energy and protein sources, factors influencing adoption and challenges faced by broiler farmers. The willingness to adopt innovation in agriculture has brought about various techniques that are hypothetically used to improve the agricultural industry. The reason why respondents would accept adoption is because the introduction of the new innovation (amaranthus and sorghum) could potentially meet farmers' needs of affordable feed prices and feed accessibility, increased rate of returns, enable farmers to earn higher income, economies of scale and competitive advantage between conventional and non-conventional feed. This chapter will present the adoption willingness results followed by a chapter summary.

6.2 RESULTS

This chapter is based on three (3) objectives. The first objective is to determine the willingness of broiler farmers to adopt alternative feeds made from sorghum and amaranthus as energy and protein sources. The second objective is to ascertain factors influencing their willingness to adopt whilst the third and last objective is to identify challenges experienced in broiler production. Therefore, the results will be presented in sections **6.2.1- 6.2.4**.

6.2.1 Willingness to adopt alternative chicken feeds

The cost of conventional feed has become a major challenge to farmers. As a result of this, there has been an interest in developing innovation changes of feed in the hope that it will reduce feed costs. The adoption of alternative chicken feed is often influenced by factors such as feed prices, protein (nutritional) content, productivity and production cost of chickens directly relating the amount of feed fed as conveyed by Proskina *et al.* (2016). In the current study, the alternative chicken feeds will be made from amaranthus and sorghum as energy and protein sources. Farmers have always used conventional feed that achieves specific attributes such as live weight, meat quality and so forth. Since the study intends to determine the acceptability of amaranthus and sorghum as alternatives to the conventional feed that dominate the broiler industry, it was therefore important to ascertain the important attributes preferred by farmers.

Data on the acceptability of amaranthus and sorghum as energy and protein sources was collected. The information was important to ascertain factors that could affect the willingness to adopt alternative chicken feeds. The desired attributes, affordability and accessibility have a major influence on the farmer when making a decision to adopt a new innovation thus, these attributes are also evaluated. The aim of this section is to present the results of assessing the acceptability of alternative chicken feed and its attributes. The results are presented from sections **6.2.1.1 – 6.2.1.4**.

6.2.1.1 *Desired chicken attributes*

The desired chicken attributes used to assess the acceptability of alternative chicken feeds made from amaranthus and sorghum as energy and protein sources are improved feed efficiency, improved energy levels per kg weight gain, reduced feed efficiency as chickens get older, high feed intake, contains all nutrients required by chicken, improved live weight and low mortality rate. Live weight was measured because higher live weight will enable farmers to access lucrative markets. This means that the availability of markets will increase or improve profit margins. The chickens will be resistant to diseases and will have weight uniformity compared to conventional ones. Therefore, mortality rate will decrease because of improved live weight. It is important to have low mortality rates because farm productivity will improve, and this change will influence positive sales. This will enable farmers to manage their running costs better. Another important attribute is high feed intake which will ultimately increase live weight of chickens, improve feed efficiency (FCR) and energy level per kg weight gain. However, high feed intake will increase feed costs. These attributes are important to produce fast growing chickens that will increase profitability. Improved feed efficiency will increase animal performance and productivity, meaning that the kg of the chicken meat produced per kg of feed will increase. This section will focus on the willingness to adopt alternative chicken feeds if it can improve the desired attributes as presented in **Table 6.1**.

Table 6.1: Attributes influencing farmers' willingness to adopt alternative chicken feeds (n=70).

Variables	**Number of respondents (%)**			**Mean Score (MS)**	**Mean Rank (MR)**
	Will not consider	**Might consider**	**Will definitely consider**		
Improved live weight	2.9	5.7	91.4	2.89	1
Low mortality rates	2.9	8.6	88.6	2.86	2
Contains all nutrients required by chicken	2.9	10.0	87.1	2.84	3
Improved feed efficiency	2.9	10.0	87.1	2.84	3
Improved energy levels per kg weight gain	2.9	12.9	84.3	2.81	4
High feed intake	10.0	11.4	78.6	2.69	5
Reduced feed efficiency as chickens get older	15.7	22.9	61.4	2.46	6
Average	**5.3**	**11.6**	**82.6**	**2.77**	**-**

The results in **Table 6.1** shows that in general, 82.6% of the respondents were willing to adopt alternative chicken feeds containing amaranthus and sorghum as energy and protein sources respectively, if it will improve all the desired attributes presented in the above Table. A mean score of 2.77, which indicate that generally the respondents would definitely consider adopting the alternative chicken feeds, supports this. The mean rank indicates that improved live weight was the most important attribute (MR=1) that influences a farmer's decision to adopt alternative chicken feeds containing amaranthus and sorghum as sources of energy and protein, respectively. The least important attribute was reduced chicken efficiency as the chickens get older (MR=6). The descriptive statistics results presented in

Table 6.1 do not show the level of significance between the desired attributes that influences farmers' willingness to adopt alternative chicken feeds. Consequently, Friedman's test was performed to determine the significant differences between all seven desired attributes in **Table 6.1**.

In the results of Friedman's test, a chi-square value of 50.45 with a degree of freedom (df) of six (6) was obtained. The significant value achieved was 0.05; therefore, there exists a statistically significant difference between the seven desired attributes that were measured in the study (live weights, mortality rates, nutrients required by chicken, feed efficiency, energy levels per kg weight gain, feed intake, feed efficiency as chickens get older). **Table 6.2** presents the results of Wilcoxon signed rank test showing the differences between the desired attributes influencing farmers' willingness to adopt alternative chicken feeds.

Table 6.2: Results of Wilcoxon signed rank test for chicken attributes desired by the respondents (n=70)

Variable	Ranks	N	Mean Rank	Sum of ranks	Z	Asymp. Sig. (2-tailed)
Improved energy levels per kg weight gain and Improved feed efficiency	Negative Ranks Positive Ranks Ties	4 2 64	3.50 3.50	14.00 7.00	-.816	0.414
Reduced feed efficiency as chickens get older and improved feed efficiency	Negative Ranks Positive Ranks Ties	20 3 47	12.75 7.00	255.00 21.00	-3.673	<0.001
High feed intake and improved feed efficiency	Negative Ranks Positive Ranks Ties	9 4 57	8.33 4.00	75.00 16.00	-2.121	0.034
Contains all nutrients required by chicken- improved feed efficiency	Negative Ranks Positive Ranks Ties	3 4 63	4.67 3.50	14.00 14.00	0.000	1.000
Improved live weight and improved feed efficiency	Negative Ranks Positive Ranks Ties	2 5 63	4.00 4.00	8.00 20.00	-1.134	0.257
Low mortality rates and improved feed efficiency	Negative Ranks Positive Ranks Ties	4 5 61	5.00 5.00	20.00 25.00	-.333	0.739
Reduced feed efficiency as chickens get older and improved energy levels per kg weight gain	Negative Ranks Positive Ranks Ties	18 2 50	11.00 6.00	198.00 12.00	-3.580	<0.001
High feed intake and improved energy levels per kg weight gain	Negative Ranks Positive Ranks Ties	9 4 57	7.89 5.00	71.00 20.00	-1.857	0.063
Contains all nutrients required by chickens and improved energy levels per kg weight gain	Negative Ranks Positive Ranks	2 5	5.25 3.50	10.50 17.50	-.632	0.527

	Ties	63				
Improved live weight and improved energy levels per kg weight	Negative Ranks Positive Ranks Ties	0 5 65	0.00 3.00	0.00 15.00	-2.236	0.025
Low mortality rates and Improved energy levels per kg weight gain	Negative Ranks Positive Ranks Ties	2 5 63	4.00 4.00	8.00 20.00	-1.134	0.257
High feed intake and reduced feed efficiency as chickens get older	Negative Ranks Positive Ranks Ties	8 18 44	12.38 14.00	99.00 252.00	-2.004	0.045
Contains all nutrients required by chickens and reduced feed efficiency as chickens get older	Negative Ranks Positive Ranks Ties	2 21 47	12.75 11.93	25.50 250.50	-3.531	<0.001
Improved live weight and reduced feed efficiency as chickens get older	Negative Ranks Positive Ranks Ties	1 22 47	7.50 12.20	7.50 268.50	-4.108	<0.001
Low mortality rate and reduced feed efficiency as chickens get older	Negative Ranks Positive Ranks Ties	2 22 46	8.50 12.86	17.00 283.00	-3.957	<0.001
Contains all nutrients required by chickens and high feed intake	Negative Ranks Positive Ranks Ties	1 8 61	3.00 5.25	3.00 42.00	-2.373	0.018
Improved live weight and high feed intake	Negative Ranks Positive Ranks Ties	1 10 59	3.50 6.25	3.50 62.50	-2.697	0.007
Improved live weight and improved energy levels per kg weight gain	Negative Ranks Positive Ranks Ties	3 10 57	4.50 7.75	13.50 77.50	-2.311	0.021
	Negative Ranks	1	2.00	2.00	-1.134	0.257

Improved live weight and contains all nutrients required by chickens	Positive Ranks Ties	3 66	2.67	8.00		
Low mortality rates and contains all nutrients required by chickens	Negative Ranks Positive Ranks Ties	3 3 64	3.00 4.00	9.00 12.00	-.333	0.739
Low mortality rates and improved live weight	Negative Ranks Positive Ranks Ties	2 0 68	1.50 0.00	3.00 0.00	-1.414	0.157

The results in **Table 6.2** show that from 21 paired attributes, only 11 desired attributes differed significantly at 1% ($p \leq 0.01$) and 5% ($p \leq 0.05$) levels. These paired attributes are reduced feed efficiency as chickens get older and improved feed efficiency ($Z=-3.673$; $p<0.001$). Since the mean rank (MR) for improved feed efficiency (negative ranks) was higher (MR=12.75), it implies that the respondents were more willing to adopt an alternative chicken feed if it improves feed efficiency compared to reduced feed efficiency as chickens get older. The Z-score value and significant value for high feed intake and improved feed efficiency recorded were -2.121 and 0.034 ($p \leq 0.05$), respectively. Meaning that, improved feed efficiency was more preferred by the respondents compared to feed intake when it comes to the adoption of alternative feeds. This notion is supported by a higher mean rank for feed efficiency or negative ranks (MR=8.33). The significant value for reduced feed efficiency as chickens get older and improved energy levels per kg weight gain recorded was <0.001 and the Z-score value was -3.580. The mean rank (MR) for negative ranks (improved energy levels per kg weight gain recorded) was higher at 11.00 denoting that respondents preferred their chickens to improve in energy levels as they get older from amaranthus and sorghum as alternative chicken feeds. The Z-score value and the significance value for improved live weight and improved energy levels per kg weight gain were ($Z=-2.236$; $p=0.025$) at 5% significance level ($p \leq 0.05$). The results imply that positive ranks or improved live weight was significantly preferred than the other because of the high mean rank (MR=3.00). Regarding high feed intake and reduced feed efficiency as chickens get older, the significant value achieved was 0.045 at 5% significance level ($p \leq 0.05$) with Z-score value of ($Z=-2.004$). The mean of the positive ranks (high feed intake) was larger (MR=14.00) than that for negative ranks (reduced feed efficiency as chickens get older) suggesting that the respondents were considering high feed intake more when accepting the use of unconventional chicken feed made from amaranthus and sorghum as energy and protein sources. The statistical relationship between contains all nutrients required by the chicken and reduced feed efficiency as chickens get older attributes was statistically significant ($p<0.001$) at 1% ($p \leq 0.01$) and the Z score value was ($Z=-3.531$). Since the mean rank for the negative ranks (reduced feed efficiency as chickens get older) was higher (MR=12.75), it shows that chicken farmers in Gauteng were willing to adopt alternative chicken feeds if it will result in the feed efficiency of the chickens as they get older. On the other hand, the Z-score value and significance value for improved live weight and reduced feed efficiency as chickens get older were (Z=-4.108; p<0.001). The mean of the positive ranks (improved live weight) was larger (MR=12.20) than negative ranks (reduced feed efficiency of the chickens as they get older), suggesting that farmers will adopt the proposed alternative chicken feeds, if it will improve the live weight gained from using the conventional chicken feed. Low mortality rate and reduced feed efficiency attributes were statistically significant) at 1% significance level (p<0.01). The Z-score value of both attributes was -3.957, respectively, implying that respondents were considering the adoption of amaranthus and sorghum as alternative sources of energy and protein if it reduces mortality rate. This was supported by the mean score of 12.86 (MR=12.86), which was high. The results of the findings between contains all nutrients required by the chickens and high feed intake attributes showed that the Z-score value and significant value recorded were (Z=-2.373; p=0.018) at 5% significance level. The mean of the positive ranks (contains all nutrients required by the chickens) was more at (MR=5.25), meaning that respondents were willing to use an alternative feed if it can contain all nutrients required by the chickens. Improved live weight and high feed intake attributes recorded a significant value of (p=0.007) and Z-score value of (Z=-2.697). The mean rank of positive ranks (improved live weight) was higher (MR= 6.25), this implies that improved live weight was the most preferred attribute by respondents when considering the use of unconventional chicken feed. Similarly, improved live weight and improved energy levels per kg weight gain recorded a significant value of (p=0.021) and Z score value of (Z=-2.311) at 5% significance level. The mean of improved live weight (positive ranks) was higher than negative ranks (improved energy levels per kg weight gain) which was supported by mean rank of (7.75). The results mean that improved live weight is the most considered attribute when accepting the adoption of alternative chicken feeds made from amaranthus and sorghum as energy and protein sources.

6.2.1.2 *Affordability attributes (n=70)*

Animal feed has become a major challenge since the cost of feed is expensive and farmers are struggling to keep up with the rising feed costs. This is mainly due to fact that feeds account for about 50–70% of the total costs in animal production. Protein ingredients are one of the most expensive inputs even though they are not included in large quantities as compared to other ingredients. As a result, the introduction of alternative and unconventional chicken feed as a solution to chicken feed costs problem is essential and this could promote cost-effectiveness. The objective for this section is to measure the willingness of farmers to adopt alternative chicken feeds made from amaranthus and sorghum as energy and protein sources if it will reduce the price per bag of feed ingredient, reduce cost of chicken feed, reduce the number of bags of chicken feeds purchased and reduce the number of feedbags purchased as presented in **Table 6.3.**

Table 6.3: Results of affordability attributes influencing the willingness to adopt an alternative chicken feed (n=70).

Variable	Number of respondents (%)			Mean score (MS)	Mean Rank (MR)
	Will not consider	Might consider	Will definitely consider		
Reduced number of feedbags purchased	1.4	5.7	92.9	2.91	1
Reduced cost of chicken feed	2.9	4.3	92.9	2.90	2
Reduced price per bag of feed ingredient	2.9	7.1	90.0	2.87	3
Reduce feed cost by half	4.3	11.4	84.3	2.80	4
Average	**2.9**	**7.1**	**90.0**	**2.87**	**-**

The results in **Table 6.3** indicate that a large proportion (90%) of the respondents were willing to adopt amaranthus and sorghum as alternative chicken feeds if it will be affordable. Majority (92.9%) of the respondents were also willing to adopt it if it will reduce the number of feedbags purchased. Thus, reduced number of feedbags purchased achieved a mean score of (MS=2.91), which was high. Even though reduced cost of feed had the same proportion of farmers with reduced number of feedbags purchased, it was not the most important attribute (MS=2.90) that influences farmers to adopt alternative chicken feeds made from amaranthus and sorghum as energy and protein sources. The least preferred attribute was reduced feed costs by half. A mean score of 2.80 supports this notion. The results imply that reduction in the number of feedbags purchased was the most preferred attribute for farmers to accept this adoption because the price of feed would be less than that of the conventional feed.

The descriptive statistical results presented in **Table 6.3** do not show the level of significance between all four (4) attributes that influences farmers' willingness to adopt alternative feeds made from amaranthus and sorghum. Therefore, it was important to perform Friedman's test to determine the level of significance among all affordability attributes. The mean ranks recorded in the Friedman's test results support the mean ranks in **Table 6.3.** The results of the findings showed that the attributes were statistically significant at p-value of 0.029 with chi-square value of 9.00 and a degree of freedom (df) of 3 was obtained. Therefore, there exists a statistically significant difference at 1% and 5% significance levels between all four attributes (reduced number of bags of chicken feeds purchased, reduced cost of chicken feed, reduced price per bag of feed ingredient, reduce feed cost by half). Friedman's test only discloses whether or not there is a significant statistical difference among the attributes but does not exactly show where the difference occurs. To determine where the difference is, the Wilcoxon signed rank test will be used. **Table 6.4** presents the Wilcoxon sign rank test affordability attributes that will influence the willingness to adopt alternative chicken feeds made from amaranthus and sorghum.

Table 6.4: Results of Wilcoxon sign test results for affordability attributes (n=70).

Variables	Ranks	N	Mean Ranks	Sum of Ranks	Z	Asymp. Sig. (2-tailed)
Reduced price per bag of feed ingredient and reduced cost of chicken feed	Negative Ranks Positive Ranks Ties	0 2 68	0.00 1.50	0.00 3.00	-1.114	0.157
Reduced price per bag of feed ingredient and reduced number of bags of chicken feeds purchased	Negative Ranks Positive Ranks Ties	0 2 68	0.00 1.50	0.00 3.00	-1.342	0.180
Reduced price per bag of feed ingredient and reduce the feed costs by half	Negative Ranks Positive Ranks Ties	6 2 62	4.67 4.00	28.00 8.00	-1.508	0.132
Reduced cost of chicken feed and reduce the feed costs by half	Negative Ranks Positive Ranks Ties	1 1 68	1.00 2.00	1.00 2.00	-0.447	0.655
Reduced cost of chicken feed and reduced number of feedbags purchased	Negative Ranks Positive Ranks Ties	7 1 62	4.57 4.00	32.00 4.00	-2.111	0.035
Reduced number of feedbags purchased and reduce the feed costs by half	Negative Ranks Positive Ranks Ties	8 2 60	5.75 4.50	46.00 9.00	-1.999	0.046

Table 6.4 indicates that from six (6) paired affordability attributes, only two (2) were statistically significant at 5% level of significance ($p \leq 0.05$) whereas four were not. The paired attributes that showed a significant difference are reduced cost of chicken feed and reduced number of bags of chicken feeds purchased (sig=0.035) at 5% significance level and the Z-score value of (Z=-2.111) was achieved. Since the mean rank for the negative ranks (reduced number of bags of chicken feeds purchased) was higher at (MR=4.57). The results imply that respondents were willing to adopt an alternative chicken feed if the number of feedbags purchased reduces. The Z-score value and the significant value for reduced number of feedbags purchased and reduce the feed costs by half were Z=-1.999 and 0.046 ($p < 0.05$), respectively. Meaning, between the reduced number of feedbags attribute and reduced feed cost by half attribute, farmers preferred the alternative chicken feed to reduced feed costs by half (MR=5.75).

6.2.1.3 *Accessibility attributes*

The accessibility of unconventional chicken feed is important because it will greatly benefit the farmers. If feed is accessible, the production of chickens will be improved. The willingness to adopt alternative chicken feeds made of amaranthus and sorghum if it is accessible was recorded using the following attributes: short distance to the market, lower transport costs to buy feed, feed accessible at any time of the day and easy access of the supplier location. Information on feed accessibility at any time was collected because feed is not always available when it is needed. The inaccessibility of feed is bad for performance and growth of chickens because the quality of feed purchased is eventually compromised when there is insufficient feed which means that profit margins will decrease. **Table 6.5** presents the results of accessibility attributes.

Table 6.5: Descriptive statistics results of accessibility attributes (n=70)

Variable	**Number of respondents (%)**			**Mean Score (MS)**	**Mean Rank (MR)**
	Will not consider	**Might consider**	**Will definitely consider**		
Lower transport costs to buy feed	1.4	2.9	95.7	2.94	1
Feed accessible at any time of the day	1.4	2.9	95.7	2.94	1
Supplier location is easily accessible	1.4	2.9	95.7	2.94	1
Short distance to the market	2.9	2.9	94.3	2.91	2
Average	**1.7**	**2.9**	**95.3**	**2.93**	**-**

Table 6.5 indicates that on average, a large proportion (95.35%) of farmers were considering the adoption of alternative chicken feeds, if it is accessible. The mean rank for lower transport costs to buy feed, feed accessible at any time of the day and supplier location is easily accessible attributes were (MS=2.94) each, which was the same. The lowest accessibility attribute was if it is a short distance to the market supported by a mean score of 2.91, which was low. The results imply that lower transport costs to buy feed, feed accessible at any time of the day and supplier location is easily accessible attributes were equally preferred by the respondents. Because of that, further analysis was done to determine if there was a significant difference between the attributes. To determine the significant difference between the accessibility attributes, the non-parametric Friedman's test was performed.

Friedman's test results indicated that the relationship between the accessibility attributes was not statistically significant ($p>0.05$). The degrees of freedom and chi square recorded for both was 3. This means that there was no significant effect of the attributes to adopt alternative chicken feeds made from amaranthus and sorghum as energy and protein sources, meaning that there were no significant differences found in the accessibility attributes presented in the above table. Therefore, further analysis of a post-hoc test was not performed.

6.2.2.1 *Overall willingness to adopt alternative chicken feeds*

The overall descriptive statistics of farmers' willingness to adopt alternative feeds made from amaranthus and sorghum ingredients was assessed. The variability among the three variables (accessibility, affordability and desired attributes) was assessed and the results are presented in **Table 6.6**.

Table 6.6: Overall willingness to adopt alternative chicken feeds (n=70)

Variable	Number of respondents (%)			Mean score (MS)	Mean rank (MR)
	Will not consider	Might consider	Will definitely consider		
Accessibility	1.77	2.9	95.35	2.94	1
Desired Attributes	5.32	11.64	82.64	2.80	2
Affordability	2.87	7.12	90.02	2.80	3
Average	**3.3**	**7.2**	**89.3**	**2.84**	**-**

The overall results provided in **Table 6.6** depicts that on average, 89.3% of farmers were willing to adopt alternative chicken feeds if it will be accessible, affordable and have all the desired attributes. The highest mean score obtained was 2.94 for accessibility whereas affordability and desired traits each achieved a mean score of 2.80. This implies that accessibility was the most important attribute as presented in **Table 6.6**. Although the proportion of respondents willing to adopt an alternative chicken feed if it is affordable was higher than desired attributes' proportion, the mean scores achieved were the same, meaning that the attributes were equally considered as the most significantly important attributes. The descriptive statistics results however did not show the level of significance of the attributes. Therefore, a post-hoc test was carried out using Friedman's Test to determine the overall statistical significance for all the groups of attributes altogether influencing the willingness to adopt alternative chicken feeds made from amaranthus as a protein source.

The Friedman's test results indicated that accessibility attributes were the most important attributes influencing the willingness to adopt alternative chicken feeds made from amaranthus and sorghum as energy and protein sources, the notion was supported by a mean rank of (2.13), which was high. The mean rank for affordability attribute was (1.95) while the least mean rank was 1.92 for desired attributes. Overall, there was a statistical significance (p-value is 0.01) for all the three (3) groups (Desired attributes, affordability and accessibility) at 1% level of significance where (chi-square=10.73; df=2). This means that there was a significant difference in the preference for the three (3) attributes for farmers to adopt alternative chicken feeds. Wilcoxon sign rank test was performed to determine where the significant difference was. **Table 6.7** presents the Wilcoxon sign rank test results for all the groups of attributes that will influence the willingness to adopt alternative chicken feeds.

Table 6.7: Results of Wilcoxon sign rank test results for affordability, accessibility and desired traits (n=70)

Variables	Ranks	N	Mean Ranks	Sum of Ranks	Z	Asymp. Sig. (2-tailed)
Affordability-Desired attributes	Negative Ranks Positive Ranks Ties	6 7 57	7.58 6.50	45.50 45.50	0.000	1.000
Accessibility-Desired attributes	Negative Ranks Positive Ranks Ties	0 10 60	0.00 5.50	0.00 55.0	-3.162	0.002
Accessibility-Affordability	Negative Ranks Positive Ranks Ties	0 8 62	0.00 4.50	0.00 36.00	- 2.640	0.008

Table 6.7 indicates that from three paired attributes that influences the willingness to adopt alternative chicken feeds made from amaranthus and sorghum as energy and protein sources, two paired attributes were statistically significant at 1%. The paired attributes that showed a significant difference (p=0.002) were accessibility and desired attributes with Z-score value of -3.162 and accessibility and affordability attributes with Z-score value of -2.640 (p=0.008). This means that farmers were more willing to adopt alternative chicken feeds made from alternative feed if it was more accessible (MR=5.50) compared to the desired attributes (MR=0.00) that may be achieved. With regards to the accessibility and affordability paired attributes, respondents were willing to adopt the alternative chicken feed if it was more accessible (MR=4.50) rather than if it was affordable (MR=0.00).

6.2.3 Factors influencing adoption willingness

This section presents the results of the factors influencing the adoption willingness of Gauteng chicken farmers to adopt alternative chicken feeds. **Table 6.8** shows the model fitting information.

Table 6.8: Model fitting information (n=70)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept only	46.358			
Final	0.000	46.358	12	<0.001

Table 6.8 shows that the p-value is <0.001, which is statistically significant. This implies that the model is significant and can be used to predict the threshold.

The results of the Goodness-of-fit of Pearson and Deviance are presented in **Table 6.9**.

Table 6.9: Goodness-of-fit (n=70)

	Chi-Square	df	Sig.
Pearson	0.768	126	1.000
Deviance	1.478	126	1.000

The results presented in **Table 6.9** show that the p-value for Pearson's chi-square is 1.000 which is not statistically significant at 5% level of significance. Therefore, the model used for this analysis was not suitable for the data. The Deviance chi-square was also not statistically significant (p>0.05). Hence, the results of both Pearson and Deviance (Goodness-of-fit) measures used may not produce the same results always. **Table 6.10** depicts Pseudo R-Square.

Table 6.10: Pseudo R-Square (n=70)

Cox and Snell	0.484
Nagelkerke	1.000
McFadden	1.000

Table 6.10 presents the three (3) pseudo-R-Square values. The R-squared values in OLS regression did not have equivalence on logistic regression. R-squared values stated did not have the exact meaning as OLS regression because their analysis was insignificant. **Table 6.11** presents the results of the parameter estimates of the ordered Logit Model (OLM) of the factors influencing the willingness to adopt alternative chicken feeds.

Out of the twelve (12) selected variables in the Ordered Logistic Model presented in **Table 6.11**, only eight were positive predictors (number of chicken houses, carrying capacity, number of employees, number of production cycles per year, distance to the nearest store, anticipated weight of chickens using proposed alternative chicken feed and farm/plot size). However, four positive variables (number of chicken houses, number of production cycles per year, average weight of chickens and anticipated weight of chickens using the proposed alternative chicken feed) were statistically significant at 5% level of significance ($p \leq 0.05$). The result implies that a significant increase in production cycle will increase farmers' willingness to adopt. Increasing production cycles means that the number of chicken houses will increase. Therefore, the willingness to adopt the alternative chicken feeds will increase. Additionally, an increase in the anticipated weight of chickens will also affect the willingness to adopt, which will increase.

On the other hand, the results in **Table 6.11** also showed that four (4) variables (number of feedbags utilised, mortality rate, pricing of chicken and farming experience) were negative. Although the variables were negative, mortality rate and number of feedbags utilised were statistically significant at 5% ($p=0.048$ and 0.038). This implies that there is a negative correlation because an increase in mortality rate will decrease the willingness of farmers to adopt. Which means that farmers with high mortality rate were reluctant to adopt chicken feed innovation. Farmers with more feed utilised were also not willing to adopt the alternative chicken feeds made from amaranthus and sorghum.

Table 6.11: Ordered Logistic Model (OLR) results of the factors influencing net farm income (n=70)

	Variable	**Estimate**	**Std. Error**	**Wald**	**Sig.**	**95% Confidence Interval**	
						Lower Bound	**Upper Bound**
Threshold	[Will not consider adopting = 1]	186.058	145.487	1.635	0.201	-99.091	471.208
	[Might consider adopting = 2]	246.745	184.057	1.797	0.180	-114.001	607.490
Location	Number of chicken houses	239.511	120.743	3.935	**0.047**	2.858	476.163
	Number of chicken (carrying capacity)	191.348	118.864	2.591	0.107	-41.620	424.316
	Number of employees	80.878	72.333	1.250	0.264	-60.891	222.648
	Distance to the nearest feed store	26.634	20.326	1.717	0.190	-13.205	66.473
	Number of production cycles per year	247.609	117.901	4.411	**0.036**	16.528	478.690
	Number of feedbags utilised	-328.292	157.882	4.324	**0.038**	-637.735	-18.850
	Average weight of chickens	484.931	253.198	3.668	0.055	-11.328	981.190
	Anticipated chicken live weight from alternative chicken feed	979.951	474.005	4.274	0.039	50.917	1908.984
	Mortality rate (%)	-146.101	73.755	3.924	**0.048**	-290.659	-1.544
	Pricing of chicken	-103.485	81.115	1.628	0.202	-262.469	55.498
	Farming experience	-0.464	0.781	0.353	0.552	-1.994	1.066
	Farm/plot size (ha)	4.029	2.830	2.026	0.155	-1.519	9.576

6.2.4 Challenges faced by farmers using conventional chicken feed.

This section presents and discusses the constraints of chicken farmers in Gauteng province. The results on challenges faced by farmers with conventional chicken feed are presented in **Table 6.12**.

Table 6.12: Challenges faced by farmers with chicken feed and farming in general in the study area (n=70)

No	Challenges	Frequency	Percentage (%)
1.	High feed prices	21	30
2.	Low quality feed	9	13
3.	Lack of access to markets	8	11
4.	Inadequate nutrients in some feeds	5	7
5.	High transport costs	5	7
6.	Low profit margins	5	7
7.	High mortality rate	5	7
8.	Reduced chicken live weight	5	7
9.	Long distance to feed store	4	6
10.	Limited government intervention	4	6
11.	Reduced production cycles	4	6
12.	Lack of transport to purchase feed	3	4
13.	Inconsistent feed quality	3	4
14.	Lack of nutritional/ingredient information on feedbags	3	4
15.	Lack of participation in the pricing of feed	2	3
16.	Lack of feed subsidy	2	3
17.	Purchasing feed on credit is not permitted	2	3
18.	Unavailability of feed during certain periods	2	3
19.	High cost of production inputs	2	3

The information presented in **Table 6.12** show that high feed prices, low quality feed and lack of access to markets were common challenges acknowledged by most of the respondents. Less than one-third (30%) of the farmers indicated that their major challenge with chicken farming was high feed prices. In addition, inadequate nutrients in low quality feed was bad for chicken development. Farmers who earned less income were disadvantaged because a large portion of their input costs was spent on feed. Those with lack of market access were consistent with **Table 4.3** which discovered that majority (84%) of the respondents did not have market access while 16% of the remaining farmers had access to penetrate the broiler markets. Less than one-tenth (7%) of the farmers experienced high transport costs constraints which delayed feeding plans due to the fact that transport money would not be readily available when feed finishes before the anticipated period. On the other hand, high mortality rate also proved to be a constraint, this was consistent with **Figure 5.8**. More than half (52.9%) of the farmers reported to have mortality rate of less than 5%, followed by 44.3% with death rates between six (6)% to 15% while the rest of the farmers (2.3%) had mortality rates above 16%. Decreasing trend in live weight was observed when chickens were fed with cheaper feed. Weight gained from feeding is significant because it is an indication that the chickens are performing. However, the weight drops due to low quality feed. **Figure 5.9** showed that they are always anticipating bigger chickens to improve profit margins. **Table 6.12** also shows that lack of government intervention (access to government feed subsidy and access to extension services) was one of the major constraints and this is supported by **Table 4.3** which depicts that a large proportion (81%) had not received feed subsidy and extension services (54%) from the government while the rest of the farmers had access to the aforementioned government benefits. **Table 6.12** shows the rest of the challenges faced by the farmers.

6.2.5 Reasons why farmers were not willing to adopt the alternative chicken feeds.

During data collection, participants were overly excited hearing about the alternative feeds made from amaranthus and sorghum ingredients as energy and protein sources and that the alternative feed could potentially be cost-effective, accessible and could contain all the desired nutrients required for improved performance and growth in chickens. As a consequence, the willingness of Gauteng broiler farmers to adopt the alternative feeds made from amaranthus and sorghum as energy and protein sources was remarkably high: majority (89.33%) were definitely considering adopting the proposed feed whereas 7% indicated that they might consider. The remaining 3% were not willing to consider adopting the alternative chicken feeds made from amaranthus and sorghum.

Those who were not willing to adopt the alternative chicken feeds however stated their reasons for not willing to adopt the alternative chicken feeds made from amaranthus and sorghum ingredients as energy and protein sources. The reasons were:

- Cultural beliefs and values do not permit them to accept the alternative chicken feeds made from amaranthus and sorghum.

- Farmers perceive it as risky, and they are not willing to take any risks with feed that has not yet been tested.
- General scepticism and associated technology rejection.
- New feed may have low quality nutritional content which could negatively affect their profit margins.
- Uncertainty over consumers' acceptability of products from chickens raised on amaranthus and sorghum and potential positive impacts.
- Respondents were afraid of the unknown outcomes pertaining to the performance of chickens after consuming the feeds.
- Proposed feed may be associated with health risks.

6.3 DISCUSSIONS

6.3.1 Desired attributes

In general, the results of the desired attributes (traits) showed that more than four-fifth (82.6%) of the respondents were willing to adopt the alternative chicken feeds made from amaranthus and sorghum if it will improve live weight, lower mortality rate, contain all the nutrients required by the chickens, improve feed efficiency, energy levels per kg weight gain of birds, feed intake and reduce efficiency as chickens get older desired traits in six weeks. The most important attribute preferred by farmers was the ability of the alternative feeds to improve live weight (MR=1) whereas reduced feed efficiency as the chickens get older was the least preferred attribute (MR=6). In support, Dana *et al*. (2010) in Ethiopia discovered that chicken live weight and growth rate (weight gain and live weight at market age) are "adaptation traits" which farmers desire to improve their chicken production. The results are consistent with those of Abdelqader *et al*. (2007), which discovered that growth rate and body size are some of the most important traits that chicken farmers in Jordan preferred because they positively influence the live weight of chickens. Chicken live weight is important because bigger chickens could yield higher profit margins. Hence, farmers are willing to accept the alternative chicken feeds if it will improve chicken live weight because the ingredients in feed can have a significant impact on chicken weight (Astral Foods, 2019). Bigger chickens are good for business because the weight of chicken meat influences farm profit margins (Assan, 2013).

Moreover, Friedman's test results revealed that there is a statistical significance at 1% and 5% significance levels between the chicken attributes desired by the respondents in order to adopt the alternative chicken feeds. However, the results of Wilcoxon's signed rank test revealed that only 11 paired desired attributes were statistically significant. The findings showed that the respondents were significantly willing to adopt the alternative chicken feeds if it improved feed efficiency compared to reduced feed efficiency as chickens get older. This is because an improvement in feed efficiency reduces the amount of feed required for broiler growth and the cost of production (Zhang & Aggrey, 2003). Improved energy levels per kg weight gain was preferred to reduced feed efficiency as chickens get older attribute because the right amount of energy levels in chicken diet is likely to result in low feed cost per unit of product. Therefore, improving energy levels per kg weight gain requires more feed consumption (increase feed intake) to meet the desired energy requirements (Nahashon *et al*., 2006). A study done by Munt *et al*. (1995) discovered that achieving good feed intake is essential for efficient nutrient utilisation and a good growth rate. As a result, broiler farmers in Gauteng considered the adoption of the alternative chicken feeds made from amaranthus and sorghum if it will improve feed intake compared to reduced feed efficiency as chickens get older attribute because feed intake is expected to influence chicken weight gain, feed conversion ratio, feed cost and carcass quality (Ahiwe *et al*., 2018). On the contrary, reduced feed efficiency as chickens get older was preferred to feed that contains all nutrients required by the chicken because improvements in feed efficiency can increase the profitability of the poultry enterprises by lowering production costs (Willems *et al*., 2013).

In this case, improved feed efficiency was the most ideal for farmers compared to high feed intake. This may be because the poultry industry prioritizes improved feed efficiency as it has the potential to reduce feed costs and nitrogen excretion (Sharma *et al*., 2018). Farmers in the current study were in favour of improved live weight compared to reduced feed efficiency as chickens get older since good returns can be achieved if chickens are sold at an optimal market weight (Wang *et al*., 2012). Concerning low mortality rate in comparison to reduced feed efficiency as the chickens get older, the farmers were significantly in favour of achieving low mortality rate. The reason could be that low mortality rate in livestock enterprises diminishes negative cash flow from broiler operating activities (Razzaque *et al*., 2009). Moreover, in the aforementioned study, it was reported that farmers with low mortality rates could potentially achieve high profits. On the other hand, Altahat *et al*. (2012) revealed that high mortality rates are associated with lower profitability in poultry production. Concerning broiler nutrition, the respondents were significantly willing to adopt the alternative chicken feeds made from amaranthus and sorghum diets if it will contain all nutrients required by the chickens compared to high feed intake. This may be because nutritional components are crucial as they ensure optimal performance in terms of feed conversion ratio, live weight and high meat yield (Olushola, 2011). High feed intake does not necessarily mean that the feed contains all the necessary nutrients required by the chickens. Therefore, it is not surprising that the farmers were in favour of chicken feed that contained all the necessary nutrients even if the feed intake was low. Moreover, feed intake could be reduced if the energy levels in chickens are higher than what is required while chicken live weight improves when chickens are fed with correct diets (Leeson & Summers, 2001). In addition, improved chicken live weight was more preferred than energy levels per kilogram (kg) weight gain attribute. Bigger chickens in broiler production are desired because the weight of the chicken (average chicken live weight in the current study was 1.9 kg) influences farmers' profit margins (Assan, 2013). In support, Gueye *et al*. (1998) discovered that the price of chickens largely depends on the chicken body weight. It is not surprising for chicken live weight to influence farm returns because bigger chickens generate more profit through the cost price. Higher profits are achievable when broiler enterprises meet the required market weight of broilers at six (6) weeks.

6.3.2 Affordability Attributes

On average, the study discovered that a majority (90.0%) of broiler farmers in Gauteng province were willing to adopt the alternative chicken feeds if they were affordable. Affordability was about reducing the following: number of feedbags purchased, cost of chicken feed, price per bag of feed ingredient and feed cost by half. Reduced number of feedbags purchased (MR=1) was the most preferred affordability attribute while reduced feed costs by half attribute (MR=4) was the least. In support, Thirumalaisamy *et al*. (2016) discovered that the use of non-conventional feed ingredients made to formulate low-cost feed significantly reduced the cost of poultry feeds. In the current study, it was ideal for farmers to prefer the alternative chicken feeds that will reduce the number of feedbags purchased because it is associated with production costs. According to Mabelebele *et al*. (2011), high cost of feed is a challenge to the resource-poor and small-scale farmers. Hence, the search for alternative feed sources has become inevitable to reduce feed cost (Swain *et al*., 2014). Moreover, Friedman's test results revealed that there was a statistically significant relationship between all affordability attributes. However, the results of Wilcoxon's signed rank test showed that only two out of six paired attributes were significantly different. The findings showed that the respondents were significantly willing to adopt the alternative chicken feed if it could reduce feed costs by half compared to reducing number of feedbags per cycle. This is because farmers strive to produce broiler chicks at low cost. That could be achieved if the cost of chicken feed is low. The preference for reduced feed cost may be due to the fact the largest proportion of operational costs for poultry producers is feed (Henseler *et al*., 2013; NAMC, 2015; Machethe, 2016; Ncube *et al*., 2017). If the cost of feed is reduced, production efficiency and farm profit may increase (Samarakoon & Samarasinghe, 2012; Poultry World, 2013). Low cost of animal feed ingredients may ultimately improve the feed quality and increase production performance of broilers (Thirumalaisamy *et al*., 2019). In support of substituting conventional feed with non-conventional chicken feed made from amaranthus and sorghum, Mmanda *et al*. (2020) showed that replacement of fish meal in the diet for juvenile Nile tilapia with cattle blood, fish frames, freshwater shrimp and brewery spent yeast, reduced feed costs per kg and body weight gain. Furthermore, reduced number of feedbags purchased was significantly favoured compared to reduced cost of chicken feed attribute. This could be because purchasing few feedbags will automatically reduce the cost of feed; hence, the quantity of feedbags was more important to the farmers.

6.3.3 Accessibility Attributes

The accessibility attribute results showed that on average, four-fifth (95.3%) of the respondents considered the adoption of the alternative unconventional chicken feed if it will achieve low transport costs, be readily available and accessible at any time of the day, have easy supplier location (accessible destination) and will involve reduced distance travelled to the nearest feed store. Low transport costs (MR=1), feed accessibility at any time (MR=1) and shorter distance to the supplier location (MR=1) were the most important attributes whereas easy access to the supplier location (MR=2) was the least desired attribute. In support, Ochieng (2012) indicated that a decrease in distance travelled to the market increases the probability of feed adoption, while an increase in distance reduces the probability of adoption. According to Rathod *et al*. (2017), farmers are unlikely to adopt innovation if distance is increased. Ideally, farmers are more comfortable with a possible distance that they can easily reach on their own. When the distance to input stores is close, farmers are most likely to adopt innovation. However, the results from the research conducted by Makate *et al*. (2017) showed that distance travelled to access inputs negatively and significantly influenced adoption of sustainable agricultural practices in Southern Africa. With regards to feed accessibility at any time, farmers in the current study indicated that feed is not always available at any time. For example, unavailability of feed at the nearest feed stores forced farmers to travel longer distances in search of feed. As a result, their transactional costs are more likely to increase. In support, Gecho and Punjabi (2011) indicated that inputs are not always readily available at all times and in all places especially in rural communities. As a result, farmers in the study area preferred chicken feed stores that are in close proximity where feed are always available whenever required. Friedman's test results revealed that the relationship between accessibility attributes was not statistically significant. Because there was no significant difference found between the accessibility attributes, Wilcoxon's signed rank test was not performed.

6.3.4 Overall willingness to adopt results

The study discovered that the most important attribute preferred by the respondents to adopt the alternative chicken feed was accessibility (MR=1) followed by desired chicken attributes (MR=2) and affordability (MR=3). Farmers preferred the accessibility of chicken feed because inputs are essential elements for effective agricultural production value chain (Mtombeni *et al*., 2019). In contrast, Van den Ban *et al*. (1995) found that farmers were more interested in the cost incurred (affordability) and benefits received from the feed ingredients rather than attributes such as feed conversion ratio and live weight gains. Moreover, Friedman's test results revealed that there was a statistically significant relationship at 1% significance level between the desired, affordability and accessible attributes. However, the results of Wilcoxon's signed rank test showed that only two out of the three paired attributes were statistically significant at 1% significance level. Wilcoxon signed rank test results revealed that the respondents were significantly willing to adopt the alternative chicken feeds if they were accessible compared to achieving desired chicken attributes. For example, Khapayi and Celliers (2016) indicated that farmers that are close to the road where transport is accessible are better integrated to the markets compared to those who are not. In the current study, it was found that respondents preferred shorter distances to nearest feed stores (average distance travelled by farmers in the current study was 20 km) because they would not have to incur additional transport costs. In support, Solomon *et al*. (2011) and Yemane (2014) in Ethiopia and Olalekan and Simeon (2015) in Nigeria discovered that distance from the nearest stores affects the adoption of improved agricultural technologies. Therefore, farmers are unlikely to adopt innovation if distance is increased (Rathod *et al*., 2017). According to Salasya *et al*. (2007), farms that are located close to feed stores are able to adopt new technology due to better access to inputs, supplier location, and less transport costs.

6.3.5 Factors influencing adoption willingness

The current study found that there were positive and negative factors that influenced adoption willingness of alternative chicken feeds. The positive factors were number of chicken houses, number of chickens (carrying capacity), number of employees, number of production cycles per year, distance to the nearest feed store, average chicken live weight, anticipated chicken live weight and farm/plot size. However, only number of chicken houses, number of production cycles per annum and anticipated chicken live weight were statistically significant at 5% significance level. This shows that respondents who had more production cycles per annum achieved higher broiler production (number of chickens) and anticipated bigger chickens. On the other hand, the negative factors that influenced adoption willingness were number of feedbags utilised, mortality rate, pricing of chicken and farming experience. The number of feedbags utilised, and mortality rate were the only two factors which were statistically significant ($p \leq 0.05$). When the number of feedbags utilised per cycle increases, the mortality rate of chickens reduces. Salasya *et al*. (2007) had similar findings on distance travelled and number of livestock that had a positive impact on adoption in Western Kenya. The findings of the current study are in accordance with Selaledi *et al*. (2021) where it was also discovered that distance to feed stores and flock size positively influenced the willingness to accept yellow mealworm as chicken feed in South Africa. Massresha *et al*. (2021) however found that distance to the nearest market negatively and significantly affected the decision to adopt various agricultural technologies. The results of farm size agree with what Mengstie (2009) discovered that farm size was positively and significantly associated with the adoption of introduced soil and water conservation practices. Furthermore, the current study found that farming experience (average farming experience was nine years) negatively influenced the willingness of farmers to adopt alternative chicken feeds. In support, Machete (2016) discovered that farmers' experience had a negative impact on broiler production, broiler output, and ultimately, technical efficiency.

6.4 CHALLENGES OF BROILER PRODUCTION

The results showed that the main challenge faced by the farmers was in relation to high feed costs in broiler production which impeded 30% of the respondents from purchasing quality feed. Low quality feed at 13%, lack of access to markets at 11%, high transport costs, inadequate nutrient in feeds, low profit margins, high mortality rate and reduced live weight at 7% were the major reported challenges that hindered farmers from attaining maximum production yields. In support, Rana *et al*. (2012) indicated that farmers in Bangladesh struggled with high feed costs and credit. In addition, Machete (2016) found that lack of market access at 97.7%, high mortality rate at 81.40%, lack of funds at 47.7% and expensive feed at 39.5% were major challenges experienced by broiler farmers in Limpopo province. According to Moobi and Oladele (2012), farmers lack funds because of insufficient financial services and credit used to cover agricultural production costs. Regarding market access, Selaledi (2017) discovered similar findings to those of the current study that small-scale farmers were struggling to access markets for their chickens. However, in their study, inadequate road infrastructure and lack of transport to facilitate the transportation of produce were the constraints which contributed to lack of access to markets. According to Yemane *et al*. (2016), continuous increase in commercial poultry feed prices was one of the challenges that affected the sustainability of poultry production and expansion of small-scale farms. For example, Oluwatayo *et al*. (2011) found that high cost of feed was a challenge especially to the resource-poor and small-scale farmers. This means that high feed costs could be the major factor, if not the most important one, causing broiler operations to not progress.

6.5 REASONS WHY FARMERS REJECT ADOPTION

The results found in the current study indicated that three percent of the broiler farmers rejected the adoption of alternative chicken feeds made from amaranthus and sorghum ingredients. This may be because they were uncertain about consumers' acceptability (of chicken meat raised on amaranthus and sorghum), fear of the unknown risk, ethical and cultural values prohibited them from accepting new chicken feeds, lack of product or service knowledge, adoption perceptions and farmers' perceptions of the proposed feeds. In support, Specht *et al*. (2019) mentioned that if an innovation is not accepted, it could be due to impending adoption factors such as production methods and applied technologies, uncertain impacts, product characteristics, related target groups, ethical factors and factors related to (non-supportive) framework conditions. Furthermore, uncertainties about the potential positive impact of the alternative feed could lead to negative perceptions and hinder adoption acceptance. Some of the respondents in the study indicated that they will not adopt alternative chicken feeds if it has sorghum ingredients because it goes against their Islamic faith. Sorghum has a high starch content and is used for ethanol production, due to that, the consumption of alcohol-based food and beverages are forbidden in the Islamic religion. This is consistent with what Lekhaya (2013), and Tanko (2020) found that farmers could not adopt innovation due to cultural beliefs. Cultural beliefs can impede adoption even though some innovations can yield optimal profit (Lekhaya, 2013). Moreover, Tanko (2020) showed that cultural and religious values affect the adoption of agricultural technology. Another reason is that farmers rejected the adoption of innovation due to insufficient knowledge about alternative chicken feeds (Selaledi *et al*., 2021). These results may be explained by the fact that there is not much research on this topic in South Africa for farmers to accept the adoption of amaranthus and sorghum as energy and protein sources for chicken feeds. Hence, farmers perceive it as risky, and they are not willing to take any risks with feed that has not yet been tested.

6.6 CHAPTER SUMMARY

The main objectives of this chapter were to determine the willingness of farmers to adopt alternative chicken feeds made from amaranthus and sorghum as energy and protein sources, ascertain factors influencing farmers' willingness to adopt alternative feeds and identify the challenges experienced by broiler farmers. The results showed that majority of the farmers were willing to adopt the alternative chicken feeds if it will be accessible, affordable and achieve desired chicken attributes. The most important variable under desired attributes was improved live weight. The results of Wilcoxon sign rank test discovered 11 significant paired variables for desired chicken attributes. The first four paired significant attributes were: improved feed efficiency-reduced feed efficiency as chickens get older, improved energy levels per kg weight gain-reduced feed efficiency as chickens get older, improved feed intake- reduced feed efficiency as chickens get older and feed efficiency as chickens get older-contains all nutrients required by the chicken. The second four paired attributes were: improved feed efficiency-high feed intake, improved live weight-reduced feed efficiency as chickens get older, low mortality rate-reduced feed efficiency as the chickens get older and contains all nutrients required by the chicken-high feed intake attribute. The last three paired significant attributes were: improved live weight-high feed intake, improved live weight-improved energy levels per kg weight gain and improved live weight-contains all the nutrients required by the chicken attributes.

Under affordability, the most important attribute was reduced number of feedbags utilised. The results of Wilcoxon sign rank test indicated only two paired significant affordability variables. The two variables were: reduced number of feedbags purchased-reduced cost of chicken feed and reduced feed costs by half-reduced number of feedbags purchased. With regards to accessibility, lower transports costs, feed accessible at any time and accessible supplier location attributes were considered important. The overall results that compared farmers' willingness to adopt alternative chicken feeds using three main variables (desired chicken attributes, affordability and accessibility), showed that accessibility of chicken feeds was the most important adoption determinant.

The results of OLR discovered that the number of chicken houses, number of production cycles per year and of chickens and anticipated chicken live weight were positive and significant predictors of farmers' willingness to adopt alternative chicken feeds. On the other hand, mortality rate and number of feedbags utilised significantly influenced farmers' willingness to adopt alternative chicken feeds, but the influence was negative. However, some farmers were adamant about alternative chicken feeds made from amaranthus and sorghum because they believed that it would not help reduce feed costs. In addition, some of the farmers feared uncertain risks which may come with the proposed substitute feed, they also had adoption perceptions and other related concerns. Moreover, the respondents indicated that high feed costs coupled with other challenges was the major challenge which impeded them from maximising their broiler production potential.

CHAPTER 7

7 CONCLUSION AND RECOMMENDATIONS

7.1 INTRODUCTION

The purpose of this chapter is to make conclusions and provide recommendations based on the findings of the study. The study aimed to assess the acceptability of alternative chicken feeds made from amaranthus and sorghum. The study focused on the following objectives:

i. To profile farmers' socio-demographic characteristics.
ii. To determine the operation and production characteristics of broiler enterprises.
iii. To determine farmers' willingness to adopt alternative chicken feeds made from amaranthus and sorghum as energy and protein sources, respectively, and influencing factors.
iv. To identify the challenges experienced by broiler farmers.

7.2 CONCLUSION

Based on the key findings related to the objectives of the study, the conclusions drawn are presented between sections 7.2.1 and 7.2.5.

7.2.1 Socio-demographic characteristics

The study found that a majority of broiler farmers were married Black African males above 50 years of age with an average farming experience of nine years. Thus, broiler farmers in the study area had adequate farming experience; however, youth participation was low because less than 20% of the respondents were between 18 and 35 years old. Again, the findings indicated that broiler farming was highly transformed from racial affiliation perspective. However, gender wise, this was not the case because the study discovered that male farmers were dominating. It was discovered that more than four-fifth (94%) of the respondents had formal education (primary to university level); most farmers could read and write because they had basic education. The socio-economic characteristics findings revealed that half (50%) of the respondents privately owned their farmland with an average size of 11.17 ha. The results implied that most poultry farmers in the study area had adequate land ownership; therefore, they could invest in farm infrastructure and use land as collateral to access funding from financial institutions. From income perspective, the study found that majority (64.4%) of the respondents relied on non-farming activities to earn a living and the amount generated from farming activities was between R10 001 and R90 000 per annum. It showed that most farmers generated insufficient net farm income that could not sustain their livelihood. As a result, farmers had off-farm income from different sources to supplement their net farm income, and ultimately sustain their livelihood. Because net farm income is important in farming, Ordered Logistics Regression (OLR) performed discovered that gender, carrying capacity of chicken houses and number of production cycles per annum positively and significantly influenced annual net farm income. It was concluded that male farmers, farmers with more production cycles per annum and chicken houses with high carrying capacity made more profit from broiler farming.

The null hypothesis was that socio-demographic characteristics (age, farming experience, gender, education level, number of production cycles, feed costs, net income, size of poultry structure, numbers of birds per cycle, mortality rate and weight of live birds) do not positively influence the willingness of poultry farmers to adopt alternative feeds made from amaranthus and sorghum. The decision about the null hypothesis is as follows:

- Age: accept
- Gender: reject
- Type of land occupation: accept
- Farming experience: accept
- Farm/plot size: accept
- Number of chicken houses: accept
- Carrying capacity per house: reject
- Distance to feed store: accept
- Government-subsidised feed: accept
- Number of production cycles per year: reject
- Number of feedbags utilised per cycle: accept
- Average live weight: accept
- Mortality rate: accept
- Chicken price: accept

The results for access to market, extension services and government subsidised feeds showed that a large percentage (84%) of the respondents had no access to market. In addition, 81% of the farmers did not receive subsidised chicken feed from government while 54% of the respondents indicated that they had no access to extension services. This implied that most broiler farmers did not benefit from government support services. Moreover, access to reliable market was a challenge for most broiler farmers.

7.2.2 Operations of the broiler enterprises

The study found that on average, the number of people employed by the respondents was two; thus, that broiler farming created few employment opportunities in the study area. On average, the farmers had two chicken houses which accommodated about 1 804 birds with 7.3% mortality rate per cycle. The findings implied that broiler farmers in the study area were involved in small-scale broiler production and achieved chicken mortality rate higher than the average South African mortality rate (6%). The average number of feedbags per production cycle and production cycles per annum were 112 and five (5), respectively. It showed that broiler farmers in the study area had resting periods between production cycles. The type of chicken feed preferred by majority (73%) of the respondents was pellet diets compared to mash and crumbles. Again, on average, the respondents travelled 20 km to purchase chicken feed from their nearest feed stores. This shows that feed stores that sell pellet feed preferred by most farmers were accessible, from distance point of view. Moreover, the average chicken live weight achieved by the respondents was 1.9 kg sold at R56.00 per live chicken. However, the respondents anticipated to achieve 2.0 kg chicken live weight from the new feeds. It meant that respondents anticipated a higher chicken live weight from the alternative chicken feeds. Therefore, the new chicken feeds should enable farmers to achieve an average chicken live weight above 1.9 kg.

The correlation results showed that the number of chicken houses had positive and statistically significant relationship with the carrying capacity of the farm, number of employees, production cycles per year and the number of bags of feed purchased per cycle. Therefore, large-scale broiler farmers produced more chickens continuously throughout the year; as a result, they were able to create employment opportunities. The carrying capacity of chicken houses was found to be positively and significantly correlated with number of employees, number of production cycles, number of feedbags purchased and average live weight of chickens at six weeks of age. The findings implied that farmers whose chicken houses had high carrying capacity created more employment opportunities (jobs) because they were in production for the most part of the year. In addition, they achieved high chicken live weight because they utilised more feedbags. It was found that average live weight has positive and statistically significant correlation with the price of chickens. Farmers with bigger chickens sold them at higher prices. However, mortality rate had negative and statistically significant correlation with the number of chicken houses. In conclusion, farmers with few chicken houses experienced low mortality rate.

7.2.3 Farmers' willingness to adopt the alternative chicken feeds

The research found that majority (90%) of broiler farmers in Gauteng province were willing to adopt alternative chicken feeds made from amaranthus and sorghum as energy and protein sources, respectively. Therefore, there is a high demand for alternative chicken feeds amongst broiler farmers in the study area. The overall results of the mean rank showed accessibility of chicken feed (MR=1) was the most important attribute associated with the adoption of the alternative chicken feeds, followed by desired chicken attributes (MR=2) and affordability (MR=3). The results of Friedman's test revealed that there was a statistically significant difference ($p<0.01$) between the three variables (desired attributes, affordability and accessibility). A Post-hoc test performed using Wilcoxon sign rank test discovered that the pairing of accessibility and desired attributes; and accessibility and affordability was statistically significant ($p<0.01$). The conclusion was that farmers were more willing to adopt the alternative chicken feeds made from amaranthus and sorghum if it was more accessible than achieving desired chicken attributes. In addition, broiler farmers were willing to adopt the alternative chicken feeds if it was more accessible rather than affordable.

According to the mean rank outputs, the most important variable of accessibility that influenced farmers' willingness to adopt the alternative feeds was lower transport costs to buy feed, feed accessible at any time of the day and supplier location is easily accessible attributes, which ranked the same (MR=1). The second most important accessibility variable was short distance to the market. About desired chicken variable, the conclusion drawn from the mean ranks was that improved live weight was the most important attribute. Chicken live weight was followed by the following attributes: low mortality rates, availability of all nutrients required by chicken, improved feed efficiency, improved energy levels per kg weight gain, high feed intake, and reduced feed efficiency as chickens get older as the least important attribute. From affordability perspective, the most important variable that influenced the adoption of the alternative chicken feed was reduction of feedbags utilised, followed by reduction of the following variables: cost of chicken feed, price per bag of feed ingredient and feed cost by half.

7.2.4 Factors influencing farmers' willingness to adopt alternative feeds

It was discovered that the number of chicken houses, number of production cycles per annum and anticipated chicken live weight positively and significantly influenced the willingness of farmers to adopt the alternative chicken feeds made from amaranthus and sorghum as energy and protein, respectively. In conclusion, farmers who had more chicken houses, were in production for the most part of the year and anticipated high chicken live weight. They were also willing to adopt the alternative chicken feeds made from amaranthus and sorghum as sources of nutritional components (energy and protein).

7.2.5 Challenges experienced by broiler farmers

The results showed that high feed cost was the main challenge farmers faced in broiler production which impeded 30% of the respondents from purchasing quality feed. Other challenges were low quality feed (13%) and lack of access to markets (11%). Some other challenges were high transport costs, inadequate nutrient in feeds, low profit margins, high mortality rate and reduced live weight at 7%. In addition, long distance to feed store, limited government intervention and reduced production cycles at 6%, lack of transport to purchase feed, inconsistent feed quality, lack of nutritional/ingredient information on feedbags at 4%; and lack of participation in the pricing of feed. Also, lack of feed subsidy, purchasing feed on credit, unavailability of feed during certain periods, high cost of production inputs at 3% were some of the challenges that hindered farmers from attaining maximum production yields. This implied that most farmers encountered some, if not all the production problems. These challenges mostly affect their broiler production and as a result, they affect the future growth of the poultry industry.

7.3 RECOMMENDATIONS

The following recommendations were made based on the findings of the study:

i. To secure the future of livestock production in Gauteng province, young people between ages18 and 35 should be encouraged to participate in farming activities because presently, just a few of them are involved in broiler farming.

ii. The net farm income of broiler production increased significantly when broiler farmers had chicken houses with high carrying capacity and production cycles per annum; thus, it is suggested that farmers should expand their production to generate more net farm income.
iii. The level of education of broiler farmers was found to correlate with farm/plot size; thus, it is recommended that farmers should acquire more education in order to increase their chances of owning land privately.
iv. The results however indicated that not all the farmers have access to government services and market access, thus, it is recommended that farmers get sufficient government services and markets to succeed in their agricultural activities.
v. Since broiler farmers hire two employees on average, it is recommended that farmers increase their carrying capacity (number of chickens) to employ more people.
vi. To increase the adoption rate of alternative chicken feeds, it is recommended that the new chicken feeds made from amaranthus, and sorghum be accessible.
vii. The findings showed that most broiler farmers were willing to adopt alternative chicken feeds made from amaranthus and sorghum. Thus, it is recommended that the feed manufacturers explore alternative non-conventional chicken feed made from amaranthus as a source of energy and sorghum as a source of protein.
viii. Since the number of chicken houses and production cycles per annum was a significant predictor of farmers' willingness to adopt alternative chicken feeds, it is recommended that chicken feeds made from amaranthus, and sorghum should target large-scale farmers who are constantly in production.
ix. Anticipated chicken live weight significantly influenced farmers' willingness to adopt alternative chicken feeds made from amaranthus and sorghum as energy and protein sources; it is recommended that the alternative chicken feed improves chicken live weight achieved by broiler farmers.
x. The results showed that high feed costs was the main challenge farmers experienced in broiler production. Thus, it is recommended that the new non-conventional feed made from amaranthus, and sorghum be affordable.
xi. There is a need to conduct an experiment to compare the performance of broiler chickens fed with amaranthus and sorghum as energy and protein sources against conventional feed made from maize and soybeans.

xii. Since the research is continuous, it is recommended that further research be conducted to determine the cost required to produce unconventional broiler chickens using Amaranthus and Sorghum as energy and protein sources, respectively.

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APPENDIX 1: RESEARCH QUESTIONNAIRE FOR FARMERS

RESEARCH TOPIC: **THE WILLINGNESS OF BROILER FARMERS IN THE GAUTENG PROVINCE OF SOUTH AFRICA TO ADOPT ALTERNATIVE FEEDS MADE FROM AMARANTHUS AND SORGHUM**

GENERAL INFORMATION

QUESTIONNAIRE NUMBER	
DATE OF INTERVIEW	
NAME OF MUNICIPALITY	

A. DEMOGRAPHIC INFORMATION

NO	**Demographic Information**	**Code**	**Answer**
1	Age group	1= 18-35 2= 36-45 3= 46-55 4= 56-65 5= >65	
2	Gender	0=Male 1=Female	
3	Race	1 = African 2 = White 3 = Coloured 4 = Indian 5 = Other (Specify)	
4	Marital Status	1 = Single 2 = Married 3 = Divorced 4 = Widow 5= Cohabitation 6 = Other (specify)	
5	Level of Education	1=Never been to school 2=No formal Education 3=Primary Education 4=Secondary Education	

		5=College Education 6=University Education 7=Other (Specify)	

B. SOCIO–ECONOMIC CHARACTERISTICS

NO	Characteristics	Code	Answer
6	Type of land occupation	1 = Inherited (freely acquired) 2 = Land tenure (communal/ government land) 3 =Rented/ Leased 4 =Purchased (freehold) 5 =Other (Specify)	
7	Farming experience	Number of years	
8	Farm/plot size (ha)	Indicate the actual size	
9	Number of chicken houses	Number	
10	Number of chickens per farm (Carry capacity)	Number	
11	Main source of income	1 =Employed 2 = Self-employed 3 =Social grant 4 =No income 5 =Farming 6 =Other (Specify)	
12	Number of employees	Number	
A	Full-time employees	Number	
B	Part-time employees	Number	
13	Distance to the nearest feed store	Km	
14	Are you receiving government subsidised feed?	0=No; 1= Yes	
15	Access to extension services	0=No; 1= Yes	
16	Access to formal market	0=No; 1= Yes	
17	Net income in the previous year	Amount (R) ‘000 1 = <10 000 2 = 10 001-30 000 3 = 30 001-90 000 4 = 90 001-120 000 5 =>120 000	

C. PRODUCTION FACTORS

18	Number of production cycles per year	Number	
19	Number of feedbags utilised per cycle	Number	
A	Starter	Number	
B	Grower	Number	
C	Finisher	Number	
20	Average live weight of birds (chickens)	Weight in kg/bird	
21	Anticipated weight of the birds using the proposed alternative feeds made from amaranthus and sorghum as energy and protein source	Weight in kg/bird	
22	What is the mortality rate of the chickens in percentage (%)	%	
23	Price of one chicken	Amount (R)	
24	**Preferred form of feed during the following growing phases:**		
A	Starter	0 = Mash 1=Crumbled 2= Pellet 3= None	
B	Grower	0 = Mash 1=Pellet 2 = Crumbled 3=None	
C	Finisher	0 = Mash 1=Pellet 2= Crumbled 3=None	

D. WILLINGNESS TO USE ALTERNATIVE CHICKEN FEEDS

	Question	Will not consider 1	Might consider 2	Will consider 3	Answer (Office use only)
25	**Your willingness to adopt alternative (new) chicken diet made of sorghum and amaranthus if it can give you the following desired traits in six week:**				
a	Improved feed efficiency				
b	Improved energy levels per kg weight gain				
c	Reduced feed efficiency as chickens get older				
d	Improved feed intake				
e	Contains all nutrients required by chicken				
f	Improved live weight				
g	Low mortality rates				
26	**Your willingness to adopt alternative (new) chicken diet made of sorghum and amaranthus if it is affordable ……..**				
a	Reduced price per bag of feed ingredient				
b	Reduced cost of chicken feed				
c	Reduced number of bags of chicken feeds purchased				
d	Reduce the feed costs by half				
27	**Your willingness to adopt alternative (new) chicken diet made of sorghum and amaranthus if it is accessible………….**				
a	Short distance to the market				
b	Lower transport costs to buy feed				

c	Feed accessible at any time of the day				
d	Supplier location is easily accessible				
28	Willingness to adopt (Overall)				

F. GENERAL QUESTIONS

29. What are the challenges you have experienced thus far with regards to broiler production?

THANK YOU FOR YOUR PARTICIPATION

APPENDIX 2: PARTICIPANT INFORMATION SHEET

CAES Ethics clearance reference number: **2019/CAES_HREC/170**

31 January 2022

TITLE: THE WILLINGNESS OF GAUTENG POULTRY FARMERS TO ADOPT ALTERNATIVE CHICKEN FEEDS

Dear prospective participant,

My name is Motlatso Shee Marape and I am conducting a research with Prof. M. Mabelebele, a Professor in the Department of Agriculture and Animal Health towards a Master’s degree in Agriculture at the University of South Africa and Mr. M.S. Maake, a Senior Lecturer in the Department of Agriculture and Animal Health towards a master’s degree in agriculture at the University of South Africa. We are inviting you to participate in a study entitled the willingness of Gauteng poultry farmers to adopt alternative chicken feeds.

WHAT IS THE PURPOSE OF THE STUDY?

The purpose of the study is to assess farmers’ acceptability of alternative chicken feeds made from sorghum and amaranthus.

WHY AM I BEING INVITED TO PARTICIPATE?

I chose you to participate in the study because you are a broiler farmer in Gauteng province. Your personal information was received from the Gauteng Department of Agriculture and Rural Development. The approximate number of participants targeted is 95 households.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

For you to participate in this study, you are required to do the following:

- Consent before participating in the study;
- Participate in telephonic interviews conducted by the researcher; and/or complete the research questionnaire; and

- Not to provide your real name during the interviews or completion of the survey questionnaire.

The questionnaire will include general questions, demographic information, socio-economic characteristics, broiler production factors, willingness to use alternative chicken feeds attributes and challenges you have experienced thus far with regards to broiler production. The expected time needed to complete the questionnaire is about 20 minutes. It will take about 15 minutes to conduct the interview, if you prefer to be interviewed.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you decide to take part, you will be given a call to go through this information sheet and be asked whether you consent to participation or not. You are free to withdraw at any time and without giving a reason. Participants will participate purely by choice and participants will be free to withdraw at any time without providing reasons for their decision. Confidentiality will be observed professionally, and participants' identity will not be revealed. The names of the participants will not be included in the research publications emanating from the study.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

The potential benefits of taking part in this study are:

- It will help to determine the operation and production characteristics of broiler enterprises;
- It will also help to determine farmers' willingness to adopt the alternative chicken feeds made from amaranthus and sorghum as energy and protein sources;
- It will help to ascertain factors influencing farmers' willingness to adopt alternative feeds made from amaranthus and sorghum as energy and protein sources;
- The outcome of the study will play a significant role in the development of new alternative chicken feeds made from amaranthus and sorghum that will assist in feed cost reduction and improve chicken live weight in Gauteng province.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

There are no foreseeable physical risks associated with this study. The interviews conducted will not include emotional or sensitive questions.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

Confidentiality will be observed professionally, and identity of participants will not be revealed. The names of the participants will not be included in the research publication. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Electronic information of your answers will be stored on a password protected computer by the researcher. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. The electronic copies will be permanently deleted from the hard drive of the computer by using a relevant software programme after a period of five years.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

No payment or reward is offered for participating in this study.

HAS THE STUDY RECEIVED ETHICS APPROVAL?

This study has received written approval from the Research Ethics Review Committee of the College of Agriculture and Environmental Sciences (CAES) Ethic Committee, UNISA. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Motlatso Shee Marape on 076 725 2478 or e-mail marape.shee@gmail.com ; the findings are accessible for a period of five years. Should you require any further information or want to contact the researcher about any aspect of this study, please contact Prof. M. Mabelebele on 011-471-3983; e-mail at mabelm@unisa.ac.za ; and Mr. M.S Maake on 011-471-3103; email at maakems@unisa.ac.za

Should you have concerns about the way in which the research has been conducted, you may contact the research ethics chairperson of the College of Agriculture and Environmental Sciences (CAES) Ethics committee, Prof MA Antwi on (011) 670-9391 or e-mail at antwima@unisa.ac.za , if you have any ethical concerns.

Thank you for taking time to read this information sheet and for participating in this study.

Motlatso Shee Marape

APPENDIX 3: CONSENT TO PARTICIPATE IN THE STUDY

I, __________________ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to telephonic interview responses in the research questionnaire.

Participant Name & Surname………………………………………… (please print)

Participant consent agreement ………………………..……Date…………………

Researcher's Name & Surname……………………………………… (please print)

Researcher's signature…………………………………………. Date……………