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Comparative Analysis of Traditional and Modern Broiler Farms Using Google Colab *t*-test and Data Visualization

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ABSTRACT

This study aims to compare production performance between modern and traditional broiler farming systems in Indonesia and to evaluate the potential of digital data recording for decision-making support. Despite high feed prices, welfare concerns, and socioeconomic constraints, many farmers utilize modern technology to enhance their efficiency. Due to cost and production, many traditional farmers continue to use traditional farming practices. Production data were collected from modern and traditional farms in Gunungkidul District, Yogyakarta Province. Data were analyzed using Python-based t-tests and correlation heatmaps in the Google Colab environment. Data analysis revealed significant differences ($p < 0.01$) in feed intake (FI) and performance index (PI), but not in body weight (BW), average daily gain (ADG), or feed conversion ratio (FCR). Traditional and modern farming systems differ in FI and PI. Heatmaps enhance understanding of correlations, revealing a high association between FI, BW, and FCR ($r \geq 0.70$), whereas modest relationships exist between FI, BW, and ADG. The results enable farmers to determine whether to enhance elements with moderate and strong correlations or solely those with strong correlations; they also permit the cooperative to assess farmers' production based on broiler production and management practices.

1. INTRODUCTION

Indonesian farmers face challenges in terms of sustainability, animal care, and risk management. These challenges can be overcome through feed efficiency, antibiotic-free processes, and new nutritional solutions to improve industry sustainability and social acceptance. Given that Indonesia's broiler meat production reached 3,765,573.09 tons in 2022, marking an 18.2% increase from 2021, the feasibility and profitability of broiler farming, particularly within a partnership model, are critical for its continued development and growth (Akhiroh *et al*., 2023). Indonesian farmers face challenges in terms of sustainability, animal care, and risk management. These challenges can be overcome through feed efficiency, antibiotic-free processes, and new nutritional solutions to improve industry sustainability and social acceptance. Given that Indonesia's broiler meat production reached 3,765,573.09 tons in 2022, marking an 18.2% increase from 2021, the feasibility and profitability of broiler farming, particularly within a partnership model, are critical for its continued development and growth (Akhiroh *et al*., 2023). Consequently, evaluating the economic viability and operational distinctions between traditional and modern broiler farming methods becomes essential for strategic planning and technological integration within this expanding sector (Morato *et al*., 2024). Such a comparison allows for a comprehensive understanding of how different farming approaches impact productivity, resource utilization, and overall sustainability, particularly given the rapid increase in broiler meat production (Longgy & Widianingrum, 2024).

Despite extensive research on improving poultry production, a notable gap exists in comprehensive, statistically rigorous comparative analyses that explicitly quantify the performance disparities between traditional and modern broiler farms within the Indonesian context, particularly concerning specific morphometric observations and the application of accessible, open-source analytical platforms like Google Colab. This study aims to bridge this gap by conducting a detailed statistical comparison, including morphometric analysis, utilizing Google Colab to provide a clear, data-driven understanding of these differences (Lase *et al*., 2023). This approach will not only highlight the advantages of modern farming techniques but also offer actionable insights for improving traditional practices, thereby supporting the broader goals of sustainable agricultural development and enhanced food security (Sa'ad *et al*., 2025). Furthermore, by leveraging platforms like Google Colab, this research democratizes advanced analytical techniques, making sophisticated data interpretation accessible to a wider audience, including smallholder farmers and agricultural policymakers (Kebede *et al*., 2023). Furthermore, by leveraging platforms like Google Colab, this research democratizes advanced analytical techniques, making sophisticated data interpretation accessible to a wider audience, including smallholder farmers and agricultural policymakers (Kebede *et al*., 2023). Understanding the growth dynamics and physiological parameters of broiler chickens under various husbandry and environmental conditions is crucial for optimizing feed conversion ratios and predicting slaughter-age body weight (Quintana-Ospina *et al*., 2023).

This study will contribute novel insights by employing a comparative statistical analysis, specifically utilizing Google Colab for *t*-tests and data visualization, to elucidate the precise differences in productivity, profitability, and animal welfare indicators between traditional backyard and modern commercial broiler farming systems in Indonesia. This will involve a rigorous examination of various parameters, including feed conversion rates, growth rates, mortality rates, and economic returns, to provide a holistic understanding of both methodologies (Baráth *et al*., 2024). The findings will offer actionable recommendations for policymakers and farmers, guiding the adoption of more efficient and sustainable practices within the Indonesian poultry industry, especially considering the current limitations in local chicken productivity (Ramadhani *et al*., 2023). The findings will offer actionable recommendations for policymakers and farmers, guiding the adoption of more efficient and sustainable practices within the Indonesian poultry industry, especially considering the current limitations in local chicken productivity (Ramadhani *et al*., 2023; Tribudi *et al*., 2023). Moreover, this research will highlight the potential for leveraging readily available digital tools, such as Google Colab, to empower local stakeholders with advanced analytical capabilities, facilitating data-driven decision-making to enhance farm efficiency and output. Ultimately, this research aims to foster agricultural development and empower local farmers by providing evidence-based strategies for optimizing broiler production (Paymode & Malode, 2022).

The results of this study are expected to guide future research in the livestock industry, especially on data-driven decision-making and issues related to substantially lower costs. This focus on cost-efficiency and data accessibility via platforms such as Google Colab corresponds with the overarching objective of rendering modern agricultural analytics accessible to a broader spectrum of stakeholders, thus fostering better-informed and sustainable farming practices. The study examines the existence of a statistically significant difference between modern and traditional broiler systems.

2. MATERIALS AND METHODS

2.1. Study Area and Data Collection

Data were collected from modern and traditional farms in Gunungkidul District, Yogyakarta Province. This geographical focus allows for a localized comparative analysis, providing insights directly relevant to regional agricultural practices and potential interventions. The selected district provides a representative sample of both established commercial operations and prevalent traditional backyard farming systems, enabling a robust comparative analysis of their operational metrics and productivity. Data was collected from 10 farmers each in the modern and traditional categories, from the year 2023, with a minimum production period of 4 periods per year. As for the data types, they can be presented in Table 1.

Table 1. Column Names and Descriptions of the Dataset

Column Name	Data Type	Description
Cage	Categorical	The type of cage (0 = modern, 1 = traditional)
Period	Numeric	The period of broiler
Date	Date	The date of data
Age	Numeric	The age of broiler
FeedIntake	Numeric	The feed intake of broiler
Culling	Numeric	The culling of broiler
Death	Numeric	The death of broiler
Depletion	Numeric	The depletion of broiler
LiveBirdBefore	Numeric	Previous number of chickens
LiveBirdAfter	Numeric	Number of chickens after depletion
%Live	Numeric	Percentage of live bird
LiveWeightBird	Numeric	Weight of chicken per bird
ADG	Numeric	Average daily gain
FCR	Numeric	Feed conversion ratio
BIP	Numeric	Broiler index performance

2.2. Performance Calculation

This research utilizes a web-based system that allows farmers to input data. The production data collected facilitates further calculations, such as determining daily weight gain (*ADG*) using the appropriate formula based on body weight data.

$$ADG = \frac{FBW - IBW}{NoD} \tag{1}$$

with *FBW* is final body weight (g), *IBW* is initial body weight (g), and *NoD* is number of days (day).

Simultaneously, data on total feed consumption and body weight increment can be utilized to compute the Feed Conversion Ratio (FCR) using the following formula:

$$FCR = \frac{TFC}{TWG} \tag{2}$$

with *TFC* is total feed consumption (g), and *TWG* is total weight gain (g).

Performance Index (*PI*), commonly utilized as a measure of farmers' success, was calculated as the following:

$$PI = \frac{La \times LW}{FCR \times Age} \times 100 \tag{3}$$

with *La* is live avaibility (%), *LW* is live weight (kg), *FCR* is feed convertion ratio, and *Age* is animal age (day).

2.3. Statistical Analysis

An elevated PI signifies superior overall performance, indicative of efficient growth, reduced mortality, and practical feed usage. This procedure involves implementing a digital recording system that farmers can complete. Subsequently, the results can undergo further calculations, and additional insights can be derived using Python code executed in Google Colab, which is more efficient due to its utilization of Google's server infrastructure, by using the *t*-test (unequal variance/Welch's *t*-test) methodology to compare the two based on the formula:

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \tag{4}$$

with $\overline{X_1}$ and $\overline{X_2}$ is means of groups 1 and 2, s_1^2 and s_2^2 is variances of groups 1 and 2, and n_1 and n_2 is sample sizes of groups 1 and 2.

Figure 1 shows the data flow from farmers to Python code for further insights. Converting data into actionable knowledge is advantageous for farmers, establishing a basis for informed decision-making. The monitoring procedure within the enclosure can begin at the start of maintenance, unlike traditional approaches that provide only a retrospective analysis of the production process before the broiler harvest period.

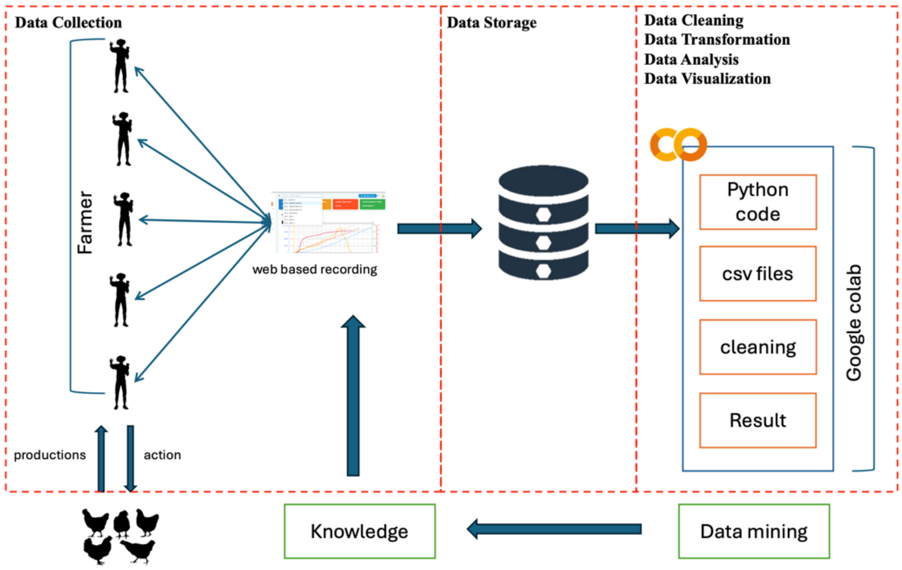

Figure 1. The process of transferring data from farmers to the system and processing it to gain knowledge, using Google Colab as a tool for data mining

3. DATA ANALYSIS

Data on agricultural production is gathered from farmers employing the system. The retained data is subjected to a cleansing procedure to remove redundant information, followed by a classification process based on farm area, strain type, data integrity, and analogous production cycles. This condition ensures that the rearing environment is consistent or comparable, mitigating environmental influences on the data acquired during the calculation process. Table 2 establishes the procedures executed during this process. By recognized protocols and studies on diverse broiler farm data, traditional and modern, discussions will continue sequentially as detailed below.

Table 2. Stages in conducting data processing

Stages	Technology
Data Collection	Web digital recording
Data Storage	MySQL
Data Cleaning	Pandas
Data Transformation (Data Aggregation)	Pandas, Excel
Data Analysis	Python in Google Colab
Data Visualization	Python in Google Colab

3.1. Data Collection

The data collection process involves the development of a digital recording platform designated as a system-as-a-service (SaaS), accessible to numerous farmers. This platform incorporates a feature for automatic calculations of additional data, such as body weight, enabling the system to compute concurrently. This step is crucial for the success of subsequent analysis. Although the data collection process is laborious, the insights can be utilized in various contexts and applications when executed methodically and effectively. The data collection process is illustrated in Figure 2. The data acquired from the digital recording process encompasses various elements, including farm location data (which can be classified by region), information on broiler strains utilized, broiler producer data, details on feed and drug suppliers, vaccines, and other chemicals (OVK), as well as broiler production data across multiple production periods.

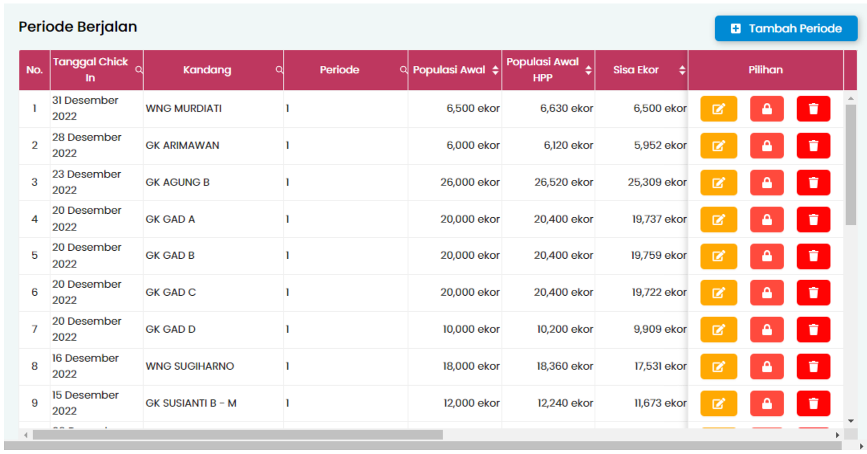

Figure 2. Process of data collection in digital recording

3.2. Data Storage

The data input by the farmers is stored in the AWS cloud server in the SQL file format using MySQL, allowing data to be stored on a large scale and organized. MySQL was selected due to its user-friendliness and configurability. This research indicates that MySQL is straightforward to install and operate, even for individuals lacking extensive technical knowledge, rendering it an ideal option for database management courses. Another rationale for employing MySQL is its superior performance and efficiency in handling extensive databases. MySQL is recognized for efficiently executing CRUD (Create, Read, Update, Delete) operations across diverse data sizes. However, speed-related issues may arise that can be mitigated with specific improvements. Moreover, the rationale for flexibility and scalability is the optimal selection for achieving superior performance, ranging from a tiny database to a substantial one, particularly in animal husbandry research, where data volumes are typically extensive, as indicated by the studies. MySQL can manage varying-sized databases and may be connected with other applications to enhance data management efficiency.

3.3. Data Cleaning

The subsequent procedure involves data cleaning and eliminating highly nuisance-prone data. This process can be executed using Python code and the Pandas library to enhance efficiency; the distribution of missing values across different tests is visualized in Table 3.

Data cleaning is a crucial phase in big data analysis, particularly within the poultry sector, where the volume and diversity of obtained data can be substantial. This procedure guarantees that the data utilized for analysis is more precise and dependable. Raw data frequently has missing, duplicate, or erroneous information, commonly termed "dirty data." Data cleansing will enhance data quality and facilitate sound decision-making. Data cleansing is a crucial preliminary phase in big data analysis, influencing the quality of the analytical outcomes. Cleaner data enables more accurate and efficient analysis.

This cleaning method does not alter the number of rows in the data but modifies the number of columns, allowing for the deletion of unused columns to mitigate confusing variables. This study utilizes the fifth period's contemporary and traditional farmers' production data. The process of data cleaning from raw to refined data is illustrated in Figure 3.

Table 3. Statistics before and after data cleaning

Criteria	Statistics Before Cleaning	Statistics After Cleaning
Number of Rows	59,757	52,515
Number of Columns	15	23
Missing Values	241	0
Duplicate	185	0

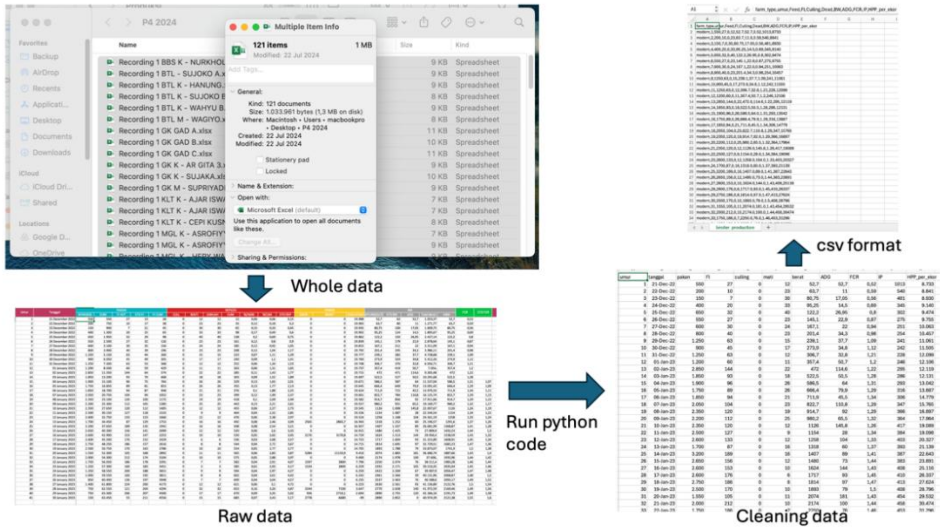

Figure 3. Data cleaning process

3.4. Data Transformation (Data Aggregation)

Data that has been cleaned and is still in XLSX format is then re-checked to make sure it is appropriate and then converted to a CSV file using pandas. The conversion process with Python code is executed to enhance speed and efficiency in obtaining a CSV file from the preceding XLSX file. CSV is a basic text format that can be readily read and modified without sophisticated tools.

In this data aggregation process, data is also labeled according to the condition of the farm, and aspects such as those shown in Table 4 are used to distinguish between modern and traditional maintenance systems.

Table 4. The difference between traditional cages and modern cages, based on the literature

Aspects	Traditional Cage	Modern Cage	Source
Cage technology	Open cage, manual, simple	Closed, automatic	(Honig *et al.*, 2024)
Environmental Control	Weather-dependent, natural ventilation (open and close the cage)	Fully controlled, automatic with inlet and outlet	(Hendrikus *et al.*, 2022; Iriani *et al.*, 2024)
Production Scale	Small (less than 3000 bird/period)	Great (more than 3000 birds/period)	(Sari *et al.*, 2021)
Feed Efficiency	Less efficient	Highly efficient	(Tauson, 1998; 2002)
Health Management	Manual, high disease risk	Automatically, low disease risk	(Honig *et al.*, 2024)
Initial Cost	Low	High	(Sari *et al.*, 2021)
Production Results	Lower	Higher and uniform	(Tauson, 2002)
Environmental Impact	High pollution potential	Environmentally friendly	(El-Maghawry, 2024;

3.5. Data Analysis

All the data that will be analyzed is stored in Google Drive to simplify the calculation process. This allows the data to be synchronized and processed with Python within the Google Colab environment. This process requires libraries from pandas and NumPy.

4. RESULTS AND DISCUSSION

Boxplots can be used to visually represent the outcomes of this data processing, which can also be displayed in Table 5, which contains the overall data processing results.

Table 5. The results of the *t*-test data analysis of the difference between modern management and traditional management

Parameters	FI (g/bird/day)		BW (g/day)		ADG (g/bird/day)		FCR		PI	
Management	M	T	M	T	M	T	M	T	M	T
Data 1	20	20	63	63	50	50	0.39	0.39	282	282
Data 2	20	20	74	74	30	30	0.53	0.53	347	347
Data ..	…	…	…	…	…	…	…	…	…	…
Data ..	…	…	…	…	…	…	…	…	…	…
Data ..	…	…	…	…	…	…	…	…	…	…
Data 39	186	186	2.466	2.466	97	97	1.53	1.53	382	382
Data 40	190	190	2.563	2.563	0	0	1.54	1.54	354	354
Average	110.68	77.87	1220.15	1046.53	70.49	66.71	1.13	1.25	390.17	327.34
SD	63.24	42.25	931.09	782.82	41.58	27.20	0.28	0.30	127.34	29.23
t-statistic	-2.71		-0.88		-0.47		-1.77		-2.93	
p-value	0.008		0.380		0.641		0.079		0.004	
Conclusion	**		ns		ns		ns		**	

Note: FI = Feed Intake, BW = Body Weight, ADG = Average Daily Gain, FCR = Feed Conversion Ratio, PI = Performance Index, M = Modern farming system, T = Traditional farming system, SD = Standard Deviations. The data show contrasting values due to the different values of various modern and traditional farming companies. ns = non-significant, ** = highly significant difference. The samples from conventional and modern farming systems are similar in terms of the feed nutrient data used, as they come from the same industry partner.

4.1. Feed Intake

Factors affecting broilers' feed intake (FI) include feed processing, nutritional makeup, feed form, and feeding method. The management of traditional and modern farming systems yields significantly different (P<0.01) outcomes, attributable to the distinct feeding management practices. Traditional systems exhibit sensitivity to feed adjustments, as each feed substitution incurs substantial costs. In contrast, modern farming systems are characterized by innovation and a reduced sensitivity to fluctuations in feed costs. Contemporary agricultural practices consistently consider the feed form component relative to the age of broiler chickens, along with prior research that posits particle size and feed form (mash or pellet) influence feed intake. Pelleted feed generally enhances feed intake and growth relative to mash, although it may increase abdominal fat (Abdollahi *et al*., 2018; Massuquetto *et al*., 2018; 2019). Traditional farming systems frequently supply feed in unsuitable forms for the production age, particularly as mash, which adversely affects feed consumption. This aligns with findings from Abdollahi *et al*. (2018) indicating that fine-grinding processing methods can diminish feed intake by elevating digesta viscosity.

4.2. Body Weight

The body weight of traditional and modern farming systems' yields isn't different (not significant outcomes). A broiler's body weight (BW) can be affected by several factors, including nutrition. The nutritional value of feed is determined by the amount of energy and protein delivered. In certain farms, particularly those that use plasma core partners, the feed that is provided tends to have a relatively similar nutritional content, particularly concerning the requirements for energy and protein. Consequently, this is the reason why the outcomes of traditional farming systems and modern farming systems are not considerably different from one another. According to the findings of several earlier studies, the level of energy and the proportion of protein in the diet significantly impact broilers' body composition and weight. This finding is consistent with those studies' conclusions. According to (Deaton *et al*., 1983; Eits *et al*., 2002; Salas *et al*., 2019) the article, diets high in calories tend to induce fat deposition, but diets with the appropriate protein ratio are essential for stimulating muscle building.

4.3. Average Daily Gain

The average daily gain of traditional and modern farming systems isn't different (not significant). Factors affecting Average Daily Gain (ADG) in broilers are complex and involve various aspects, including nutritional factors, especially crude protein. In certain farms, particularly those that use plasma core partners, the feed that is provided tends to have a relatively similar nutritional content, particularly regarding the requirements for energy and protein. The body weight of the broilers strongly influences the amount of ADG, so there is no difference in the amount of

ADG between traditional and modern farming systems. The crude protein content in the feed used tends to be by the standards provided by broiler strain producers, so the effect of crude protein supplementation tends to be the same. This is in line with research done by (Dehghani-Tafti & Jahanian, 2016) explained that the level of crude protein in the diet affects ADG, with a decrease in crude protein reducing ADG during the starter and grower periods.

4.4. Feed Conversion Ratio

The feed conversion ratio (FCR) is similar. Outcomes are influenced by a variety of factors, including the nutritional aspect. The feed's metabolizable energy (ME) and crude protein (CP) levels significantly affect the FCR. An increase in ME usually reduces feed consumption but can increase fat deposition, while CP/AA density is directly proportional to carcass and breast meat yield (Cozannet *et al*., 2021; Ndlebe *et al*., 2023). Furthermore, Cozannet *et al*. (2021) explained that digestible lysine content and available phosphorus also affect FCR. A decrease in available phosphorus can increase FCR, while adding exogenous enzymes can reduce this negative impact. While traditional and modern farming systems have uniform nutrient content, they do not significantly impact FCR changes.

4.5. Performance Index

Broiler farming is a significant sector within the livestock business, characterized by an increasing global demand for chicken meat. The performance index (PI) is a crucial instrument for evaluating the efficacy of broiler production, encompassing factors such as body weight, feed efficiency, and mortality rate. The performance index of traditional and modern farming systems yields significantly different ($P<0.01$) outcomes, and traditional and modern farming systems exhibit substantial differences attributable to variations in management and efficiency. This aligns with the assertion by Vanda *et al*. (2023) elucidating those distinct rearing systems, including closed cages, stages, and posts, which influence broilers' body weight and mortality rate. Enclosed cages demonstrated optimal outcomes, exhibiting the most significant body weight, the lowest death rate, and the highest performance index. Management methods significantly impact the outcomes of production indicators, aligning with Ali & Hossain (2010), who assert that factors such as farmer education, experience, farm size, and interaction with extension workers substantially affect production performance. Issues like elevated feed costs and inferior feed quality might diminish performance.

Implementing PLF is crucial for enabling farmers to comprehend the evaluation process expeditiously. Data mining performance classification algorithms can categorize farms according to management techniques and rearing conditions. Key characteristics in this classification are feed conversion, daily weight increase, and productivity index (Franco & de Alencar Nääs, 2021). The PI calculation process in traditional farms typically occurs after the harvest period. In contrast, in modern farms, it can be conducted at any time due to the substantial cage capacity and the practice of thinning broilers based on market objectives, necessitating daily data evaluation. PI is often determined by multiplying average body weight by feed efficiency or by dividing by feed conversion. This provides a comprehensive overview of efficiency and productivity (Bird, 1955). Establishing more sustainable raising systems and enhancing animal well-being are necessary, and they can influence performance and meat quality (Fotou *et al*., 2024).

4.6. Data Visualization

Data visualization is essential in data processing, as it helps transform raw data into meaningful insights. By choosing the correct type of visualization and using the appropriate tools, information can be effectively conveyed to farmers. Visualization is essential in data processing, as it helps identify patterns, trends, outliers, and relationships in data that may be difficult to understand if only viewed in tables or raw numbers. In this study, the visualization process was carried out using box plots to display data distribution and identify outliers. Big data visualization helps in data analysis and opens up significant business opportunities by uncovering valuable information in complex data relationships (Sun *et al*., 2019).

Python code was created to find out the relationship between parameters by adding a heatmap function to find out the correlation and how strong the correlation between parameters is. While the results of data visualization in the form of a heatmap of broiler production parameters can be shown in Figure 5. Correlation data can be used to determine the relationship or association between two variables. For example, when a farmer wants to increase body weight, the farmer must be able to increase feed intake (correlation 0.74) and improve FCR (correlation 0.86), and so

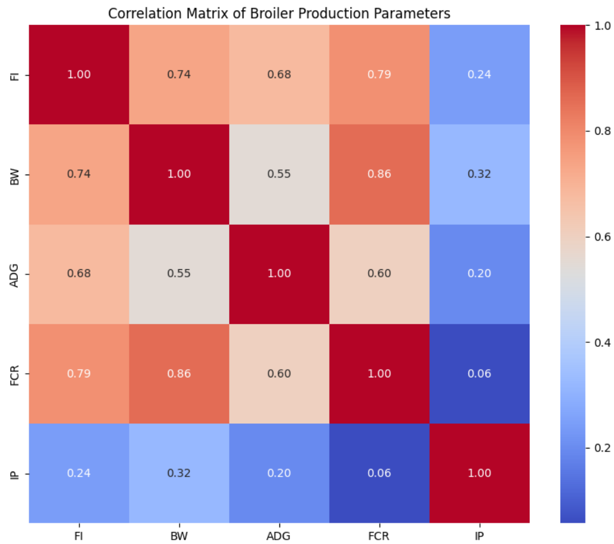

Figure 5. Data visualisation using heatmaps to determine the correlation between parameters

on, namely by looking at the correlation value compared to the strength of the correlation relationship, which ranges from 0 to 1, and the closer to 1, the stronger the relationship. Thus, an overview can be established indicating that the results obtained in this study demonstrate a favorable correlation. This graphic summary aids in identifying multiple strongly interconnected elements. It facilitates decision-making through interpretation, which aligns with the (Schober & Vetter, 2020) idea that a correlation closer to 1 indicates a stronger relationship. It is essential to evaluate the confidence interval of the observed coefficient to assess the strength of the relationship within the population. Based on previous research conducted by Schober & Vetter (2020) it is explained that various somewhat arbitrary cut-points have been proposed to categorize the strength of the relationship using descriptors like "weak" (e.g., $r < 0.40$), "moderate" (e.g., r = 0.40 to 0.69), or "strong" (e.g., $r \geq 0.70$). Farmers can more easily interpret the relationship between variables by understanding the correlation categories in data analysis. From Figure 5 above, the strong relationship between variables is between FI with BW and FCR because it has an $r \geq 0.70$. In contrast, the relationships between variables that are classified as moderate are FI with ADG, BW with ADG, and ADG with FCR. From these results, farmers can choose whether to focus on improving variables with moderate and strong relationships or only strong ones.

5. CONCLUSION

The application of traditional and modern farming systems for farmers has its own preferences, because it involves several considerations, including the need for investment in its development, the availability of land, the availability of skilled human resources, and the understanding of the farmers themselves of the needs of farmers in developing their livestock business. Through the case taken from the data of farmers in Gunungkidul district, Yogyakarta, it was found that the difference in the application of traditional and modern farming systems made a difference in the results obtained, although other components, including macroclimate factors and feed, were the same. The chicken strain (obtained from the same feed industry partner) had very significant differences ($P<0.01$) in feed intake (FI) and performance index (PI) but did not differ in terms of body weight (BW), average daily gain (ADG), and feed conversion ratio (FCR).

Farmers can more easily interpret the relationship between variables by understanding the correlation categories in data analysis. The strong relationship between variables is between FI with BW and FCR because it has $r \geq 0.70$. In contrast, the relationships between variables classified as moderate are FI with ADG, BW with ADG, and ADG with FCR. From these results, farmers can choose whether to focus on improving variables with moderate and strong relationships or only strong ones.

The use of digital recording technology and also PLF can provide insights that farmers easily understand in making decisions regarding the livestock production process that is done, because the principle is that data will become more meaningful if it can be processed into knowledge and information that can be used as a stone tool for farmers in making decisions easily, quickly, and precisely. Through the application of automatic calculations using Python code that is run in the Google Colab environment, it will provide a speedy process of data cleaning, data transformation, data analysis, and visualization so that the application of digitalization of broiler farms can run efficiently because it has a good impact on farmers in increasing PI, which makes the basis for farmers to collaborate with other companies and improve the production process of broiler farms in a better direction.

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AUTHOR CONTRIBUTION STATEMENT

Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
BDAN	✓		✓						✓					
GAI	✓													
ARSP										✓				
APN										✓				

C: Conceptualization
M: Methodology
So: Software
Va: Validation
Fo: Formal Analysis
I: Investigation
D: Data Curation
R: Resources
O: Writing - Original Draft
E: Writing - Review & Editing
Vi: Visualization
Su: Supervision
Fu: Funding Acquisition
P: Project Administration

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