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The Resilience of Smallholder Layer-Chicken Farmers Throughout the COVID-19 Pandemic: Evidence from Indonesia

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ABSTRACT

Smallholder layer-chicken farming in Indonesia is essential to ensure national food production, food security, and economic resilience. During the COVID-19 pandemic, small-scale layer-chicken farming exhibited adaptability. This study aims to assess the smallholder layer-chicken farmers resilience in Indonesia during the challenges posed by the COVID-19 pandemic. This research employed cross-sectional data collected from February to July 2023 from 114 smallholder layer chicken farmers in West Java, Central Java, and East Java using a purposive sampling technique. Data analysis used descriptive statistics, financial analysis, and the Wilcoxon Signed Rank Test. The results showed that the COVID-19 pandemic impacted the decline in the population and production of layer-chicken at the beginning of the COVID-19 pandemic but subsequently demonstrated an increase afterward. Financial analyses showed an increase in operational costs, specifically feed and labor, during the COVID-19 pandemic. The layer-chicken farms could adapt and maintain profitability amidst increasing operational costs. The findings showed that the COVID-19 pandemic significantly impacted increasing feed costs ($p<0.05$) and labor costs ($p<0.05$). The revenue-cost ratio remained relatively stable. The study also showed significant differences in profit levels before, during, and after the COVID-19 pandemic ($p<0.05$). Profit levels decreased during the beginning of the COVID-19 pandemic and recovered afterward, showcasing the smallholder layer chicken farmer's resilience during the COVID-19 pandemic. These findings offer valuable insights for policy formulation aimed at fortifying the resilience demonstrated by smallholder layer-chicken farming in Indonesia amidst the challenges posed by the COVID-19 pandemic and other potential crises in the future.

Keywords: farmer income; farmer resilience; poultry farming; small-scale farmers

INTRODUCTION

Smallholder layer-chicken farming in Indonesia holds a significant and indispensable position in the country's agriculture development (Hatta *et al.*, 2023). The role of smallholder layer-chicken farming extends far beyond mere agricultural contributions (Dixon *et al.*, 2021). It serves as a vital pillar for Indonesia's overall socioeconomic growth. It provides affordable protein sources (Attia *et al.*, 2022). Eggs are a low-cost food source that contains complete protein, essential vitamins, minerals, and bioactive compounds that can reduce the risk of chronic disease for children and adults (Walker & Baum, 2022). Eggs are a nutritional source and represent a readily accessible and cost-effective source of animal protein for millions of people in Indonesia and worldwide (Hayes *et al.*, 2021). Furthermore, layer-chicken farming supports rural development and poverty alleviation by offering employment opportunities and additional income to numerous smallholders. The importance of this sector extends well beyond the confines of agriculture, impacting the lives of millions of Indonesians and significantly contributing to their prosperity and well-being.

In Indonesia, smallholder layer-chicken farming is characterized by small-scale operations, reared in rural regions, and typically managed by resource-constrained farmers (Setiadi *et al.*, 2022). Despite these characteristics, it makes substantial contributions to Indonesia's food security. Smallholders could play a vital role in fulfilling the demand for animal products in developing countries (Das & Samanta, 2021). Eggs, an outcome of layer-chicken farming, constitute an affordable and accessible source of animal protein, particularly in low-income households in Indonesia. Moreover, smallholder layer-chicken farming

is an income source for countless rural families, strengthening the regional economy.

However, the outbreak of the COVID-19 pandemic in early 2020 exposed the poultry sector to unexpected challenges. Smallholder layer-chicken farmers faced market uncertainty, fluctuating demand, logistical bottlenecks, and financial constraints (Attia *et al.*, 2022; Hafez *et al.*, 2021). The unpredictability of the market price and the uncontrolled variable cost of several essential farm inputs, such as feed, have also become significant concerns for stakeholders. Small farms faced difficulty surviving during the COVID-19 pandemic because they could not adopt alternatives like distribution channels, online sales platforms, and biosecurity to protect their flocks and maintain egg production compared to larger farms. Hamid *et al.* (2016) investigated that companies have different marketing, distribution, and production methods, and they can determine their own prices without being frequently subject to government control. Furthermore, the increasing centralized power of agribusiness and food processing companies challenged smallholder farmers (Holt-Giménez & Altieri, 2012; Horst & Marion, 2019). As a result, they fared better during the COVID-19 pandemic.

The importance of resilience among smallholder layer-chicken farmers during the COVID-19 pandemic has been instrumental in ensuring the continuity and sustainability of small-scale laying chicken farms. Even though small-scale farms were affected by the COVID-19 pandemic when the pandemic first hit, the impact they experienced was not too severe. Smallholder layer-chicken farmers remarkably adapted to access family labor and bargain labor with locals to minimize the cost (Marsden *et al.*, 2023). However, the government's role was also necessary to support smallholder chicken farmers in recovering their businesses during the COVID-19 pandemic. This resilience was important not only for the livelihoods of smallholder farmers but also for the economic recovery during the COVID-19 pandemic (Bamidele *et al.*, 2023; Pu & Zhong, 2020).

Previous research reported the COVID-19 pandemic impact on poultry businesses in other countries (Nordhagen *et al.*, 2021; Fang *et al.*, 2021) and in some locations in Indonesia partially (Syahlani *et al.*, 2021; Setiadi *et al.*, 2022; Sholihin *et al.*, 2022; Ermanda *et al.*, 2023). Our novel approach expands on previous regional studies by conducting a nationwide assessment. It focuses on laying chicken population centers across Indonesia. This research fills this gap, offering a comprehensive understanding of smallholder layer-chicken farming practices during the COVID-19 pandemic. This research also delves into the resilience of smallholder layer chicken farmers. Prior research on resilience in layer-chicken farming in Indonesia has been conducted (Syahlani *et al.*, 2021), yet it remains partial in scope. These research findings are crucial to provide a potential blueprint for policy formulation and offer valuable insights to enhance the growth of smallholder chicken layer farming.

This research aims to assess the resilience of smallholder layer-chicken farmers in Indonesia during the COVID-19 pandemic. Furthermore, this research contributes to empirical evidence for policy development to enhance the resilience of smallholder layer-chicken farming in the future.

METHODS

Source and Sampling Method

The research was conducted at the center of the poultry farm in Indonesia. Indonesia's primary center for layer chicken is on Java Island. Based on the statistical data center, 61.44% of the average layer chicken population is in Java. The averages population of layer chickens in East Java, West Java, and Central Java were 86.74, 34.34, and 29.93 thousand heads, respectively (Figure 1). Then, the selection of regency in each province was based on the highest layer chicken population. All selected regencies were Bogor, Semarang, and two other regencies, Lamongan and Kediri, represented West Java, Central Java, and East Java Province, respectively.

The sampling method for this research was the purposive sampling technique. In this study, the sample is restricted to the criteria of smallholder layer chicken farmers (Regulation of the Minister of Agriculture Number 14 of 2020). Smallholder farmers were chosen because most layer farmers in Indonesia are small-scale farmers. Therefore, all respondents used in this study were smallholder layer chicken farmers.

Sample Size

Table 1 presents the sample size categorized by province and regency. The table highlights that East Java has the largest overall sample size (57 samples) compared to West Java (24 samples) and Central Java (33

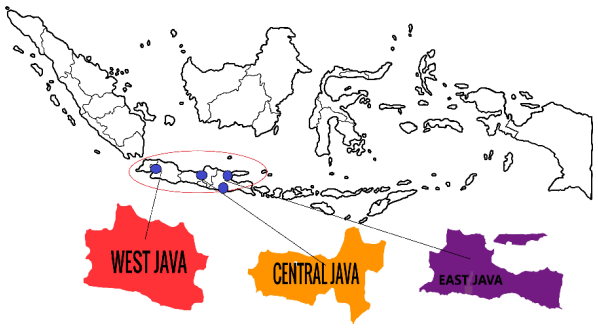

Figure 1. The research sites map in the West Java, Central Java, and East Java Provinces

Table 1. Sample size of smallholder layer chicken farmers

Province	Regency	Layer chicken farmers (people)
West Java	Bogor	24
Central Java	Semarang	33
East Java	Lamongan	23
	Kediri	34
	Total	114

samples). The total samples used in this study were 114 samples for smallholder layer chicken farmers.

Data Collection

Data was obtained directly from layer chicken smallholder farmers before, during, and after the COVID-19 pandemic through interviews using structured questionnaires. The data collected before the COVID-19 pandemic were from January 2019 to March 2020; data during the COVID-19 pandemic were from April 2020 to December 2021; data after the COVID-19 pandemic were from January 2022 until the time of the interview. The interviews were conducted retrospectively, relying on participants' recall of events, data, and experiences before and during the COVID-19 pandemic. The interviews were conducted from February 21st to July 15th, 2023.

Observed Variables

Several parameters relevant to the resilience of smallholder layer-chicken farms have been identified, including population, egg productivity and production, and financial analysis before, during, and after the COVID-19 pandemic. We used operational cost, fixed costs, revenue, profit, and revenue-cost (R/C) ratio variables as financial parameters. In addition, we obtained data on feed cost, labor cost, and farmer profit to analyze statistical differences before, during, and after the COVID-19 pandemic.

Analyses Method

The analytical methods employed in this study encompassed descriptive statistics, financial analysis, and the Wilcoxon Signed Rank Test. Descriptive statistics were employed to provide a comprehensive overview of the dataset and to summarize key variables related to smallholder layer-chicken farming before, during, and after the COVID-19 pandemic. The mean (average) provides a measure of central tendency and was computed using the formula:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \quad ...(1)$$

Where $\bar{x}$ represents the mean, n is the total number of observations, and is the number of individual data points.

The standard deviation measures the dispersion of data around the mean and was calculated using the formula:

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2} \quad ...(2)$$

Where σ represents the standard deviation.

The financial analysis was applied to assess the financial performance and the resilience of smallholder layer-chicken farmers. Profit, a fundamental measure of financial performance, was calculated using the formula (Pyndick & Rubinfeld, 2015):

$\pi = TR - TC$

$\pi = TR - (FC + VC)$ ... (3)

Where π represents the profit per year, TR is the total revenue per year, TC is the total cost per year, FC is the fixed cost per year, and VC is the variable cost per year.

The Wilcoxon Signed Rank Test was employed to determine the statistically significant differences of profit levels in two periodic times, between before and during the COVID-19 pandemic and between during and after the COVID-19 pandemic. Wilcoxon Signed Rank Test was suitable for non-normally distributed data. According to Conover (1999), the formula for the Wilcoxon Signed Rank Test statistic (Z) is:

$$Z = \frac{T - \frac{n(n+1)}{4}}{\sqrt{\frac{n(n+1)(2n+1)}{24}}} \quad ...(4)$$

Where T is the sum of the signed ranks, and n is the number of observations. The crucial value of Z is compared to the critical values to determine statistical significance. To calculate the test statistic (Z), we first determine T, which represents the sum of the signed ranks of the differences between paired observations. Positive differences are assigned ranks from 1 to n, while negative differences are assigned a rank from -1 to -n. The absolute value of the differences is used to calculate T. The formula for T is:

$T = min\ (W^+, W^-)$ ... (5)

Where W^+ is the sum of ranks for positive differences and W^- is the sum of ranks for negative differences. The statistical hypothesis in this study is:

Ho: There is no significant difference in profit levels before and during the COVID-19 pandemic.

H1: There is a significant difference in profit levels before and during the COVID-19 pandemic.

RESULTS

Population and Production of Smallholder Layer-Chicken Farmers

Table 2 shows an overview of the layer chicken population, total production, and productivity of layer chickens before and after the COVID-19 pandemic in Indonesia. The layer chicken population accounted for 4,266 heads before the COVID-19 pandemic (2019). However, in the early period of the COVID-19 pandemic, the layer chicken population experienced a decline of 3,595 heads (2020) and 3,402 heads (2021). After the COVID-19 pandemic, the population experienced a slight increase to 3,936 heads. Despite the challenges posed by the COVID-19 pandemic, smallholder layer-chicken farms in Indonesia demonstrated resilience in maintaining their populations.

Before the COVID-19 pandemic in 2019, the average egg productivity for layer chickens in Indonesia

was 82.44%, and egg production accounted for 3.52 tons per day (Table 2). At the beginning of the COVID-19 pandemic, the average egg productivity for layer chickens slightly decreased to 80.67%, and the average egg production decreased to 2.90 tons per day. The COVID-19 pandemic brought about a slight decline in egg productivity and a reduction in egg production. In 2020, the average egg productivity dropped to 80.67%, or decreased by 2.15%, reflecting the initial challenges during the COVID-19 pandemic faced by smallholder layer chicken farming. The average daily egg production decreased to 2.90 tons per day, or a decrease of 17.61%, signifying a decrease in the overall output.

In 2021, the average egg productivity for layer chickens remained steady at 80.73%, and average egg production continued to decline to 2.75 tons per day or continuously decreased by 5.17%. This suggests that despite efforts to maintain productivity levels, the sector still faced ongoing COVID-19 pandemic impacts that affected the overall output of eggs. These impacts could include disruptions in the supply chain and changes in consumer demand. Furthermore, in 2022, the average egg productivity for layer chickens slightly increased to 81.35% or increased by 0.77%, and the average egg production rebounded to 3.20 tons per day or increased by 16.36%. Despite these setbacks, there were signs of improvement in productivity levels by 2022, indicating the resilience of smallholder layer-chicken farms in adapting to and overcoming the impacts of the COVID-19 pandemic.

Financial Analysis of Smallholder Layer-Chicken Farmers

Table 3 shows a financial analysis of layer chicken farms before and after the COVID-19 pandemic at a scale of 100 heads from survey locations. In 2019, before the pandemic, the average total operational costs were 25.927 million IDR per year. It increased by 8.38%, becoming 28.100 million IDR in 2020, then continuously increased by 10.24% to 28.583 million IDR in 2021. After the COVID-19 pandemic, the average total operational cost remained high, with the increase reaching 14.84% and reaching 29.775 million IDR in 2022.

Fixed costs, consisting of cage depreciation, equipment depreciation, and other expenses, remained relatively consistent over the years. These costs are associated with maintaining infrastructure and equipment for the functioning of the operational business. Stable fixed costs indicate that the chicken layer farms were able to manage efficiently during the COVID-19 pandemic. Average cage depreciation was 385 thousand IDR, and

Table 2. Average population, total production, and productivity of layer chickens before and after the COVID-19 pandemic at the research sites in Indonesia

Condition*	Year	Population (heads/farmers)	Egg productivity (%)	Egg production (ton/day)
Before COVID-19 pandemic	2019	4,266	82.44	3.52
During COVID-19 pandemic	2020	3,595	80.67	2.90
	2021	3,402	80.73	2.75
After COVID-19 pandemic	2022	3,936	81.35	3.20

Note: *Mean of feed consumption by 114.71 g/head/day and feces production by 66 g/head/day before, during, and after the COVID-19 pandemic.

Table 3. Financial analysis of layer chicken farming before, during, and after the COVID-19 pandemic at a scale of 100 heads obtained from survey locations (Thousand IDR/year)

Item	Before pandemic	During pandemic		After pandemic
	2019	2020	2021	2022
Average operational costs				
Purchase of pullets	5,200	7,000	7,200	7,500
Feed	24,090	26,098	26,098	28,105
Vaccines, vitamins, medicines	425	450	450	500
Electricity and water costs	1,200	1,200	1,200	1,200
Labor costs	1,800	2,000	2,000	2,000
Total operational costs	25,927	28,100	28,583	29,775
Average fixed costs				
Cage depreciation	385	385	385	385
Equipment depreciation	332	332	332	332
Other costs (land rent, taxes)	90	90	90	90
Total fixed costs	807	807	807	807
Average revenue				
Eggs sales	35,588	39,238	40,150	42,888
Cull hen sales	2,520	3,240	2,880	2,880
Manure waste	251	241	230	253
Total revenue	38,359	42,719	43,260	46,021
Profit	4,837	5,165	5,506	5,909
Revenue-cost ratio	1.1443	1.1375	1.1458	1.1473

average equipment depreciation was 332 thousand IDR. Revenue consists of income from egg sales, cull hen sales, and manure waste. Average egg sales generated most of the revenue, increasing from 35.59 million IDR in 2019 to 42.89 million IDR in 2022.

Average profit before the COVID-19 pandemic in 2019 accounted for 4,837 thousand IDR, increasing slightly to 5,165 thousand IDR in 2020 after the pandemic, further growing to 5,506 thousand IDR in 2021, and finally reaching 5,909 thousand IDR in 2022. Despite the initial impact of the COVID-19 pandemic in 2020 and increased operational costs, profitability remained relatively stable. The subsequent years (2021 and 2022) showed continued growth in profitability. Despite the initial impact of the pandemic on operational costs, smallholder layer-chicken farms managed to maintain profitability levels. There were slight increases observed in the years following the pandemic. This resilience in profitability suggests adaptability and effective management strategies employed by smallholder layer-chicken farms to mitigate the impacts of the COVID-19 pandemic on their financial performance.

The Resilience of Smallholder Layer-Chicken Farmers during the COVID-19 Pandemic

For layer chicken feed and layer chicken labor costs, the p-values for both the Shapiro-Wilk and Kolmogorov-Smirnov tests are less than 0.05 (Table 4), indicating that the data were not normally distributed. The Wilcoxon test results for feed costs reveal a statistically significant difference (Z= -3.175, p= 0.001) between the costs before and during the COVID-19 pandemic. The results indicate that the COVID-19 pandemic impacted feed costs in smallholder layer-chicken farming. Similarly, the Wilcoxon test for labor cost in layer chicken farms shows a significant difference (Z= -2.142, p= 0.032) before and during the COVID-19 pandemic. Positive rank percentage, higher than negative rank percentage (Table 5), showed that labor costs also increased during the pandemic compared to before the COVID-19 pandemic. Smallholder layer-chicken farms faced increased operational expenses during the pandemic period, attributed to various factors such as supply chain disruptions and changes in labor availability. Smallholder layer chicken farmers demonstrated resilience by adapting to cost fluctuations and managing their resources effectively to sustain their operations.

The Wilcoxon test results (Table 6) revealed a statistically significant difference in profit between the periods before and during the COVID-19 pandemic (Z= -1.974, p= 0.048, p<0.05). The rejection of Ho indicates a significant change in profit levels during the pandemic. Furthermore, during the period encompassing the COVID-19 pandemic and afterward, the Wilcoxon test results indicated a significant difference in profit levels

Table 4. Normality test output of feed cost and labor cost variables on broiler and layer chicken farming obtained from survey locations

Variables	Shapiro Wilk test		Kolmogorov Smirnov test		Hypothesis testing
	Statistic	Sig.	Statistic	Sig.	
Diff before-during the COVID-19 pandemic of layer chicken feed cost	0.556	0.000	0.317	0.000	p-value < 0.05 (Rejected Ho)
Diff before-during the COVID-19 pandemic of layer chicken labor cost	0.631	0.000	0.229	0.000	p-value < 0.05 (Rejected Ho)

Table 5. Wilcoxon signed rank test output of feed cost and labor cost variables on layer chicken farming obtained from survey locations

Variables	Z test	Asymp. Sig. (2-tailed)	Negative ranks[a] (%)	Positive ranks[b] (%)	Ties[c] (%)	Hypothesis testing
Layer chicken feed cost before and during the COVID-19 pandemic	-3.175	0.001	24.73	75.27	0.00	p-value < 0.05 (Rejected Ho)
Layer chicken labor costs before and during the COVID-19 pandemic	-2.142	0.032	26.60	68.09	5.32	p-value < 0.05 (Rejected Ho)

Note: a. The value during the Covid-19 pandemic < the value before the Covid-19 pandemic; b. The value during the Covid-19 pandemic > the value before the Covid-19 pandemic; c. The value during the Covid-19 pandemic = the value before the Covid-19 pandemic.

Table 6. Wilcoxon signed rank test output of farmer profit variable on layer chicken farming obtained from survey locations

Variables	Z test	Asymp. Sig. (2-tailed)	Negative ranks[a] (%)	Positive ranks[b] (%)	Ties[c] (%)	Hypothesis testing
Profit of layer chicken farms before and during the COVID-19 pandemic	-1.974	0.048	52.13	47.87	0.00	p-value < 0.05 (Rejected Ho)
Profit of the layer chicken farms during and after the COVID-19 pandemic	-2.923	0.003	36.17	59.57	4.26	p-value < 0.05 (Rejected Ho)

Note: a. The value during the Covid-19 pandemic < the value before the Covid-19 pandemic; b. The value during the Covid-19 pandemic > the value before the Covid-19 pandemic; c. The value during the Covid-19 pandemic = the value before the Covid-19 pandemic.

(Z= -2.923, p= 0.003, p<0.05). The rejection of Ho in this result suggests that there was a substantial difference in profit levels during and after the COVID-19 pandemic. Despite initial declines in the revenue cost ratio during the pandemic period, smallholder layer-chicken farms exhibited resilience by navigating through economic uncertainties and rebounding in revenue cost ratio levels post-pandemic.

The findings from Table 7 highlight the resilience of smallholder layer chicken farmers in West Java, Central Java, and East Java during the COVID-19 pandemic. Despite facing challenges such as a declining chicken population and fluctuations in the R/C Ratio, farmers showcased resilience by adapting their practices and rebounding in subsequent years. Strategies such as diversifying sales channels and engaging with local communities were instrumental in mitigating disruptions and fostering post-pandemic recovery.

DISCUSSION

In developing countries, smallholder layer-chicken farming holds a significant position in agriculture development in Indonesia. However, the COVID-19 pandemic outbreaks in early 2020 impacted the sustainability of the layer chicken farming. The decline in the layer chicken population in 2020 (Table 2) reflects the disruptions caused by the COVID-19 pandemic. Based on the direct survey at the farmer level, these disruptions could include challenges in the supply chain, decreased purchasing power resulting from a decrease in income & layoffs, and restrictions on poultry farming operations during the COVID-19 pandemic. The positive trend in the layer chicken population of 0.56% per year and egg production of 3.80% per year from 2017 to 2022 aligns with the growth trend of egg consumption, which was reported at 2.53% per year (Ministry of Agriculture, 2022). However, it is essential to note that the data on layer-chicken populations and egg production encompass smallholders, large companies, and layer-chicken egg integrator companies. In our research, we focused solely on smallholder layers of chicken at research sites. While this approach allowed us to observe a notable shock in production at the beginning of the COVID-19 pandemic, followed by an increase afterward, it also introduces a limitation to our findings.

Our findings were similar to those of the work by Ermanda *et al*. (2023), that logistics was one of the obstacles faced by farmers during the COVID-19 pandemic. The subsequent years, 2021 and 2022, witnessed a recovery in the layer chicken population. This recovery highlights the resilience and adaptability of the smallholder layer-chicken farmers in Indonesia. A study by Syahlani *et al.* (2021) stated that experience and endurance levels were important keys in conducting resilience management to mitigate the impacts of the COVID-19 pandemic on layer chicken farms in Yogyakarta Province. Farmers and stakeholders adjusted the strategies and navigated the challenges to sustain the layer chicken farms.

A positive trend emerged in 2022 as egg productivity for layer chickens increased, indicating that the sector can adapt and improve its efficiency through better management practices and by addressing some of the issues that emerged during the COVID-19 pandemic. The current study found no change in the daily feed intake of the layer chickens either before, during, or after the COVID-19 pandemic. The average daily intake remains constant at 114.71 g/head per day. That is below the range of Clark *et al.* (2019), who reported that feed intake for layer hens in a day is around 120–136 g/head. It indicated that feed intake in this current study was more efficient.

However, the study also recorded a decline in the feed quality available during the COVID-19 pandemic. The nutrient content, especially the energy and protein content of the diet, declined. Therefore, most of the egg productivity reduction (Table 2) during the COVID-19 pandemic was caused by the lower nutrient intake by the layer chicken. Kim & Kang (2022) reported that layer chicken must receive enough nutrients to guarantee and maintain optimum egg productivity. Moreover, since there was also a decrease in the number of layer chickens kept in the barn during the COVID-19 pandemic (Table 2), the average amount of egg produced (ton/day) was also decreased (Table 2). A similar finding was reported by Taiye *et al*. (2022), who conducted the study in Oyo State, Nigeria. Feed ingredients for the layer were insufficient during the COVID-19 pandemic, resulting in a decline in egg productivity.

After the COVID-19 pandemic, the average total operational cost remained high, which can be attributed

Table 7. The resilience of smallholder layer chicken farmers during the COVID-19 pandemic in research sites in Indonesia

Resilience factor	Findings
Layer chicken population	The layer chicken population showed a decline at the beginning of the pandemic but rebounded in 2022 with post-pandemic recovery (Table 2).
Financial analysis	The R/C Ratio (Revenue/Cost Ratio), although relatively stable, showed a decline at the beginning of the pandemic from 1.1443 to 1.1375. Subsequently, the R/C ratio showed an increase in 2021 and 2022, reaching 1.1458 and 1.1473, respectively (Table 3).
Flexibility in the sales chain	At the beginning of the pandemic, farmers could sell eggs directly to consumers and local traders without needing to go through lengthy sales chains.
Market diversification	Farmers were able to redirect sales to local markets and directly to consumers when large distribution markets were disrupted due to the COVID-19 pandemic.
Community engagement	There was support from the local community and/or government programs (social assistance in the form of egg products) purchased directly from smallholder layer chicken farmers.

to rising input prices, including feed, medicines, and labor costs, as well as potential disruptions in the supply chain. The subsequent years (2021 and 2022) saw a continued increase in operational costs. The average total operational costs of the layer chicken farming farms include purchasing pullets, feed, vaccines, vitamins, medicines, disinfectants, electricity and water, and labor costs. Similar to the study by Taiye et al. (2022) in Oyo State, Nigeria, the presence of the COVID-19 pandemic was statistically significant in reducing the level of income of poultry farmers due to the higher input or production costs. Moreover, a study conducted in Nigeria by Esiegwu *et al.* (2021) indicated the scarcity of production inputs and the high cost of feed ingredients, leading to high poultry product prices and high production costs. The feasibility of egg poultry in Blitar-Indonesia was also reduced during the COVID-19 pandemic (Sholihin *et al.*, 2022).

Despite the challenges posed by the COVID-19 pandemic, egg sales showed consistent growth, which suggests that there was sustained demand for eggs, potentially due to their importance as a source of animal protein. The COVID-19 pandemic did not affect egg demand at the consumer level in Indonesia (Evalia *et al*., 2022), while other countries' demand for eggs has increased by 20%–35%, such as in England (Hafez *et al*., 2021). Profitability is a crucial aspect of smallholder layer-chicken farming. Furthermore, the revenue-cost ratio is an essential metric for assessing the efficiency and profitability of layer chicken farming. The revenue-cost ratio reflects the decrease in the initial COVID-19 pandemic.

The increased cost of production, such as inputs and transportation, resulted in a decline in chicken farmer revenue and profit in Sri Lanka (Mufeeth & Kaldeen, 2022). Belarmino *et al.* (2023) reported that increasing feed costs in Brazil increased production costs, thus decreasing the farmer's profit. Furthermore, many smallholder poultry farmers in Bangladesh were also forced to shut down due to high feed costs and inadequate support from external sources (Amin *et al*., 2023). The data indicates a decrease in the revenue-cost ratio after the COVID-19 pandemic, which suggests that while revenue increased, the rate of cost increase outpaced it. However, the revenue-cost ratio improved in 2021 and 2022, reflecting a better balance between revenue and costs. The financial analysis showed the resilience of layer chicken farming in the face of the COVID-19 pandemic. Despite increased operational costs, the layer chicken farms were adaptable and profitable.

The Wilcoxon Signed Rank Test was employed to assess the impact of the COVID-19 pandemic on feed cost and labor cost variables in smallholder layer chicken farming in Indonesia. This non-parametric test was chosen since the data had a non-normal distribution and were analyzed by the Shapiro-Wilk and Kolmogorov-Smirnov tests, where the null hypothesis (Ho) of normality was rejected for all variables. The result showed that the positive rank percentage (75.27%) indicates that, on average, feed costs increased during the COVID-19 pandemic compared to before the COVID-19 pandemic. This finding is consistent with the broader economic trends during the COVID-19 pandemic, where disruptions in supply chains and increased demand for certain goods led to rising input costs and income shocks (Biswal *et al*., 2020; Kansiime *et al*., 2021; Weersink *et al*., 2021). The COVID-19 pandemic has impacted about 94.3% of micro, small, and medium-sized enterprises, primarily through decreased sales and lower access to inputs and financing (Nordhagen *et al*., 2021). Even volatile markets led to the permanent closure of many farms (Sattar *et al*., 2021).

Similarly, the Wilcoxon test for layer chicken labor cost indicates a statistically significant difference before and during the COVID-19 pandemic. This finding aligns with the challenges faced by many industries during the COVID-19 pandemic, including labor shortages, increased labor safety measures, and potential disruptions in labor supply (Fan *et al*., 2021). Even in Myanmar, more than 40% of chicken farm workers have lost permanent employment since the beginning of the COVID-19 pandemic (Fang *et al*., 2021). These findings have implications for smallholder layer-chicken farmers in Indonesia. The significant increases in feed and labor costs during the COVID-19 pandemic suggest that farmers may have had to adapt their farming practices and costs to accommodate these changes. Optimizing local feed utilization, cost-effective labor, and government support may have been essential for maintaining profitability and sustainability during the COVID-19 pandemic period. Understanding the specific costs faced by smallholder-layer chicken farmers can inform targeted interventions (Bamidele & Amole, 2021).

The Wilcoxon Signed Rank Test was also employed to evaluate the impact of the COVID-19 pandemic on farmer profit variables due to the non-normal distribution of the data. The Wilcoxon test results (Table 6) revealed a statistically significant difference in profit between the periods before and during the COVID-19 pandemic. The income reduction of the farmers during COVID-19 pandemic was due to increased feed and pullet prices. Moreover, it was also due to a reduction in the demand for poultry products because of the movement restriction (lockdown) applied by the Government during the COVID-19 pandemic. The result was similar to those reported by Setiadi *et al*. (2022) and Mishra *et al*. (2023), that the sharp decrease in the farmer's income was due to supply-demand mechanisms, which also occurs in Bangladesh (Sattar *et al*., 2021).

The statistically significant difference in profit levels observed during the COVID-19 pandemic indicated that smallholder layer-chicken farmers promptly adapted to the changing circumstances. These adaptations included production methods, farming practices, market demands, and product distribution channels. Increased online sales and marketing during the first year of the COVID-19 pandemic showed more resilience to the shocks of the COVID-19 pandemic (Durant *et al*., 2023). On the other hand, governments have implemented policies and programs aimed at assisting smallholder farmers during the COVID-19 pandemic, including financial support, access to

markets, and increasing smallholder farmers' capacity. The previous studies proved that improving chicken genetics through government policy to smallholder farming households holds great potential for economic growth and resilience during the COVID-19 pandemic (Bamidele *et al*., 2023). Resilience should not be limited to the immediate survival of layer chicken farmers but should also encompass strategies for enduring economic and sustainability challenges in the future. According to Durrant et al. (2003), the greater use of non-direct-to-consumer market channels was associated with less resilience. Producer-consumer links also increase the ability of consumers to access fresh products, higher quality, and affordable prices (Tittonell *et al*., 2021).

If compared to an avian influenza (AI) outbreak, it appears that both the COVID-19 pandemic and the Avian Influenza outbreak have significant impacts, albeit in different ways. The COVID-19 pandemic has primarily affected human health and the global economic sectors, leading to widespread health crises, economic downturns, and disruptions in various industries, including smallholder-layer chicken farms. On the other hand, Avian Influenza predominantly affects the poultry industry, causing substantial losses in poultry populations and economic damage to smallholder poultry farms (Boni *et al*., 2013). Understanding the distinct impacts of both diseases and their interactions is crucial for effective mitigation and response strategies to protect human and animal health, as well as to ensure the resilience of smallholder layer chicken farms in the face of emerging infectious diseases. This would be an interesting topic for future research to explore.

Policymakers and stakeholders can develop strategies to enhance the resilience of smallholder layer chicken farming to future disruptions. Some suggestions to cope with the impact of the COVID-19 pandemic include ensuring effective logistics and supply of critical inputs, supporting agricultural production and farmers, using innovative methods to promote sales (Pu & Zhong, 2020), providing financial support and stabilizing agriculture production and product supply (Pan *et al*., 2020). Moreover, the strengthening and the growth of smallholder farmers in facing the COVID-19 pandemic case required connection, networking, innovation, and technology adoption (O'Connell *et al*., 2021). In the future, to assist in mitigating the financial effects of potential COVID-19 pandemics, it is essential to strengthen the resilience of the layer poultry industry by making investments in dependable diagnostic tools and kits, efficient disease management and control (Jan *et al*., 2023), and research into novel treatments.

CONCLUSION

Smallholder layer-chicken farms have demonstrated resilience in maintaining their populations and productivity levels. Despite experiencing significant impacts on operational costs, particularly in feed and labor expenses, farmers have shown adaptability by effectively managing resources to sustain their operations. Fluctuations in the revenue-cost ratio throughout different COVID-19 pandemic phases highlight the sector's ability to navigate economic uncertainties and rebound in post-COVID-19 pandemic recovery. Furthermore, diversifying sales channels and engaging with local communities are crucial in mitigating disruptions and fostering resilience. These findings underline the resilience and adaptability of smallholder layer chicken farms during and after the COVID-19 pandemic in Indonesia.

CONFLICT OF INTEREST

The authors confirm no conflict of interest with any personal, financial, or other organizations related to the material discussed in the manuscript.

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REFERENCES

Amin, M. R., G. M. M. Alam, M. T. Parvin, & D. C. Acharjee. 2023. Impact of COVID-19 on poultry market in Bangladesh. Heliyon 9:e13443. https://doi.org/10.1016/j.heliyon.2023.e13443

Attia, Y. A., Md. T. Rahman, Md. J. Hossain, S. Basiouni, A. F. Khafaga, A. A. Shehata, & H. M. Hafez. 2022. Poultry production and sustainability in developing countries under the COVID-19 Crisis: Lessons learned. Animals 12:644. https://doi.org/10.3390/ani12050644

Bamidele, O., O. M. Akinsola, A. Yakubu, W. A. Hassan, U. E. Ogundu, & T. A. Amole. 2023. Growth performance, survivability and profitability of improved smallholder chicken genetics in Nigeria: A COVID-19 intervention study. Front. Genet. 13:1033654. https://doi.org/10.3389/fgene.2022.1033654

Bamidele, O. & T. A. Amole. 2021. Impact of COVID-19 on smallholder poultry farmers in Nigeria. Sustainability 13:11475. https://doi.org/10.3390/su132011475

Belarmino, L. C., M. N. Pabsdorf, & A. D. Padula. 2023. Impacts of the COVID-19 pandemic on the production costs and competitiveness of the Brazilian chicken meat chain. Economies 11:238. https://doi.org/10.3390/economies11090238

Biswal, J., K. Vijayalakshmy, & H. Rahman. 2020. Impact of COVID-19 and associated lockdown on livestock and poultry sectors in India. Vet. World 13:1928–1933. https://doi.org/10.14202/vetworld.2020.1928-1933

Boni, M. F., A. P. Galvani, A. L. Wickelgren, & A. Malani. 2013. Economic epidemiology of avian influenza on smallholder poultry farms. Theor. Popul. Biol. 90:135-144. https://doi.org/10.1016/j.tpb.2013.10.001

Clark, C. E. F., Y. Akter, A. Hungerford, P. Thomson, M. R. Islam, P. J. Groves, & C. J. O'Shea. 2019. The intake pattern and feed preference of layer hens selected for high or low feed conversion ratio. PLoS One 14:e0222304. https://doi.org/10.1371/journal.pone.0222304

Conover, W. J. 1999. Practical Nonparametric Statistics (3rd ed.). John Wiley & Sons, Inc.

Das, P. K. & I. Samanta. 2021. Role of backyard poultry in South-East Asian countries: Post COVID-19 perspective. Worlds Poult. Sci. J. 77:415–426. https://doi.org/10.1080/00439339.2021.1893620

Dixon, J. M., J. Weerahewa, J. Hellin, M. F. Rola-Rubzen, J. Huang, S. Kumar, A. Das, M. E. Qureshi, T. J. Krupnik, K. Shideed, M. L. Jat, P. V. V. Prasad, S. Yadav, A. Irshad, A. Asanaliev, A. Abugalieva, A. Karimov, B. Bhattarai, C. Q. Balgos, F. Benu, H. Ehara, J. Pant, J. Sarmiento, J. Newby, J. Pretty, H. Tokuda, H. Weyerhaeuser, L. Digal, L. Li, M. Sarkar, M. Abedin, P. Schreinemachers, Q. Grafton, R. Sharma, S. Saidzoda, S. Lopez-Ridaura, S. Coffey, S. Kam, S. Win, S. Praneetvatakul, T. Maraseni, V. Touch, W. Liang, Y. Saharawat, & J. Timsina. 2021. Response and resilience of Asian agrifood systems to COVID-19: An assessment across twenty-five countries and four regional farming and food systems. Agric. Syst. 193:103168. https://doi.org/10.1016/j.agsy.2021.103168

Durant, J. L., L. Asprooth, R. E. Galt, S. P. Schmulevich, G. M. Manser, & N. Pinzón. 2023. Farm resilience during the COVID-19 pandemic: The case of California direct market farmers. Agric. Syst. 204:103532. https://doi.org/10.1016/j.agsy.2022.103532

Ermanda, A. P., R. D. Haloho, W. S. Nugraha, T. F. Silitonga, B. P. Febrina, I. Irmayanti, N. A. Pratiwi, & A. A. Mahanani. 2023. Impact of the covid-19 pandemic on poultry feed distribution in Lima Puluh Kota District, West Sumatera Province. Agrisocionomics: Jurnal Sosial Ekonomi Pertanian 7:279–287.

Esiegwu, A. C. & R. D. Ejike. 2021. Effects of covid-19 on poultry production in south-east agro-ecological zone of Nigeria. Nigerian Journal Animal Production 48:253–261. https://doi.org/10.51791/njap.v48i4.3003

Evalia, N. A., H. Harianto, R. Nurmalina, & D. B. Hakim. 2022. Price transmission between input and output markets: The Covid-19 effect on laying hens' industry in Indonesia. Jurnal Manajemen Agribisnis 19:418-427. https://doi.org/10.17358/jma.19.3.418

Fan, S., P. Teng, P. Chew, G. Smith, & L. Copeland. 2021. Food system resilience and COVID-19 – Lessons from the Asian experience. Glob. Food Sec. 28:100501. https://doi.org/10.1016/j.gfs.2021.100501

Fang, P., B. Belton, X. Zhang, & H. Ei Win. 2021. Impacts of COVID-19 on Myanmar's chicken and egg sector, with implications for the sustainable development goals. Agric. Syst. 190:103094. https://doi.org/10.1016/j.agsy.2021.103094

Hafez, H. M., Y. A. Attia, F. Bovera, M. E. Abd El-Hack, A. F. Khafaga, & M. C. de Oliveira. 2021. Influence of COVID-19 on the poultry production and environment. Environ. Sci. Pollut. Res. 28:44833–44844. https://doi.org/10.1007/s11356-021-15052-5

Hamid, M. A., M. A. Rahman, S. Ahmed, & K. M. Hossain. 2016. Status of poultry industry in Bangladesh and the role of private sector for its development. Asian Journal Poultry Science 11:1–13. https://doi.org/10.3923/ajpsaj.2017.1.13

Hatta, M., Sulakhudin, R. Burhansyah, G. C. Kifli, D. O. Dewi, J. C. Kilmanun, D. Permana, K. Supriadi, R. Warman, H. Azis, P. T. Santari, & D. P. Widiastuti. 2023. Food self-sufficiency: Managing the newly-opened tidal paddy fields for rice farming in Indonesia (A case study in West Kalimantan, Indonesia). Heliyon 9:e13839. https://doi.org/10.1016/j.heliyon.2023.e13839

Hayes, D. J., L. L. Schulz, C. E. Hart, & K. L. Jacobs. 2021. A descriptive analysis of the COVID-19 impacts on U.S. pork, turkey, and egg markets. Agribusiness 37:122–141. https://doi.org/10.1002/agr.21674

Holt-Giménez, E. & M. A. Altieri. 2012. Agroecology, food sovereignty and the new green revolution. Journal Sustainable Agriculture 120904081412003. https://doi.org/10.1080/10440046.2012.716388

Horst, M. & A. Marion. 2019. Racial, ethnic and gender inequities in farmland ownership and farming in the U.S. Agric. Human Values 36:1–16. https://doi.org/10.1007/s10460-018-9883-3

Kansiime, M. K., J. A. Tambo, I. Mugambi, M. Bundi, A. Kara, & C. Owuor. 2021. COVID-19 implications on household income and food security in Kenya and Uganda: Findings from a rapid assessment. World Dev. 137:105199. https://doi.org/10.1016/j.worlddev.2020.105199

Kim, C. H. & H. K. Kang. 2022. Effects of Energy and protein levels on laying performance, egg quality, blood parameters, blood biochemistry, and apparent total tract digestibility on laying hens in an aviary system. Animals 12:3513. https://doi.org/10.3390/ani12243513

Marsden, A. R., K. K. Zander, & J. A. Lassa. 2023. Smallholder farming during COVID-19: A systematic review concerning impacts, adaptations, barriers, policy, and planning for future pandemics. Land 12:404. https://doi.org/10.3390/land12020404

Ministry of Agriculture. 2022. Outlook Komoditas Peternakan Telur Ayam Ras Petelur. Center for Agricultural Data and Information Systems, Ministry of Agriculture, Republic of Indonesia.

Mishra, P., A. Golaviya, K. Panchal, A. Hinsu, K. Yadav, G. Fournié, T. Barnett, P. Koringa, H. U. I. Paleja, & R. Dasgupta. 2023. Exploring the impact of COVID-19 and the associated lockdown on the production, distribution, and consumption of poultry products in Gujarat, India: A qualitative study. Poultry 2:395–410. https://doi.org/10.3390/poultry2030029

Mufeeth, M. & M. Kaldeen. 2022. Impact of COVID-19 outbreak on smallholder producers of farming products supply to tourism business in Sri Lanka. In Tourism and Hospitality in Asia: Crisis, Resilience and Recovery (p. 125–140). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-5763-5_9

Nordhagen, S., U. Igbeka, H. Rowlands, R. S. Shine, E. Heneghan, & J. Tench. 2021. COVID-19 and small enterprises in the food supply chain: Early impacts and implications for longer-term food system resilience in low- and middle-income countries. World Dev. 141:105405. https://doi.org/10.1016/j.worlddev.2021.105405

O'Connell, C., R. Gay, N. McDonald, & S. Tayal. 2021. COVID connections: Lessons from adaptations to COVID-19 as strategies for building food system resilience. Cult. Agric. Food Environ. 43:123–136. https://doi.org/10.1111/cuag.12276

Pan, D., J. Yang, G. Zhou, & F. Kong. 2020. The influence of COVID-19 on agricultural economy and emergency mitigation measures in China: A text mining analysis. PLoS One 15:e0241167. https://doi.org/10.1371/journal.pone.0241167

Pu, M. & Y. Zhong. 2020. Rising concerns over agricultural production as COVID-19 spreads: Lessons from China. Glob. Food Sec. 26:100409. https://doi.org/10.1016/j.gfs.2020.100409

Pyndick, R. S. & D. L. Rubinfeld. 2015. Microeconomics, Eight Edition. Pearson Education, Inc.

Sattar, A. Al, R. Mahmud, Md. A. S. Mohsin, N. N. Chisty, Md. H. Uddin, N. Irin, T. Barnett, G. Fournie, E. Houghton, & Md. A. Hoque. 2021. COVID-19 impact on poultry production and distribution networks in Bangladesh. Front. Sustain. Food Syst. 5:714649. https://doi.org/10.3389/fsufs.2021.714649

Setiadi, A., S. I. Santoso, S. Nurfadillah, K. Prayoga, & J. Mariyono. 2022. Economics of egg price, consumption,

and income of laying hen farmers during of COVID-19 pandemic in Central Java, Indonesia. Agrisocionomics: Jurnal Sosial Ekonomi Kebijakan Pertanian 6:394–401.

Sholihin, N., N. Haryuni, & L. Lestariningsih. 2022. The impact of the Covid-19 pandemic on the feasibility of the laying hens business in Sumberejo village, Blitar Regency, East Java Province, Indonesia. J. Dev. Res. 6:131–136. https://doi.org/10.28926/jdr.v6i1.210

Syahlani, S. P., N. M. A. Kusuma Dewi, & G. A. Insani. 2021. Resiliency management of layer poultry farm business during COVID-19 pandemic in the Yogyakarta special Province. Livest. Anim. Res. 19:217. https://doi.org/10.20961/lar.v19i2.51971

Taiye, O. B., O. B. Kehinde, O. B. Oluyemisi, & O. A. Omobolanle. 2022. Effect of COVID-19 pandemic on egg production and income of the marketers among poultry farmers in ido local government area of Oyo State, Nigeria. Russ. J. Agric. Socioecon. Sci. 8:167–175.

Tittonell, P., M. Fernandez, V. E. El Mujtar, P. V. Preiss, S. Sarapura, L. Laborda, M. A. Mendonça, V. E. Alvarez, G. B. Fernandes, P. Petersen, & I. M. Cardoso. 2021. Emerging responses to the COVID-19 crisis from family farming and the agroecology movement in Latin America – A rediscovery of food, farmers and collective action. Agric. Syst. 190:103098. https://doi.org/10.1016/j.agsy.2021.103098

Walker, S. & J. I. Baum. 2022. Eggs as an affordable source of nutrients for adults and children living in food-insecure environments. Nutr. Rev. 80:178–186. https://doi.org/10.1093/nutrit/nuab019

Weersink, A., M. von Massow, N. Bannon, J. Ifft, J. Maples, K. McEwan, M. G. S. McKendree, C. Nicholson, A. Novakovic, A. Rangarajan, T. Richards, B. Rickard, J. Rude, M. Schipanski, G. Schnitkey, L. Schulz, D. Schuurman, K. Schwartzkopf-Genswein, M. Stephenson, J. Thompson & K. Wood. 2021. COVID-19 and the agri-food system in the United States and Canada. Agric. Syst. 188:103039. https://doi.org/10.1016/j.agsy.2020.103039