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Evaluation of the Performance of Automatic Temperature Control Technology in a Closed House Broiler Chicken Production System

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Abstract

This study evaluates the performance of various automatic temperature control technologies in a closed-house system for broiler chicken production. Four key technologies were assessed: CTI 80, CTI Alpha, Punos, and Temptron, based on three main parameters: chicken mortality rate, growth (average final body weight), and production efficiency (Feed Conversion Ratio/FCR). Data were collected through direct observation, daily records, and final measurements on farms with a minimum population of 80,000 chickens per house. The statistical analysis revealed that CTI Alpha demonstrated the best performance with the lowest mortality rate (255 chickens) and high stability in temperature control. CTI 80 ranked second with performance close to CTI Alpha, followed by Punos. In contrast, Temptron exhibited the lowest performance with the highest mortality rate (595 chickens) and high data variability. The One-Way ANOVA test showed significant differences among the tested technologies ($p < 0.05$), while the Post Hoc Games-Howell analysis confirmed that CTI Alpha, CTI 80, and Punos performed significantly better than Temptron. This study recommends that farmers adopt CTI Alpha or CTI 80 technologies to optimize broiler chicken production. These technologies not only enhance productivity by reducing mortality rates but also support industry sustainability through resource efficiency and adaptability to climate change. This study provides valuable insights for farmers in selecting appropriate technologies tailored to their specific needs and contributes to the broader understanding of effective temperature control systems in broiler chicken farming.

Keywords : automatic temperature control; closed-house system; broiler chickens; production efficiency; farming technology

INTRODUCTION

The broiler chicken farming industry has become a major pillar in meeting global animal protein needs, especially in developing countries such as Indonesia. The demand for chicken meat in Indonesia continues to increase significantly, which is consistent with population growth and changes in people's consumption patterns. Based on data from the Indonesian Ministry of Agriculture, per capita chicken meat consumption in 2022 reached 12.5 kg per year, up from 9.2 kg per year in 2015. With Indonesia's population exceeding 270 million people, the total national chicken meat requirement is estimated to exceed 3.37 million tons annually, making chicken meat more popular than beef. Globally, the demand for chicken meat also continues to increase, with a projection of reaching 153 million tons in 2030, as reported in the OECD-FAO Agricultural Outlook 2023.

Thus, the sustainability of the broiler chicken farming industry is essential for addressing the challenge of high demand (Bist et al., 2024). One of the main challenges in meeting this need is to maintain the optimal environmental conditions of the cage, particularly the temperature. Temperature instability due to the tropical climate in Indonesia often triggers thermal stress in broiler chickens, which has a direct impact on decreased appetite, stunted growth, increased mortality rates, and significant financial losses. Therefore, automatic temperature control technology is an essential component of closed-house systems to ensure high productivity (Kpomasse et al., 2021). This is because automatic temperature control technology offers various advantages, such as maintaining temperature stability, increasing operational efficiency, and minimizing the risk of losses due to suboptimal environmental conditions(Liu et al., 2020).

However, the adoption of this technology still faces several significant challenges. Farmers' lack of understanding of the features and how the equipment works often results in suboptimal use of the technology(La Mema Parandy et al., 2024). In addition, the high initial investment costs for adopting automatic temperature control systems such as CTI 80, CTI Alpha, Punos, and Temptron are barriers, especially for farmers on small to medium production scales. Limited performance evaluation of the various available systems also complicates the decision-making process, making it difficult for farmers to determine which technology best suits their specific needs in terms of capacity, efficiency, and sustainability.

This condition has encouraged several studies to offer innovative solutions. Sebayang et al., (2017) designed a microcontroller-based temperature control system with a DHT11 temperature sensor and motor driver to optimize the cage temperature. Meanwhile, La Mema Parandy et al., (2024) used a Temptron as the main controller and was equipped with a heater, fan, and cooling pad to maintain the cage temperature stable. On the other hand, Surateno et al., (2024) developed an IoT-based monitoring system to control the temperature of chicken cages via a Bluetooth application. These studies show that automatic temperature control technology plays an important role in increasing the efficiency of broiler chicken farms. However, most studies have focused more on technology design and technical trials without comparing the performance of various technologies that have been used in the field. This leaves a research gap in the quantitative evaluation of the effectiveness and efficiency of automatic temperature control devices in actual broiler chicken production systems.

Although various automated temperature control technologies are available, comparative evaluations of the performance of technologies such as CTI 80, CTI Alpha, Punos, and Temptron are still very limited. In addition, the lack of quantitative studies that discuss the impact of these technologies on the mortality, growth, and production efficiency of broiler chickens in closed-house systems further emphasizes the need for further research.

The performance of the automatic temperature control system was quantitatively evaluated. This study will analyze the impact of the use of technologies such as CTI 80, CTI Alpha, Punos, and Temptron on the mortality rate, growth, and production efficiency of broiler chickens. Data analysis will be conducted using the One-Way ANOVA test method, which allows for a comparison of the effectiveness of each technology under different operational conditions. The results of this study are expected to provide practical guidance for farmers in choosing the technology that best suits their specific needs, as well as contribute to the sustainability and efficiency of the broiler chicken farming industry in facing increasing market demand.

METHODS

The performances of various automatic temperature control technologies in a closed-house system on a broiler chicken farm were evaluated. The research stages were designed systematically so that they can be easily understood and applied. This comparative descriptive study aims to compare the performances of four automatic temperature control technologies: CTI 80, CTI Alpha, Punos, and Temptron. The comparison was made based on three main parameters: a) Chicken Mortality Rate, namely the number of chickens that died during the maintenance cycle. b) Chicken Growth, namely the average weight of chickens (grams/head) at the end of the cycle. c) Production Efficiency (FCR), namely the ratio between the amount of feed used and the weight gain of chickens.

The study population comprised closed-house broiler chicken farms that used automatic temperature control technology. The study sample consisted of four farms, each using a technology (CTI 80, CTI Alpha, Punos, or Temptron). Each farm had a minimum chicken population of 80,000 in each cage to ensure valid and representative results.

1. Identification of Farms using Automatic Temperature Control Technology
   The farms that use automated temperature control technology are identified. Ensure that chicken houses have equal populations for each technology. Calibrate temperature and humidity meters.
2. Data Collection
   Data collection was carried out using three approaches: a) observation by observing the use of technology and daily temperature settings in each cage. b) Daily recording such as temperature and humidity of the cage and the number of chickens that died each day. c) Final measurement by weighing the average weight of the chickens at the end of the maintenance cycle and calculating the amount of feed used to calculate the FCR.
3. Data Analysis
   The analysis method used in this study included the following stages:
   a. The normality test uses two approaches, namely Kolmogorov-Smirnov to test whether the data distribution approaches a normal distribution. Shapiro-Wilk is used for small to medium samples ($n < 50$).

b. The homogeneity test uses Levene's test to ensure that the data variance between treatment groups is homogeneous, which is also a requirement for conducting One-Way ANOVA. If the p-value is >0.05, the data variance is considered homogeneous. After the assumptions of normality and homogeneity are met.
c. One-Way ANOVA test, which aims to test whether there is a significant difference between the performance of four automatic temperature control technologies based on mortality rates, average body weight, and production efficiency (Feed Conversion Ratio/FCR). A p-value <0.05, then there is a significant difference between the technology groups. To identify which pairs of groups were significantly different, the Post Hoc Games-Howell test was conducted, which was chosen because it does not require homogeneity of variance. Pairs of groups, such as CTI 80 vs. CTI Alpha or Punos vs. Temptron, were tested to determine which technology gave the best results based on each variable. The results of this series of analyses are expected to provide recommendations for the most effective and efficient automatic temperature control technology.

RESULT AND DISCUSSION

The results of this study show the development of broiler chickens by observing the total mortality of chickens during one maintenance period from a population of 20,000 for each temperature setting, namely Temptron, Punos, CTI 80, and CTI Alpha. The total mortality of chickens in one period provides an initial picture of the effectiveness of each tested automatic temperature control technology. The data presented in the following Figure shows that there are variations in the number of chicken deaths based on the technology used, which will be further analyzed in the next stage.

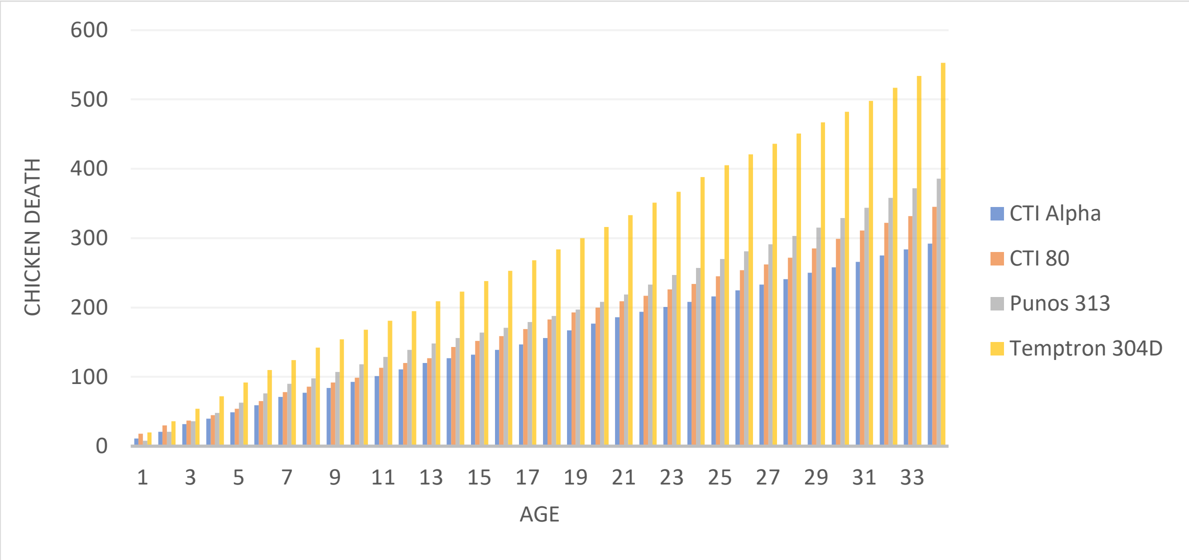

Figure 1. Number of Chicken Fatalities

Figure 1 shows that the number of chicken deaths (CHD) continues to increase with the aging of chickens (AGE) in all tested technologies. This trend is normal in broiler chicken farming, where the risk of mortality tends to increase because of various factors, such as environmental stress, disease, or quality of management. Based on the comparison, Temptron 304D recorded the highest number of deaths at each age stage, with 595 deaths at the end of the rearing period. Punos 313 performed better than Temptron 304D, but still recorded a fairly high number of deaths (398 birds. CTI 80 showed a more stable performance, with a lower number of deaths of 314 birds. CTI Alpha recorded the best performance with the lowest total deaths, namely only 255 birds throughout the rearing period. These data indicate that CTI Alpha technology provides more effective temperature control, thereby minimizing broiler chicken mortality.

The difference between the Temptron 304D and other technologies becomes larger as the chickens age, indicating the weakness of the Temptron 304D temperature control system in meeting the needs of a more stable environment in older chickens. In contrast, CTI Alpha and CTI 80 were able to maintain low mortality rates until the end of the rearing period, making these technologies more suitable for use in broiler chicken farms with a closed-house system. Based on these results, farmers are advised to use technologies such as CTI Alpha or CTI 80 to minimize chicken mortality. Meanwhile, the Temptron 304D requires further evaluation to improve its performance in temperature control. These results indicate that the effectiveness of automatic temperature control technology has a significant impact on the success of broiler chicken production, with a difference in mortality reaching more than 300 birds between the best technology (CTI Alpha) and the worst technology (Temptron 304D).

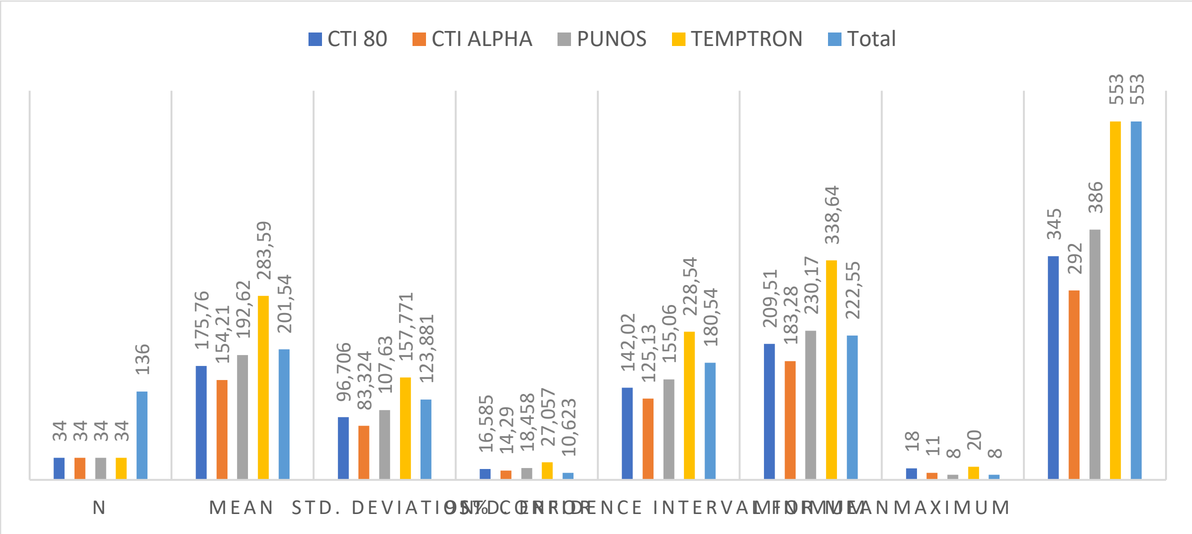

Figure 2. Chicken Development

Figure 2. explains the performance of the automatic temperature control technology based on various statistical parameters, such as mean, standard deviation, standard error, 95% confidence interval, and minimum, and maximum values. Temptron showed the highest average chicken mortality (283.59 birds) with the largest standard deviation (157.771), indicating very high data variability and unstable performance. In contrast, CTI Alpha recorded the lowest average chicken mortality (154.21 birds) and the smallest standard deviation (83.324), indicating its consistent performance in maintaining low mortality rates. The Punos and CTI 80 technologies are in between, with average chicken mortality of 192.62 birds and 175.76 birds, respectively, where CTI 80 showed better performance than Punos.

The 95% confidence intervals confirm these results, with Temptron having the widest interval range (228.54 - 338.64), confirming its inconsistent performance. In contrast, CTI Alpha had the narrowest interval range (125.13 - 183.28), reflecting its stability and reliability in maintaining the cage environment. The highest maximum mortality rate was observed in Temptron (553 birds), while the lowest maximum value was found in CTI Alpha (292 birds), demonstrating CTI Alpha's ability to minimize mortality. Thus, CTI Alpha is the best automatic temperature control technology for closed-house broiler chicken farms. In contrast, Temptron requires significant improvements to improve its stability and effectiveness.

NORMALITY TEST

Based on the results of the normality test in Table 1 using the Kolmogorov-Smirnov and Shapiro-Wilk methods, the chicken mortality data for each automatic temperature control technology (CTI 80, CTI Alpha, Punos, and Temptron) were declared normally distributed. In the Kolmogorov-Smirnov test, the Sig. The value for all technologies was 0.200, which is greater than 0.05, indicating that the data followed a normal distribution. Similar results were also obtained in the Shapiro-Wilk test, where the Sig. The values for all technologies was greater than 0.05 (e.g., 0.257 for CTI 80 and Temptron, 0.258 for CTI Alpha, and 0.480 for Punos), further strengthening that the data were normally distributed. Thus, these data satisfy the assumption of normality, which is an important requirement for conducting parametric statistical analysis, such as One-Way ANOVA. These results provide validity to proceed to the next stage of the analysis, including homogeneity tests and analysis of variance (ANOVA), which aim to compare the effectiveness of the automatic temperature control technologies tested.

Table 1. Normality Test

	TEMPERATURE CONTROL	*Kolmogorov-Smirnova*			*Shapiro Wilk*		
		Statistics	df	Sig.	*Statistics*	df	Sig.
Chicken Development	CTI 80	.080	34	.200*	.961	34	.257
	CTI ALPHA	.067	34	.200*	.961	34	.258
	PUNOS	.059	34	.200*	.971	34	.480
	TEMPRON	.073	34	.200*	.961	34	.257

HOMOGENEITY TEST

Based on the results of the homogeneity of variance test using Levene's test, the variance between groups of automatic temperature control technologies (CTI 80, CTI Alpha, Punos, Temptron) was declared inhomogeneous. This was indicated by the significant Levene Statistic value in all test methods (mean, median, median with adjusted df, and trimmed mean), with a Sig. Value = 0.000 for each method. The significance value is less than 0.05, the assumption of homogeneity of variance is not met. This inhomogeneity of variance indicates a significant difference in the variability of chicken mortality data between the tested technology groups. Thus, parametric statistical analysis such as One-Way ANOVA can still be performed but requires an additional approach to handle inhomogeneous variance. As a next step, the Post Hoc Games-Howell method is recommended because it does not require homogeneity of variance, allowing comparisons between groups and remain valid. These results emphasize the need for further analyses to evaluate the effectiveness of each automatic temperature control technology in more detail.

Table 2. Homogeneity Test Results

		Levene Statistics	df1	df2	Sig.
CHICKEN DEVELOPMENT	*Based on Mean*	7,609	3	132	.000
	Based on Median	7,507	3	132	.000
	Based on the Median and with adjusted df	7,507	3	104,477	.000
	Based on trimmed mean	7,607	3	132	.000

ONE-WAY ANOVA

The results of the One-Way ANOVA test showed significant differences in the number of chicken deaths based on automatic temperature control technology (CTI 80, CTI Alpha, Punos, Temptron). The Sum of Squares value between groups (330357.794) showed a large variation between technologies, with a Mean Square of 110119.265. Meanwhile, the variation within the group, represented by the Sum of Squares of 1741429.941 and the Mean Square of 13192.651, showed differences in the data of each technology group. The F statistic value of 8.347 and the significance level (Sig.) of 0.000 (less than 0.05) indicated that the differences between these technology groups were statistically significant.

Table 3. One-Way ANOVA Test Results

	Sum of Squares	df	*Mean Square*	F	Sig.
Between Groups	330357.794	3	110119.265	8,347	.000
Within Groups	1741429.941	132	13192.651		
Total	2071787.735	135			

These results indicate that the automatic temperature control technology used has a significant effect on the number of chicken deaths during rearing. Thus, further analysis is needed, such as Post Hoc Games-Howell, to identify which pairs of technology groups have significant differences. This analysis will help determine the most effective automatic temperature control technology for reducing chicken mortality(Apalowo et al., 2024).

GAMES-HOWELL POST HOC TEST

The results of the Post Hoc Games-Howell analysis show a comparison between automatic temperature control technologies (CTI 80, CTI Alpha, Punos, Temptron) based on the average difference (Mean Difference) in the number of chicken deaths. The significance value (Sig.) indicates whether the average difference between the technologies is statistically significant. From the table results, the difference between Temptron and all other technologies (CTI 80, CTI Alpha, Punos) showed significant results (p-value <0.05), with large average difference values, such as -107.824 (CTI 80 vs Temptron), -129.382 (CTI Alpha vs Temptron), and -90.971 (Punos vs Temptron). This indicates that Temptron has a significantly higher number of chicken deaths than other technologies, confirming the weakness of this technology in maintaining optimal cage environmental conditions.(Ferreira et al., 2024)

Table 4. Games-Howell Post Hoc Test

(I) TEMPERATURE CONTROL	(J) TEMPERATURE CONTROL	*Mean Difference (IJ)*	Std. Error	Sig.
CTI 80	CTI ALPHA	21,559	21,892	.759
	PUNOS	-16,853	24,815	.905
	TEMPRON	-107,824*	31,736	.007
CTI ALPHA	CTI 80	-21,559	21,892	.759
	PUNOS	-38,412	23,343	.361
	TEMPRON	-129,382*	30,599	.001
PUNOS	CTI 80	16,853	24,815	.905
	CTI ALPHA	38,412	23,343	.361
	TEMPRON	-90.971*	32,754	.036
TEMPRON	CTI 80	107,824*	31,736	.007
	CTI ALPHA	129,382*	30,599	.001
	PUNOS	90,971*	32,754	.036

In contrast, the differences between technologies other than Temptron (CTI 80, CTI Alpha, Punos) were not statistically significant. Values > 0.05, such as the comparison of CTI 80 vs. CTI Alpha ($p = 0.759$) and CTI Alpha vs Punos ($p = 0.361$). This shows that technologies other than Temptron have relatively equivalent performance in reducing chicken mortality. From this analysis, it can be concluded that CTI Alpha, CTI 80, and Punos are more effective than Temptron, while the differences between the three technologies are not statistically significant. These results provide a basis for farmers to choose technologies other than Temptron to increase productivity and reduce chicken mortality(Wasti et al., 2020).

IMPLICATIONS OF THE FINDINGS

This study provides several important implications regarding the economic impact and long-term sustainability of adopting automatic temperature control technologies, particularly CTI Alpha and CTI 80, in broiler chicken production systems:

1. Economic Impact
    a. Increased Productivity: With lower chicken mortality rates, as achieved by CTI Alpha (255 chickens) and CTI 80 (314 chickens) compared to Temptron (595 chickens), farmers can maximize broiler chicken production. This directly increases income as more chickens are sold at the end of the rearing period.
    b. Feed Conversion Efficiency (FCR): More effective technologies like CTI Alpha also can improve feed conversion efficiency, meaning less feed is required per kilogram of chicken weight gain. Improved feed efficiency significantly reduces operational costs because feed is one of the largest cost components in poultry farming.
    c. Savings on Health Costs: By reducing thermal stress and chicken mortality, technologies such as CTI Alpha and CTI 80 can decrease the need for medications and healthcare costs for chickens.
2. Long-Term Sustainability:
    a. Resource Efficiency: More reliable automatic temperature control technologies, such as CTI Alpha, can create a stable barn environment, reducing energy waste (e.g., unnecessary use of fans or heaters). This will support more sustainable poultry farming practices in the long term.
    b. Adaptation to Climate Change: In dealing with increasingly unpredictable climate change impacts, technologies like CTI Alpha and CTI 80 can help farmers adapt to extreme temperature changes, ensuring stable productivity.
    c. Reputation and Business Sustainability: Farms that use advanced and effective technologies are likely to gain a competitive edge in the market. This enhances the reputation of farmers as suppliers of high-quality chicken, which in turn supports long-term business sustainability.
3. Scalability and Broader Implementation:
   Technologies like CTI Alpha can be adopted not only by large-scale farms but also by small- to medium-scale farms, with adjustments to initial investment costs. Expanding the implementation scale can support the growth of the broiler chicken industry in Indonesia, which is critical given the projected national demand for chicken meat that exceeds 3.37 million tons per year.
4. Social and Regional Economic Impact:

The implementation of better technologies will increase farmers' incomes in rural areas, contributing to the strengthening of local economies. With more consistent production results, farmers can reduce the risk of losses caused by high mortality rates, which often lead to income instability for small-scale farmers.

The adoption of automatic temperature control technologies, such as CTI Alpha and CTI 80 not only has the potential to improve broiler chicken production efficiency but also delivers positive economic impacts, such as increased income and reduced operational costs. In the long term, these technologies support the sustainability of broiler chicken farming through efficient resource management, adaptation to climate change, and contributions to local economies. Therefore, adopting these technologies is a strategic step in addressing the continuously growing market demand and the need for sustainability in the poultry farming industry.

CONCLUSION

Based on the results of the conducted research, it can be concluded that automatic temperature control technology has a significant influence on the success of broiler chicken production in a closed-house system. CTI Alpha technology has proven to have the best performance in reducing broiler chicken mortality, with the lowest total mortality of 255 chickens during one maintenance period. CTI 80 and Punos technologies are in the next position with total mortality of 314 chickens and 398 chickens, respectively. In contrast, Temptron recorded the highest mortality rate of 595 chickens, indicating a much lower performance compared to other technologies.

Based on the descriptive statistical analysis, CTI Alpha also showed high consistency, with the lowest average number of deaths (154.21 birds) and the smallest standard deviation (83.324), indicating a more stable performance compared to other technologies. Temptron had the highest average number of deaths (283.59 birds) and the largest standard deviation (157.771), indicating unstable performance in maintaining cage conditions. The results of the One-Way ANOVA test showed a significant difference in the number of chicken deaths between automatic temperature control technologies (Sig. = 0.000, F = 8.347). Further analysis using Post Hoc Games Hall revealed that Temptron had a statistically significant difference with all other technologies (CTI Alpha, CTI 80, Punos). In contrast, the differences between CTI Alpha, CTI 80, and Punos were not significant, indicating that the three technologies had relatively equal performance in reducing chicken mortality. CTI Alpha technology is recommended as the best choice for broiler chicken farms with a closed-house system because of its reliability in maintaining temperature stability and reducing mortality. CTI 80 technology can also be a good alternative with performance close to CTI Alpha. In contrast, Temptron requires further evaluation and development to improve its stability and effectiveness.

This study shows that the use of appropriate automatic temperature control technology can improve the sustainability and efficiency of the broiler chicken farming industry, especially in the face of the challenges of tropical climate and increasing demand for chicken meat in Indonesia. The evaluation of the performance of this technology provides practical guidance for farmers in selecting a technology that suits their specific needs. This study makes an important contribution to our understanding of the effectiveness of various automatic temperature control technologies and opens up opportunities for further studies that can explore other aspects such as operational costs and effects on end product quality.

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