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The Potential of *Moringa oleifera* as a Sustainable Broiler Feed Additive: Investigating Awareness, Perceptions and Use by Broiler Farmers and Moringa Farmers in South Africa

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Abstract: *Moringa oleifera*'s high nutritional value and bioactive properties have attracted significant scientific research interest as an additive in broiler feed for sustainable broiler production. The tree's multifunctional characteristics make it a potent alternative growth promoter for broilers and a valuable resource to address Sustainable Development Goals related to poverty alleviation, food security, good health, and responsible consumption. Moreover, it provides a less expensive and environmentally friendly alternative for broiler farmers. However, less is known about the awareness, perceptions, and prevailing practices of broiler farmers and *M. oleifera* farmers regarding the plant's use as an additive. This study determined the awareness, perceptions, and practices of *M. oleifera* use among broiler and *M. oleifera* farmers in South Africa. Quantitative data collected from 165 purposively sampled small-scale broiler farmers, along with qualitative insights from 11 key informants, indicated that 66.7% of respondents, primarily females, knew about *M. oleifera* but lacked awareness of its benefits for broilers (82.4%). Awareness varied significantly ($p < 0.05$) by gender. Only 10.9% of those aware used *M. oleifera*, predominantly small-scale female farmers. Leaves and stems were common parts used, added to feed, or infused in water. Perceived benefits included improved growth rates and reduced mortalities. Large-scale broiler farmers expressed interest if provided with more information on the nutritional benefits and the availability of bulk *M. oleifera* to sustain their large operations. The study underscores the need for targeted awareness campaigns, especially among female farmers, and providing guidelines for *M. oleifera* use. Formulating broiler diets that include *M. oleifera* as an ingredient will require a consistent supply, which is currently lacking. Therefore, there is a need to address the production capacity to meet the requirements of larger broiler operations.

Keywords: antibiotics; growth promoters; broilers; natural alternatives; sustainable production

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1. Introduction

Broiler meat plays a significant role in meeting the growing global demand for animal protein. In South Africa, broiler production plays a crucial role in ensuring food security and contributing to economic growth and employment opportunities, which helps to reduce poverty and improve livelihoods [1]. While playing a significant role in economic growth and food security, the broiler industry faces an array of challenges including diseases, rising feed costs, and environmental concerns. One challenge that has gained significant attention is the ongoing debate surrounding the use of antibiotics for growth promotion. Over the years, antibiotics have played a crucial role in enhancing health

and promoting growth, thereby boosting production in the broiler industry [2]. However, there have been public health concerns that if overused in broiler production, antibiotic growth promoters (AGPs) could potentially contribute to the emergence and spread of antimicrobial resistance (AMR). South Africa has put measures in place for farmers to withdraw antibiotics from broiler diets prior to slaughter to allow time for the residues to be metabolised and flushed out of the system, making the broilers safe for human consumption. However, monitoring compliance with this guideline, particularly among small-scale farmers, could be challenging [3]. Moreover, using antibiotics is expensive, especially for resource-limited small-scale farmers. Therefore, there is a need to find affordable natural alternatives that are environmentally friendly.

Moringa oleifera is one plant that has shown significant potential as a natural growth promoter in broiler diets. *M. oleifera* possesses an excellent range of antimicrobial and antioxidant properties attributed to its high content of bioactive compounds, including flavonoids and phenols [4–6]. Compounds found within *M. oleifera*, like kaempferol and quercetin, possess anti-inflammatory properties and immunomodulatory effects, meaning they can regulate and enhance the immune system's response. The leaf powder is rich in essential amino acids, minerals, and vitamins, including vitamin B complex, vitamin C, pro-vitamin A as beta-carotene, vitamin K, and manganese, that are essential for growth [7–9]. A study by [10] reported that the predominant minerals in moringa leaf powder included calcium, magnesium, potassium, iron, and copper at 20.32, 387.83, 1545.33, 26.69, and 0.83 mg/100 g, respectively. On a dry weight basis, the protein content in moringa leaves ranges between 24 and 30 g per 100 g of dry matter [11,12]. Scientific evidence confirms that dietary inclusion of *M. oleifera* at levels lower than 5% of the total dry matter intake can improve growth performance, animal health, feed conversion ratio, and meat quality [5]. Incorporating *M. oleifera* into broiler diets has been reported to reduce the cost incurred per kilogram of weight gain for birds compared to incorporating antibiotics [13]. There is still a gap in studies that have conducted cost–benefit analyses of incorporating *M. oleifera*. Hence, there remains a need for additional research exploring the cost–benefit aspects of using moringa in various applications.

While several studies have focused on the scientific benefits of *M. oleifera* for broilers, little to no effort has been made to understand if farmers are adopting moringa as an alternative growth promoter. Addressing this knowledge gap is crucial in helping to identify the practical challenges and attitudes of farmers when it comes to adopting *M. oleifera* in their broiler production practices. Understanding whether and how farmers are incorporating *M. oleifera* in their broiler feeding strategies can provide valuable information for designing effective outreach, extension, and educational programs to promote the sustainable and optimized use of *M. oleifera* in broiler production. Additionally, this research can shed light on potential barriers or misconceptions that may hinder the wider adoption of *M. oleifera* as an alternative growth promoter.

2. Materials and Methods

2.1. Study Site Description

The study was carried out in the Limpopo and Gauteng provinces of South Africa. Limpopo and Gauteng were chosen for the study because they are the primary *M. oleifera*-producing areas in South Africa [14]. It was convenient for broiler farmers to be sampled from the same provinces. The participants of the study were only broiler and *M. oleifera* farmers.

The specific study areas were Makhado, Sekhung, HaMulima, and Randfontein Municipality. These specific study areas were selected based on the availability of extension officers to facilitate meetings with farmers.

2.2. Sampling Method and Data Collection

Ethical clearance (reference number NAS291/2022) to conduct the study was granted by the University of Pretoria Natural and Agricultural Sciences Ethics Committee. Ethical considerations were observed during and after the data collection period.

2.2.1. Broiler Farmer Data Collection

Data was collected using structured questionnaires. To validate the broiler farmer questionnaire, a draft version of the questionnaire was pre-tested using a subset of broiler farmers from Sekhung (one of the study areas). During this process, efforts were made to identify and categorise any information that was missing from the initial questionnaire draft. The questionnaire was divided into two sections. Section A focused on demographic variables, including age, gender, location of farm, level of education, marital status, and employment status, while Section B had questions on knowledge, awareness and practices relating to *M. oleifera* use. A Likert scale ranging from 1—"not at all"—to 5—"extremely knowledgeable or extremely aware"—was used to rate knowledge of *M. oleifera* and awareness of the benefits of *M. oleifera*.

Broiler farmers were purposively selected from the broiler farmers' database by extension officers from the Department of Agriculture in the respective study locations. These farmers were invited to attend information sessions held on different days across the various study areas, during which the questionnaires were disseminated. Only farmers who indicated willingness to participate and signed the informed consent form were considered for the study. A total of 165 small-scale broiler farmers participated in the study. Although the study was primarily focused on small-scale producers, additional insights were obtained through direct communication with large-scale broiler producers who possess expertise in feed formulation and have extensive industry experience. While the sample size of this group was limited, the insights gathered were considered valuable for this study.

2.2.2. *M. oleifera* Farmer Data Collection

Open-ended interviews were conducted to collect data from eleven key informants with extensive knowledge and experience in *M. oleifera* production. These key informants were identified using a snowball approach of sequential referrals. The inclusion criteria for participation required that participants had at least 100 *M. oleifera* trees on their farms. Each key informant was visited and interviewed individually at their respective farms. The research team consisted of 2 males and 2 females with previous experience in conducting interviews. Participants were provided with information about the purpose of the research, including the benefits and risks of participation. Respondents were assured of their right to withdraw from study participation at any point, and necessary precautions were taken to ensure and maintain confidentiality throughout the study. An interview guide with questions about the number of years involved in *M. oleifera* production, production constraints, and knowledge about the benefits of *M. oleifera* for broilers was used.

2.3. Statistical Analysis

2.3.1. Quantitative Data

Data from the broiler farmer survey were analysed statistically using the Statistical Package for Social Sciences (SPSS) version 22 (IBM SPSS Statistics for Windows). Descriptive statistics were used to generate frequencies of response and means. The logistic regression model was used to determine the effect of farmers' demographic characteristics on the use of *M. oleifera* in broiler feeding. The model parameters were estimated with maximum likelihood estimation technique. Binary logistic regression is a statistical technique used to estimate the probability of a dichotomous dependent variable, based on explanatory variables that are hypothesized to influence the outcome. In the current study, the dependent variable is the use or non-use of *M. oleifera*. Binary response (Yes or No)

to the use of *M. oleifera* in broiler feeding was specified as the dependent variable in the model. The binary regression model is specified below:

$$Y_i = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5 X_5 + e$$

where:

Y_i = Use of *M. oleifera* (1 = Yes, 0 No)
X_1 = Age
X_2 = Gender
X_3 = Level of education
X_4 = Marital status
X_5 = Type of broiler ownership
b_0 = Intercept
e = Error term

To ensure that statistical inferences made from the model are reliable and accurate, multicollinearity was determined, and the values were found to be within the accepted norms (tolerance not less than 0.1 and variance inflation factor of not more than 10). The Hosmer–Lemeshow test was not significant ($p > 0.05$), meaning that the model was a good fit for the observed data. One-way ANOVA was used to assess differences in broiler farm sizes across different locations. Fisher's exact test was employed to test for associations between demographic variables and awareness of the benefits of *M. oleifera* in broilers. Fisher's test was the most suitable because more than 20% of cells in the contingency table appeared to have frequencies <5. In such cases, Fisher's exact test is appropriate to use [15]. Statistical significance was set at $p < 0.05$. The null hypothesis was that there is no significant difference in the awareness of *M. oleifera* by farmers based on age, gender, level of education, marital status, location, and type of broiler ownership. Since only few large-scale producers participated in the study, their findings were used for commentary in the discussion due to insufficient data for quantitative statistical analysis.

2.3.2. Qualitative Data

Interview data was analysed following an inductive approach, applying the six-step thematic analysis proposed by [16]. Audio recordings were first transcribed and anonymised. The transcripts were read several times to identify emerging themes and sub-themes until no further themes emerged, which suggested that major themes had been identified and data saturation had been reached. Two research assistants coded transcripts independently, and the themes that emerged from their coding were compared with those found by the primary researcher as quality check and ensuring inter-reliability. The discussed themes were supported by verbatim text extracted from the transcripts. Descriptive statistics were used to describe the interviewed participants characteristics.

3. Results

3.1. Results

3.1.1. Household Demography

The majority of the respondents across the three study sites were made up of females (67.3%) (Table 1). More than half (56.2%) of the respondents were between 20 and 50 years of age. Most of the respondents had a high school education (56.4), were self-employed (72.1%), and depended on broiler sales as their main source of income (96.4%). The mean number of broilers per cycle in Randfontein was significantly ($p < 0.05$) different from the other study areas (Table 2).

Table 1. Demographic information of the participants in the study areas.

Characteristic	Location of Farm			
	HaMulima (%) *n* = 37	**Makhado (%) *n* = 52**	**Sekhung (%) *n* = 40**	**Randfontein (%) *n* = 36**
Gender				
Male	37.8	23.1	35	33.3
Female	62.2	76.9	60	66.7
Prefer not to mention	0	0	5	0
Total	100	100	100	100
Age				
20–40	21.6	42.3	42.5	19.4
41–50	18.9	38.5	10	19.4
51–60	21.7	15.4	30	30.6
>60	37.8	3.8	17.5	30.6
Total	100	100	100	
Level of Education				
Primary school	18.0	0	12.5	2.8
High school	51.0	57.7	60	55.6
Certificate	8.0	9.6	7.5	0
Diploma	14.9	23.1	10	16.6
Bachelor's	2.7	7.7	7.5	22.2
Prefer not to mention	2.7	0	0	2.8
No formal education	2.7	1.9	2.5	0
Total	100	100	100	100
Employment status				
Employed—full time	2.7	5.8	10	0
Employed—part time	2.7	0	2.5	0
Unemployed	18.9	11.6	0	19.4
Self-employed	54.1	76.9	75	80.6
Seeking opportunities	2.7	3.8	7.5	0
Retired	18.9	1.9	5	0
Total	100	100	100	100
Marital status				
Married	51.4	44.2	52.5	44.4
Not married	48.6	55.8	47.5	52.8
Prefer not to mention	0	0	0	2.8
Total				

Table 2. Average number of broilers per cycle in different locations.

Location	Test of Homogeneity of Variance				ANOVA	
	Means	**±Std. Error**	**Levene's Statistic**	**Sig.**	**F**	**Sig.**
HaMulima	338.46	34.234	10.284	0.001	13.056	0.001
Makhado	258.11	27.366				
Sekhung	360.00	73.798				
Randfontein	922.22	154.258				
Location differences						
Locations	Mean difference	Sig.				
HaMulima-Randfontein	−664.114 *	0.001				
Makhado-Randfontein	−583.761 *	0.004				
Sekhung-Randfontein	−562.222 *	0.011				

* The mean difference is significant at $p < 0.05$.

3.1.2. Knowledge about the *M. oleifera* Tree and Source of Knowledge

The results showed that 33.9% of the respondents did not know about the *M. oleifera* tree (Table 3). The knowledge of *M. oleifera* differed significantly ($p < 0.05$) according to gender and location (Table 4). Among the respondents who were knowledgeable about the *M. oleifera* tree, 56.89% cited their sources of knowledge as the community and family, while 25.86%, 15.52%, and 1.72% acquired their knowledge of the *M. oleifera* tree form the media, workshops, and extension services, respectively (Table 5). The majority of the respondents (82.4%) were not aware of the benefits of *M. oleifera* in broiler chickens (Figure 1). Awareness differed significantly ($p < 0.05$) according to gender (Table 6).

Table 3. Respondents' knowledge of the *M. oleifera* tree.

Knowledge about the *M. oleifera* Tree	**Location (%)**				
	HaMulima	**Makhado**	**Sekhung**	**Randfontein**	**Total**
Not at all	51.4	17.3	25	13.9	33.9
Slightly know	29.7	36.5	32.5	44.4	24.8
Somewhat know	13.5	15.4	0	8.3	7.3
Moderately know	2.7	21.2	27.5	22.2	21.8
Extremely know	2.7	9.6	15.0	11.1	12.1

Table 4. Effect of location, gender, level of education, marital status on knowledge of *M. oleifera*.

Variable	**Likelihood Ratio**	**Degrees of Freedom**	***p*-Value**
Age	19.755	12	0.144
Gender	14.503	8	0.022 *
Location	33.480	12	0.003 *
Level of education	35.398	24	0.055
Marital status	7.791	8	0.346
Type of broiler ownership		8	0.320

* Significant at $p < 0.05$.

Table 5. Respondents' sources of knowledge about *M. oleifera*.

Source	**Location (%)**				
	HaMulima	**Makhado**	**Sekhung**	**Randfontein**	**Total (%)**
Media	22.7	34.9	10	38.9	25.86
Extension service	0	0	5	2.8	1.72
Workshop	13.6	6.9	22.5	27.8	15.52
Community	36.4	39.5	27.5	22.2	35.34
Family	27.3	18.7	25.0	0	21.55

Table 6. Factors influencing the awareness of the benefits of *M. oleifera*.

Variable	**Likelihood Ratio**	**Degrees of Freedom**	***p*-Value**
Age	18.354	12	0.206
Gender	16.602	8	0.020 *
Location	20.243	12	0.058
Level of education	20.276	24	0.637
Marital status	4.639	8	0.605
Type of broiler ownership	10.939	8	0.472

* Significant at $p < 0.05$.

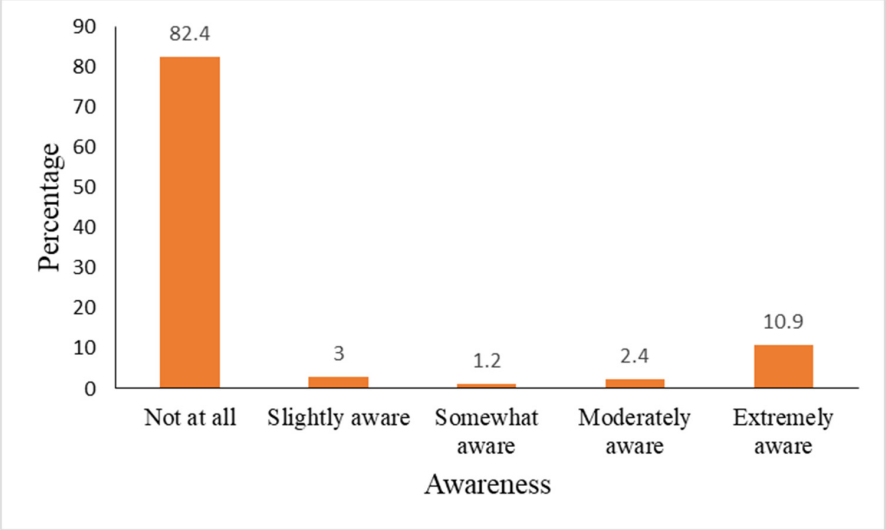

Figure 1. Percentage of farmers' awareness of *M. oleifera* benefits in broiler chickens.

3.1.3. Status of *M. oleifera* Use by Broiler Farmers

A total of 89.1% of the respondents were not using *M. oleifera* in their feeding routine (Figure 2). Among the 10.9% of the respondents who indicated that they were using *M. oleifera*, the majority (61.1%) used leaf powder as an additive to the commercial feed, while the remainder added chopped stems to drinking water. The use of *M. oleifera* was significantly ($p < 0.05$) influenced by gender and location (Table 7).

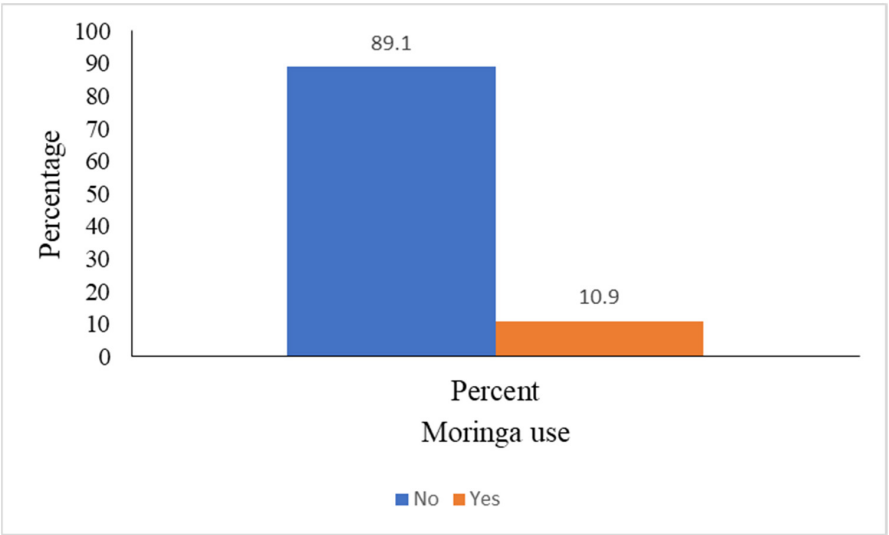

Figure 2. Percentage of farmers using *M. oleifera* in broiler chicken feed.

Table 7. Logistic regression results of factors influencing the use of *M. oleifera*.

Variables	Coefficient (B)	Standard Error	Exp (B)	*p*-Value
Age	−0.003	0.021	0.997	0.88
Gender	1.738	0.802	5.687	0.03 [a]
Level of education	−0.184	0.229	0.832	0.42
Location	0.597	0.267	1.817	0.03 [a]
Type of broiler ownership	−0.066	0.553	0.515	0.230
Number of broilers per cycle	0.000	0.001	0.842	1.000
Constant	−2.611			

[a] Significant at $p < 0.05$; −2 Log likelihood = 87.571.

3.2. *M. oleifera* Farmers Key Informant Interview Results

The majority of the participants (63.6%) were female. More than half (54.5%) of the participants fell in the age range from 41 to 50 and had obtained formal education (72.7%). Only 27% of the participants were cultivating *M. oleifera* on more than 8 hectares of land, while the rest were cultivating less than that (Table 8). Three key themes emerged from the thematic analysis. Quotes included in the results are verbatim quotes recorded during individual interviews.

Table 8. Characteristics of the key informants interviewed.

Variable		Frequency
Male		4
Female		7
Age range	20–40	1
	41–50	5
	51–60	3
	>60	2
Education	Primary School	1
	High School	4
	Bachelor's degree	2
	Master's degree	2
	Not mentioned	2
M. oleifera farming experience (years)	1–3	0
	4–7	4
	8–10	2
	>10	5
Area allocated for *M. oleifera* cultivation (hectares)	0–2	4
	2.1–4	1
	4.1–8	3
	>8	3

3.2.1. Theme 1: *M. oleifera* Production

Four subthemes, namely experience and reason for *M. oleifera* farming, cultivation and harvesting, constraints, and opportunities for expansion, were identified under this theme.

Experience and reasons for M. oleifera farming

Participants stated a varied number of years in *M. oleifera* production. The number of years in production ranged from 6 years to more than a decade. Participants grew *M. oleifera* for various reasons, including a source of income, for nutritional and health benefits, due to an interest in organic farming, and for soil health benefits.

> "*A friend of mine introduced me to M. oleifera many years ago. I think he's a permaculture specialist. How he introduced it to me, it was you can grow M. oleifera and make extracts and spray your crops. So, I grew M. oleifera, took the leaves, put in water, take the water, spray my crops and I had very good, good quality crops. So, I went on like that for years from 2002 just using M. oleifera for enhancing growth of my crops. And some of the leftover I would put in the compost, make compost… In 2016, I started exporting M. oleifera*" (F. 05)

Cultivation and harvesting of *M. oleifera*.

Throughout the interviews, what was common across all participants was the ease of cultivating *M. oleifera*. "*These trees last for a long time and they require minimum attention once they are fully grown*" (F. 02)

Participants reported that it takes between 3 and 12 months for a *M. oleifera* tree to grow and start harvesting leaves. The interviews revealed that the *M. oleifera* tree grew well in warmer temperatures, ideally between 25 °C and 35 °C, and did not perform well during colder seasons. Therefore, summer and spring were the preferred times of

planting. Participants noted that the *M. oleifera* tree requires water during the early stages of development and is drought-tolerant once established. Some of the respondents stated that they were practicing organic *M. oleifera* production, which prohibits the use of synthetic chemicals such as fertilisers and pesticides. "*In all honesty, managing M. oleifera trees is not expensive at all. The plant is very resilient. I practice organic farming because that's what our clients want. I grow the trees naturally; no pesticides or fertilisers are used in my farm*" (F. 09).

Participants described the harvesting of *M. oleifera* leaves as a labour-intensive exercise because leaves must be carefully handpicked. Outsourcing labour, predominantly to women and youth from the community, was a common practice during harvesting. "*I usually recruit people from around the community to assist at the farm during harvesting and most of these are youth and women.*" (M. 10). Harvesting of leaves from established trees was routinely carried out every 3 to 4 months, depending on availability of forage. While some participants were unable to provide precise leaf matter yield figures, a commonly anticipated leaf matter yield was a minimum of 15 metric tonnes per hectare each year.

3.2.2. Theme 2: Broiler Market Access

The prices of 1 kg of *M. oleifera* powder stated by participants was not uniform. Prices ranged from R50 per kg to R120 per kg. Respondents indicated that prices were negotiated based on the amount of input and cost of production. One responded stated that in most cases buyers determined the price. "*It's very shocking. In this country, people will buy even 20 rand a kilo or something, 30 rand a kilo in the country. People will buy that. Because how they do it, they will buy it and go package it and sell for more. Because somebody will tell you, I'm a processor, I want M. oleifera, I want to go sell it, they will pay that small*" (F. 05).

The *M. oleifera* market is still in its infancy in South Africa. Market access was described as one of the biggest challenges by some participants. Traders, agroprocessors, pharmaceutical companies, and community members were identified as the primary local buyers of *M. oleifera*. Participants involved in the export market were exporting *M. oleifera* at approximately $6.00/kg. These participants however indicated that the export market was costly and difficult to access, and required large quantities of *M. oleifera* supplies which they currently lack. "*The client, I sell for is looking for 15 tons every month. But I haven't gotten to 10 tons every month because I still have fewer quantities of M. oleifera.*" (F. 03).

3.2.3. Theme 3: Benefits of *M. oleifera* for Broilers

M. oleifera was reported to be used not only in broiler feed but also for feeding goats, cattle, and rabbits. "*. . .Yes, we used to blend chicken feed with M. oleifera and feed it to broilers and layers to improve growth egg size. We were also saving money on feed. It took the layers 5 years to lay eggs. As a result, the period of egg production increased. The Department of Agriculture even came to ask how our chickens were still laying eggs after so many years, and we informed them it was due to feeding M. oleifera.... when we feed M. oleifera to goats, we get twins.*" (M. 04).

The interviews revealed that participants were not marketing *M. oleifera* powder to any animal feed producers or broiler farmers. One participant mentioned that marketing *M. oleifera* powder as a feed ingredient to broiler farmers was challenging due to misinformation and a lack of trust. "*Broiler farmers do not have enough knowledge about M. oleifera's benefits for broiler chicks. When we approach them, they believe we can kill their chickens since we lack proof or sufficient evidence*" (M. 02). A significant limiting factor that emerged was the insufficient knowledge and absence of validated standards for using it as an animal feed. Participants expressed interest in exploring the broiler feed market, recognizing its potential to boost their market.

4. Discussion

The findings from this study showed that the majority of broiler farmers were female. A similar trend was reported by [17,18], who found that women were primarily responsible for rearing chickens in South African smallholder farms. Women play a crucial role in raising broiler chickens in many smallholder farms in South Africa. In a survey conducted

by [19], out of the 236 small-scale broiler farm owners interviewed, 144 were women. The common narrative is that women are usually responsible for managing smaller livestock such as chickens, goats, and sheep, which are reared closer to home [20,21]. This responsibility is often driven by the need to generate income for their families and the cultural expectation of women being responsible for household tasks.

This study showed that farmers averaged 450 birds per cycle with a range of 100–500 and largely relied on broiler sales as their major source of income. This concurs with findings by [22], who reported that more than 75% of smallholder farmers produced fewer than 1000 birds per cycle. This could be attributed to the fact that most smallholder farmers are resource-constrained and do not have input in or access to large markets. Despite having challenges in accessing markets, most smallholder broiler farmers obtain high gross margins per bird, since they can sell all birds in a batch within a few days in the informal market. The National Agricultural Marketing and Research Council (NAMC) recently conducted a study across eight provinces in South Africa and found that smallholder farmers typically raise 1300 birds per cycle and sell approximately 1100, generating net farm income ranging from USD 800.00 to USD 1340.00. According to [23], smallholder farmers use income from farm sales to pay school fees, cover medical bills, and purchase other agricultural inputs.

A significant number of respondents indicated that they knew about the *M. oleifera* tree. There were no differences in knowledge across the different farm sizes, locations, genders, or age groups. Knowledge about the *M. oleifera* tree was attributed to the community, family history, or the media. A study by [24] also found that most consumers in Africa obtained their knowledge about *M. oleifera* from their families and communities. The extensive knowledge reported in the present study could be attributed to the widespread prevalence of *M. oleifera* production in the study areas. According to [14], the first *M. oleifera* seeds in South Africa were cultivated in the Limpopo province due to its favourable climatic conditions. Consequently, a majority of the Limpopo population owns a *M. oleifera* tree in their backyards.

Among the group of respondents who indicated their awareness of the *M. oleifera* tree, only a few were aware of *M. oleifera*'s benefits for broiler chickens. The majority of those were females. This could be attributed to the African cultural practice in which custodians pass knowledge from one generation to another within families and communities. Given that females are more actively engaged in broiler production, it is likely that they have been sharing knowledge about the benefits of *M. oleifera* for broilers within their families and communities. Therefore, there is a need for awareness campaigns targeted at females to educate communities in other parts of the country about the benefits of *M. oleifera* for broiler chickens.

The same female farmers who were aware of the benefits of feeding *M. oleifera* to their broilers primarily used leaf powder and crushed stems. This suggests that there is an association between awareness and use. This supports findings by [25], who reported that low levels of awareness contributed to poor adoption of improved agriculture technologies. A study by [26] also concluded that training and farmers' awareness positively influenced the use of a value addition technique by farmers. The lack of awareness and accurate information from trusted sources, such as public extension service providers largely contribute to farmers' reluctance to adopt new technologies. The present study suggests that information regarding the potential benefits of *M. oleifera* for chickens has not reached a wider audience. This could be attributed to lack of community engagements to disseminate research findings. According to [27], the absence of structured support systems and networks, coupled with lack of regularisation strategies and clear criteria for supporting quality, protection, and presumed efficiency of plants like *M. oleifera*, has posed challenges in integrating them into both small scale and commercial production.

The leaf powder was added to commercial feed, while the crushed stems were mixed into drinking water. The bulk of the *M. oleifera* used by these farmers was sourced from their backyards. This aligns with recent findings by [18], who reported that smallholder

chicken farmers in the Vhembe district municipality of South Africa were using *M. oleifera* leaves either soaked in water or as dried powder mixed with chopped fresh aloe vera in drinking water to treat conditions such as diarrhoea, Newcastle, and duck disease. *M. oleifera*'s effectiveness in treating infections could be attributed to its antimicrobial properties. *M. oleifera* has been reported to possess polyphenolic compounds which are effective against a wide range of bacteria, viruses, and fungi [6].

Among large-scale farmers that gave insights for the study, none were incorporating *M. oleifera* in their operations. They primarily cited two main limitations: limited information on the nutritional benefits of *M. oleifera* and uncertainty regarding the consistent availability of *M. oleifera* supplies for their larger operations. However, the majority indicated that they would consider the use of *M. oleifera* if their concerns were addressed. The present study showed that *M. oleifera* farmers currently have limited production capacity to meet the demands that maybe required by larger broiler operations. The majority of the *M. oleifera* farmers identified in this study were female small-to-medium scale farmers who owned less than 5 hectares of land, producing at least 10 tonnes of leaf powder per hectare. Similar findings were reported by [28], who reported that the majority of *M. oleifera* farmers in South Africa were small-scale female farmers. Additionally, this study revealed that access to markets, advanced infrastructure, and equipment for processing were major challenges for *M. oleifera* farmers. Given the significant involvement of women in *M. oleifera* production, there is a need to create an enabling environment to provide women with greater access to land, financial support, and infrastructure.

Participants in the present study noted the ease of cultivating *M. oleifera*. According to [29], *M. oleifera* is a drought-tolerant crop that requires a minimum of 400 mm of rainfall per annum and can withstand a wide range of temperatures. The interviews further revealed that the cost of producing *M. oleifera* was not a challenge, as it required less intensive care and was drought-tolerant. This concurs with findings by [30], who reported that the majority of *M. oleifera* farmers in the Limpopo province of South Africa were either using organic fertilisers or allowing the trees to grow naturally. This suggests that the cultivation of *M. oleifera* is potentially affordable and can be practiced even by resource-limited farmers. Once the production is established, to encourage uptake of *M. oleifera* by large scale operations, the government can introduce incentives for large-scale producers that incorporate *M. oleifera* in their operations. This will help improve the supply chain and attract support from large-scale broiler producers. Moreover, research has shown that *M. oleifera* trees are 20 times more efficient at absorbing carbon dioxide than general vegetation [31]. This means that upscaling *M. oleifera* production could potentially play a significant role in mitigating the effects of climate change through the carbon sequestration process.

The perceived benefits of *M. oleifera* for broilers reported by both small-scale broiler farmers and *M. oleifera* farmers in this study included improved growth rates, increased body weight, and reduced mortality. These perceived benefits align with the benefits that are reported in literature. Scientific studies [13,32–37] showed that adding *M. oleifera* to broiler diets improved growth rate, meat quality, reduced mortalities, improved blood parameters, digestibility, egg mass, and feed conversion ratio.

5. Conclusions

The extensive knowledge in published scientific research regarding the benefits of *M. oleifera* and its potential as an antibiotic growth promoter alternative has not yet been disseminated widely. Broiler farmers remain uninformed about these benefits and methods of application. Moreover, there is a limited availability of bulk *M. oleifera* production for consistent supply for feed formulations. This underscores the need for initiatives to scale up *M. oleifera* production and to raise awareness and education regarding the benefits of moringa for broilers. This can potentially drive the broader adoption of *M. oleifera* as a natural growth promoter. The potential adoption of *M. oleifera* as a natural growth promoter not only benefits individual farmers but aligns with the larger agenda of fostering

environmentally friendly and sustainable approaches in poultry production. By advocating for increased awareness and production, this article aims to play a pivotal role in catalyzing positive changes within the industry, fostering sustainable development in broiler farming, and promoting the wider acceptance of *M. oleifera* as a valuable resource for the future of poultry production.

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