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Technical and economic performance favours fully automated climate control broiler housing

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ABSTRACT

1. This study compared two broiler housing models with different technologies (conventional *versus* fully automated climate control) to verify their performance and carcass characteristics at slaughter, as well as the economics of production.
2. A database regarding 20 443 flocks of heavy broilers produced in an integrated operation during the years 2020 and 2021, in eight Brazilian regions was used in the analysis. The dependent variables included feed conversion, average live weight gain, total and partial carcass condemnation and the total mortality. For economic analysis, the production cost of each technology including feed, labour, energy, heating and depreciation was calculated.
3. The technology used in the broiler houses had a significant effect on the technical indicators which were positive for fully automated climate control in most geographical regions. One important exception was the effect on total and partial carcass condemnations, with better results seen for conventional housing. The total cost per ton of broiler meat delivered, deducting condemnation losses, was lower in the automated climate controlled housing compared to conventional housing.
4. In conclusion, there was a reduction in broiler chicken production costs for birds raised in fully automated climate controlled housing, indicating better economic results for this model in Brazil.

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KEYWORDS
Climate control; conventional housing; productivity; costs; poultry

Introduction

Brazil is the world´s second largest producer and the number one broiler exporter, currently (ABPA 2023; MAPA 2023). The Brazilian productive chain is organised as an integrated system, with a partnership between the farmer and industry that ensures high-quality production under sanitary conditions. The supply chain has a significant positive impact on the social and economic regional indicators, providing work, income and taxes with clear contributions from farmers and the urban population in terms of life quality (ABPA 2023; Talamini and Filho 2020). The integrated production system facilitates credit access as well as a continuous and accelerated use of technological innovations (Caldas et al. 2015; Manmeet et al. 2017).

Broiler performance relates directly to the environment conditions inside the housing where they are raised (Mesa et al. 2017; Yahav et al. 2001). Uncontrolled climate conditions lead to a series of adaptive behavioural, physiological and biochemical changes, causing productive and economic losses (Chib et al. 2016; Farhadi and Hosseini 2014). Choosing appropriate housing is strongly related to the environmental and geographical conditions in which the broilers are exposed during their production (Abreu and Abreu 2011; Sakamoto et al. 2020). Fully automated broiler housing can reduce external climatic effects (Bueno and Rossi 2006; Teles Junior et al. 2020; Vilela et al. 2020).

Most Brazilian broilers are raised in conventional housing, using positive pressure fans and natural lighting. These are practical systems which are simple to manage and have lower risk and investment costs (Elghardouf et al. 2023; Gillespie et al. 2017). However, broiler raised under these systems are more vulnerable to thermal stress (Sans, Tuyttens, et al. 2021; Vilela et al. 2020).

A fully automated climate control broiler house has a negative cooling pressure and an evaporative system (Abreu and Abreu 2011; Gillespie et al. 2017; Lima et al. 2021; Sans, Tuyttens, et al. 2021). This forms a 'wind tunnel' *via* the exhaust fan to cool the environment and, by using evaporative cooling plates, creates an effective thermal comfort zone for broilers (Elghardouf et al. 2023; Gillespie et al. 2017; Lacy and Czarick 1992).

The proportion of broiler houses built using different technologies is changing and has shown a trend to move from conventional to fully automated climate control (Abreu and Abreu 2011; Qi et al. 2023; Talamini et al. 2023). Producers can adopt changes in technology, but this can be expensive (Gillespie et al. 2017; Sartor et al. 2001). This represents a great challenge for all those involved, providing a chance to analyse numbers and define the necessary adjustments to continue evolving suitable rearing systems over time (Abreu and Abreu 2011; Talamini and Santos Filho 2020).

The objective of the following study was to compare technical and economic results of two housing models in Brazil, conventional and fully automated climate control, to verify which one was more sustainable for broiler production.

Material and methods

This study used an industry database of 28 282 flocks of heavy male broiler chickens, collected during the period of

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January 2020 to December 2021, from integrated producers in eight Brazilian regions. After an initial analysis of the means and variables using branch and leaf diagrams, box charts and scatter charts between two variables, 7,839 flocks were excluded. This exclusion was applied when other types of broiler housing were used ($n = 7362$), when broiler lineage was unknown or mixed ($n = 200$), there were data errors, outliers or missing data ($n = 277$). A total of 20 443 flocks were retained in the dataset, where 7,051 flocks were from houses with fully automated climate control and 13 392 from conventional ones. Nutrition management and broiler lineages were considered similar within flocks from the same agro-industry. The database was constructed based on agricultural practices and followed the Federal Law no. 11794 of scientific use of animals (Brasil 2008; Marques et al. 2009).

The conventional broiler houses had positive ventilation, remained open with bird screens and opening/closing of lateral curtains system. The main equipment used were heaters, fans, nebulisers with environmental controls. They had less automation with lower production and smaller flocks. Broiler houses with fully automated climate control had a negative ventilation system, tunnel type, curtains that were closed all the time, with only one air inlet and outlet and controlled lighting. They used heaters, exhaust fans, evaporating panels, inlets and sophisticated climate controllers with high automation and large-scale production with bigger flocks.

The response variables for the broiler housing models included feed conversion ratio (FCR), live weight at slaughter, mortality and total and partial carcass assessment, including condemnations at the slaughterhouse. A descriptive analysis of these variables was presented graphically with histograms. Subsequently, assuming the performance variables had normal distribution (Ghasemi and Zahediasl 2012), multiple regression analysis was applied to select those that explained dependent variables, including interactions. As the main objective of the analysis was to evaluate the effect of housing type (conventional *versus* fully automated climate control), this source of variation was included for model selection, regardless of significance. The stepwise method was used to select model variation sources, with significance at 5% ($p \leq 0.05$).

This study assumed binomial distribution for mortality in the rearing period, as well as for total and partial carcass condemnation due to inflammation, joint damage, skin injuries and metabolic issues (*e.g.*, ascites). Carcass condemnation was conducted by the Federal Inspection System (SIF) at *post-mortem* inspection, according to Brazilian regulation Ordinance no. 210/1998 of the Ministry of Agriculture, Livestock and Food Supply (MAPA 1998). Thus, logistic regression analysis was applied, assuming the same variation sources, selecting method and minimum significance level ($p \leq 0.05$). The over dispersion of these dependent variables required the correction of the scale factor by Pearson's X^2 statistics, performed using the GLM and LOGISTIC procedures in SAS® software (2012).

To verify the effects of broiler housing models on flock performance and economics of production, the variables used included broiler housing model (conventional or fully automated climate control); year and month of flock slaughter; broiler age at slaughter (days); broiler lineage; matrices age; incubatory origin; downtime period (days); and geographical region, as well as some variables interactions. Broiler flocks were distributed in eight geographical regions of Brazil, as shown in the map (Supplementary Figure): 1) Curitiba and North of Santa Catarina; 2) Midwest; 3) North of Paraná; 4) Northeast of Bahia; 5) Northwest of Rio Grande do Sul; 6) Santa Catarina Coast; 7) São Paulo; and 8) West of Santa Catarina. For each region, means of daily temperature and relative humidity were measured during hot (October–March) and cold (April–September) seasons of 2020 and 2021. Data were collected from the weather stations of the National Institute of Meteorology (INMET 2024) closest to the slaughterhouse in each region.

The economic analyses were based on the production costs of broiler housing models (fully automated climate control and conventional), which were calculated according to the methodology of Talamini and Filho (2020). This included items with a major impact on the broiler operational cost, such as feed, day-old chicks, labour, electric energy, firewood, maintenance and capital depreciation (buildings and equipment). The costs of feed and day-old chicks were agro-industry responsibility, whereas producer's costs were labour, electric energy, firewood, maintenance and capital depreciation.

Feed costs from consumption multiplied by the average feed price, which was the same for both types of housing, as the objective was to verify the effect of technology and not price variation on animal performance. For labour, it was assumed that one worker could attend to one fully automated broiler house of 2,970 m^2 or two conventional 1,200 m^2 houses (Talamini et al. 2023). The same remuneration for labour in both types of broiler housing was assumed, based on the national minimum wage and associated expenses. The costs of electricity and firewood used for heating were calculated for each housing model, considering the consumption per flock, multiplied by the cost per kilowatt or volume of firewood.

Depreciation was calculated adding building value with 70% of total investment with 25 years of useful life and 15% of residual value. Equipment accounted for 30% of the total capital with 15 years of service life and a residual value of 5%. Depreciation resulted from the initial value minus the residual value and divided by the useful life. Maintenance corresponded to 1% over new installation and equipment value (Talamini and Filho 2020).

The volume of annual production delivered to the slaughterhouse depended on the live weight and the average viability of the broilers, stocking density and the number of flocks produced per year in each housing model. The 'carcass with offal' production after slaughter was based on the cold carcass yield, according to Coldebella et al. (2021). The total operational production cost was calculated for each broiler housing model at the farm level, slaughterhouse and after slaughter, subtracting total and partial condemnations.

The main technical coefficients that affect productivity and performance were analysed, including broiler house size, broiler density, total number of broilers housed, total mortality, slaughter age, total live weight delivered at slaughter, downtime period between flocks, feed conversion ratio and number of flocks produced per year in each type of housing technology.

Sensitivity analysis was performed verifying the main variables' effect on operation costs differential between the housing models. The variables used were: 1) Feed price: 30% above and below the average price; 2) Facilities total value:

30% above and below each broiler housing type value; 3) FCR: −0.1 to 0 over the fully automated compared to the conventional broiler housing average; and 4) Partial and total condemnations: 0 to 50% over the fully automated value compared to the conventional broiler housing average. The results of the sensitivity analysis are presented as contour graphs. The dependent variable was the operation cost differential between the housing systems expressed in Brazilian currency (reais R$), per ton of carcass plus offal.

Results

Technical comparisons

The analysis of 20,443 broilers flocks showed that the average age and the live weight at slaughter were similar in both broiler housing models. However, the stocking density and slaughtering density were higher in the fully automated climate control models than in conventional ones (Table 1).

The number of flocks lodged per year showed geographical differences. When grouped into regions, the Northeast of Bahia had the lowest number, while Curitiba and the North of Santa Catarina had the highest (Table 2).

The effect of the broiler housing type was included and maintained in the statistical model, regardless of its significance. The explanatory variables highly dependent on (or confounded by) housing type (such as stocking and slaughtering density), were not included in the model. The sources of variation included in the final model of multiple regression analysis of the quantitative dependent variables are shown in supplementary Table S2. These represented technical performance data obtained before broiler slaughter ($p \leq 0.05$). The model coefficient (R^2) was not high, ranging from 0.50 for live weight at slaughter to 0.55 for FCR. This was expected for this sort of analysis, based on the large dataset with several unknown or uncontrolled variation sources. A model with observational and non-experimental data that explained more than 50% of feed conversion was considered reasonable.

The main aim was to evaluate broiler housing types and exploring the effect of relevant sources of variation in the results. Table 3 shows that housing type was important in the evaluated technical indicators. Despite significant interaction ($p \leq 0.05$) between housing type and region, the adjusted means of weight and feed conversion were always favourable towards the fully automated climate control housing in all geographical regions.

Table 2. Distribution of heavy male broiler flocks.

Variable	Frequency (%)
Broiler housing model	
Fully automated	7,051 (34.49%)
Conventional	13,392 (65.51%)
Production year	
2020	10,087 (49.34%)
2021	10,356 (50.66%)
Geographical region	
Curitiba and North of Santa Catarina	3,946 (19.30%)
Santa Catarina Coast	3,671 (17.96%)
North of Paraná	3,026 (14.80%)
Northwest of Rio Grande do Sul	2,911 (14.24%)
West of Santa Catarina	2,867 (14.02%)
São Paulo	1,795 (8.78%)
Midwest	1,305 (6.38%)
Northeast of Bahia	922 (4.51%)

The same main variation sources were used in the logistic regression final model for qualitative dependent variables, such as total mortality during rearing and slaughter condemnations (Table S3). The R^2 value was 0.21 for mortality, 0.26 for total carcass condemnation and 0.33 for partial condemnation. This was lower than for quantitative variables, due to the binomial probabilistic distribution of this type of variable.

The interaction between the broiler housing type and the geographical region was always significant ($p \leq 0.05$), as well as the main effect of broiler housing type, except for mortality, as shown in Table 4.

The mortality national average, adjusted to 42 d at slaughter and 16 d of downtime, was not significant ($p \leq 0.05$) when comparing the two types of housing. The same was seen for the Northwest of Rio Grande do Sul, Curitiba and North of Santa Catarina and West of Santa Catarina regions. In the Midwest, Northeast of Bahia and São Paulo regions, there was higher mortality in broilers raised in conventional housing than in automated housing, while in the Santa Catarina Coast and North of Paraná regions, the opposite occurred.

Only three regions showed significant differences between housing for total carcass condemnations, with a more favourable outcome in conventional systems. In Santa Catarina Coast and North of Paraná regions, condemnation was lower in conventional housing, while in West of Santa Catarina, less condemnations were seen in fully automated ones. For partial carcass condemnations, there was no significant difference for two regions (West of Santa Catarina and São Paulo). All other regions, including the national

Table 1. Descriptive statistics of quantitative variables of heavy male broiler flocks.

Broiler housing type	Number	Average	Median	Standard Deviation
Lodging density (broiler/m^2)				
All	20,443	12.37	12.22	1.35
Fully automated	7,051	13.70	13.81	0.89
Conventional	13,392	11.66	11.67	0.97
Slaughtering density (kg/m^2)				
All	20,443	33.12	32.88	4.46
Fully automated	7,051	36.94	37.08	3.54
Conventional	13,392	31.10	31.11	3.46
Slaughter age (days)				
All	20,443	41.87	41.65	2.44
Fully automated	7,051	41.53	41.48	2.26
Conventional	13,392	42.05	41.79	2.50
Live weight at slaughter (kg)				
All	20,443	2.87	2.86	0.21
Fully automated	7,051	2.89	2.89	0.19
Conventional	13,392	2.86	2.85	0.22

Table 3. Quantitative variables' means, adjusted to 42 days of age and 16 days of downtime, for each broiler housing type and geographical region.

Region	Broiler house type[a] Fully automated	Conventional	Pr>F
	Feed conversion		
Curitiba and North of Santa Catarina	1.659 ± 0.0032	1.709 ± 0.0030	<0.0001
Midwest	1.691 ± 0.0067	1.745 ± 0.0057	<0.0001
North of Paraná	1.696 ± 0.0033	1.732 ± 0.0032	<0.0001
Northeast of Bahia	1.693 ± 0.0123	1.766 ± 0.0114	<0.0001
Northwest of Rio Grande do Sul	1.674 ± 0.0036	1.703 ± 0.0033	<0.0001
Santa Catarina Coast	1.661 ± 0.0036	1.681 ± 0.0033	<0.0001
São Paulo	1.663 ± 0.0038	1.708 ± 0.0041	<0.0001
West of Santa Catarina	1.655 ± 0.0042	1.695 ± 0.0038	<0.0001
Average	1.674 ± 0.0037	1.717 ± 0.0026	<0.0001
	Live weight at slaughter (kg)		
Curitiba and North of Santa Catarina	2.922 ± 0.0078	2.885 ± 0.0071	<0.0001
Midwest	2.795 ± 0.0161	2.674 ± 0.0137	<0.0001
North of Paraná	2.815 ± 0.0079	2.749 ± 0.0076	<0.0001
Northeast of Bahia	2.841 ± 0.0295	2.692 ± 0.0274	<0.0001
Northwest of Rio Grande do Sul	2.918 ± 0.0088	2.901 ± 0.0079	0.0294
Santa Catarina Coast	2.996 ± 0.0088	2.923 ± 0.0078	<0.0001
São Paulo	2.943 ± 0.0091	2.892 ± 0.0098	<0.0001
West of Santa Catarina	2.914 ± 0.0101	2.858 ± 0.0092	<0.0001
Average	2.893 ± 0.0066	2.822 ± 0.0062	<0.0001

[a]Mean ± standard error

average, had a greater partial condemnation in fully automated broiler housing than in conventional ones.

Economic comparisons

The calculated cost per ton of broiler meat, excluding losses for total and partial condemnations, was 3.05% lower in the fully automated broiler housing compared to the conventional system (supplemental Table S4).

The economic sensitivity analysis used a relationship between the differential percentage in the FCR and the variations in the total value of broiler's housing facilities (Figure 1(a)) and feed price (Figure 1(b)). These results indicated lower investment in building and equipment, as well as higher feed cost, which increased the differential gain in meat production cost, for fully automated climate control housing (Figure 1). This showed a 0.65% reduction per ton of meat produced in more expensive facilities and lower FCR, culminating in 5.65% reduction for investments in cheaper projects and higher FCR (−0.1 feed/kg of live weight). The fully automated broiler houses had higher depreciation and maintenance costs than conventional systems but had better FCR.

The costs between the two types of broiler housing could be higher with better FCR and higher feed prices. Even where there was no FCR benefit, there was a reduction in the operation cost per ton of carcass plus offal produced due to labour optimisation, as one employee operated one fully automated broiler house or two conventional houses, but the latter produced less than half of the automated one.

The percentage of partial and total condemnations was higher in the fully automated housing when compared with the conventional system. Even with a 50% increase in condemnations in the fully automated housing compared to conventional systems, there was more than 2.88% cost reduction per ton from the fully automated one (Figure 2). If condemnations were equal between fully automated and conventional broiler housing, benefits would be higher with a cost reduction of 3.44% per ton produced, even when the value of broiler facilities was maintained. More expensive facilities reduce the economic differential between the two types of broiler housing.

Discussion

Fully automated broiler housing provided better environment control, improved broiler comfort and well-being, as well as favouring growth, productivity and economic returns (Chib et al. 2016; Rodrigues and Yada 2018; Yahav et al. 2001). This was due to the microclimate generated inside the broiler houses, which were more stable and had lower ambient temperature compared to conventional systems (Chib et al. 2016; Curi et al. 2014; Manmeet et al. 2017). Tunnel ventilation effectively reduced the broiler house temperature (Çayli et al. 2021; Hamrita and Conway 2017) during peak thermal stress periods, even with higher broiler density (Farhadi and Hosseini 2014). It maintained air quality regarding the concentration of ammonia and carbon dioxide

Table 4. Means and confidence intervals (95%) of qualitative variables, adjusted to 42 and 16 days of downtime, for each broiler housing type and geographical region.

Region	Mortality (%) Fully automated	Mortality (%) Conventional	Pr > χ^2	Total carcass condemnation (%) Fully automated	Total carcass condemnation (%) Conventional	Pr > χ^2	Partial carcass condemnation (%) Fully automated	Partial carcass condemnation (%) Conventional	Pr > χ^2
Curitiba and North of Santa Catarina	6.94 (6.71 – 7.18)	7.12 (6.89 – 7.37)	0.1447	0.42 (0.39 – 0.46)	0.43 (0.40 – 0.47)	0.4343	6.08 (5.79 – 6.40)	4.63 (4.40 – 4.88)	**<0.0001**
Midwest	5.94 (5.57 – 6.33)	6.93 (6.54 – 7.35)	**<0.0001**	0.44 (0.38 – 0.51)	0.42 (0.36 – 0.48)	0.3318	5.89 (5.38 – 6.45)	4.66 (4.27 – 5.08)	**<0.0001**
North of Paraná	6.54 (6.31 – 6.77)	5.87 (5.64 – 6.10)	**<0.0001**	0.75 (0.69 – 0.81)	0.46 (0.42 – 0.50)	**<0.0001**	6.56 (6.23 – 6.90)	6.11 (5.78 – 6.46)	**0.0004**
Northeast of Bahia	6.12 (5.35 – 6.98)	7.67 (6.77 – 8.67)	**<0.0001**	0.40 (0.28 – 0.58)	0.45 (0.31 – 0.64)	0.1004	7.91 (6.36 – 9.78)	5.86 (4.71 – 7.25)	**<0.0001**
Northwest of Rio Grande do Sul	6.81 (6.58 – 7.05)	6.97 (6.70 – 7.24)	0.3463	0.54 (0.50 – 0.59)	0.56 (0.51 – 0.61)	0.4144	3.30 (3.13 – 3.49)	2.39 (2.23 – 2.56)	**<0.0001**
Santa Catarina Coast	6.84 (6.57 – 7.12)	6.41 (6.16 – 6.66)	**<0.0001**	0.48 (0.43 – 0.53)	0.36 (0.32 – 0.39)	**<0.0001**	4.34 (4.08 – 4.62)	3.91 (3.68 – 4.15)	**<0.0001**
São Paulo	7.31 (7.05 – 7.59)	7.64 (7.31 – 7.97)	**0.0391**	0.71 (0.65 – 0.77)	0.71 (0.65 – 0.79)	0.8317	7.00 (6.63 – 7.39)	7.32 (6.87 – 7.80)	0.0858
West of Santa Catarina	6.75 (6.45 – 7.06)	6.76 (6.45 – 7.08)	0.7688	0.85 (0.77 – 0.93)	0.93 (0.85 – 1.03)	**0.0089**	6.59 (6.20 – 7.01)	6.36 (5.96 – 6.79)	0.1313
Average	6.64 (6.45 – 6.84)	6.90 (6.70 – 7.10)	0.2245	0.55 (0.51 – 0.59)	0.52 (0.48 – 0.55)	**0.0002**	5.78 (5.53 – 6.05)	4.92 (4.70 – 5.15)	**<0.0001**

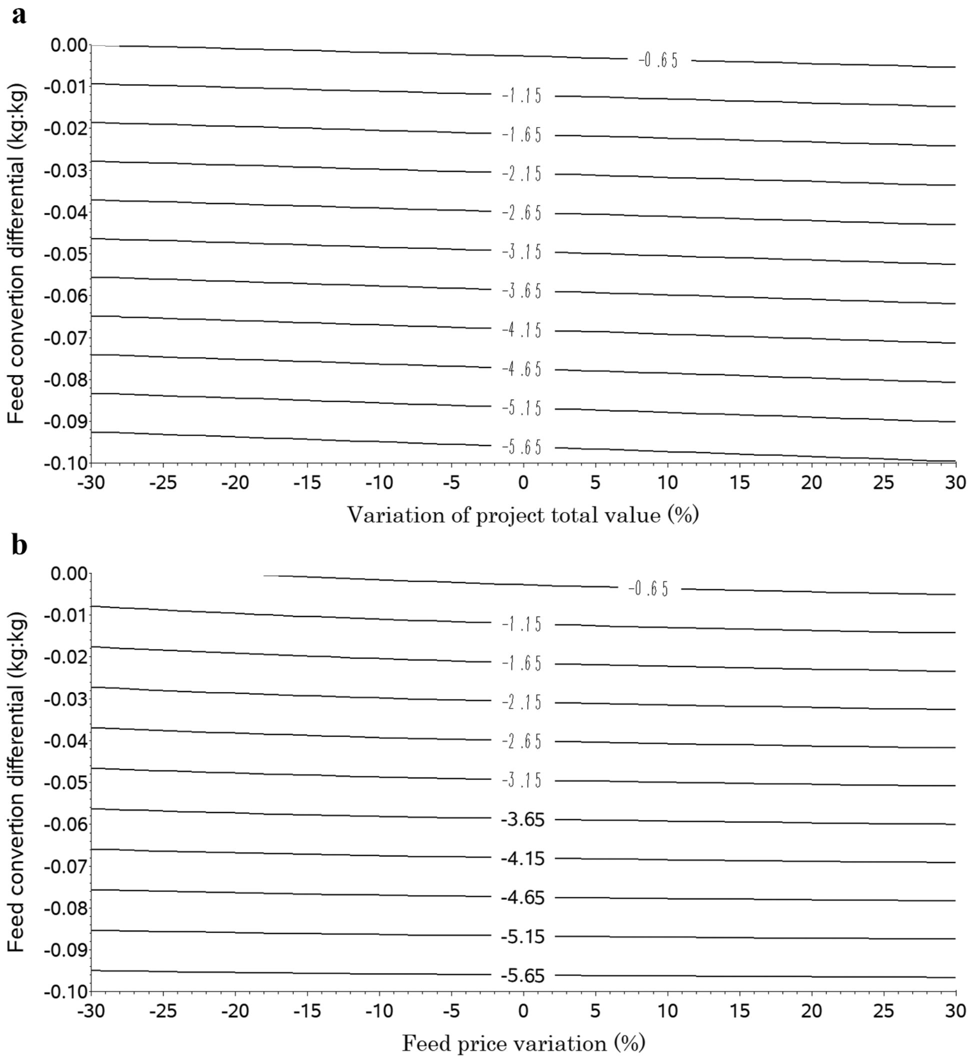

Figure 1. Contours chart of production cost per ton of carcass and offal difference (%) comparing fully automated and conventional broiler housing. Feed conversion differential with the variation of project total value (a) and with the feed price variation (b).

(Curi et al. 2014). Broilers exposed to tunnel ventilation showed better FCR and weight gain ranged from 2% to 11% higher with lower mortality compared to positive ventilation in the conventional systems (Curi et al. 2014; Hamrita and Conway 2017). These results were similar to the present study, which showed 2% gain in average slaughter weight and a reduction of 1.5% in slaughter age for the fully automated housing.

Conventional broiler houses, equipped only with positive ventilation, were not so effective in maintaining thermal comfort conditions for broilers under heat stress. This demonstrated the vulnerability of broilers in stress environments, due to the low efficiency in internal temperature dissipation, aggravated by the heat generated by animals and litter (Santos et al. 2021; Teles Junior et al. 2020).

Fully automated broiler houses need to be well insulated and sealed to function efficiently, to prevent cold or heat, sun and wind from the external environment affecting the internal climate. Knowledge of each region´s climate is fundamental and allows adjustment of the constructive systems to broilers´ needs and environmental conditions, as well as farmer's guidance for better management (Vilela et al. 2020). This results in higher productivity and lower production costs (Abreu and Abreu 2011; Li et al. 2022).

The favourable climate in Brazilian subtropical regions, such as Northwest of Rio Grande do Sul, West of Santa Catarina and Curitiba and North of Santa Catarina, allows the production using natural ventilation in conventional broiler housing (Lima et al. 2021). Regions which experience hot and humid summer conditions, as the Midwest in the present study (Table S1), simple passive ventilation is often insufficient to maintain acceptable temperatures for broiler chicken growth. In these situations, broiler houses with tunnel ventilation that cool by forced convection becomes more efficient (Hamrita and Conway 2017). The results showed an advantage of fully automated housing models in the warmer regions (Table 3), which confirmed that this technology has greater technical and economic advantages in a warmer climate than in a colder climate (Gillespie et al. 2017).

In this study, broilers raised in fully automated climate control houses in warmer Brazilian regions, such as the Midwest and Northeast of Bahia, had a lower mortality rate ($p \leq 0.05$) than those raised in conventional houses (Table 4), as previously described by Farhadi et al. (2016). Despite the higher housing density, the lower mortality was probably due to better environmental conditions (Çayli et al. 2021; Farhadi and Hosseini 2014; Rodrigues and Yada 2018; Szőllősi et al. 2021).

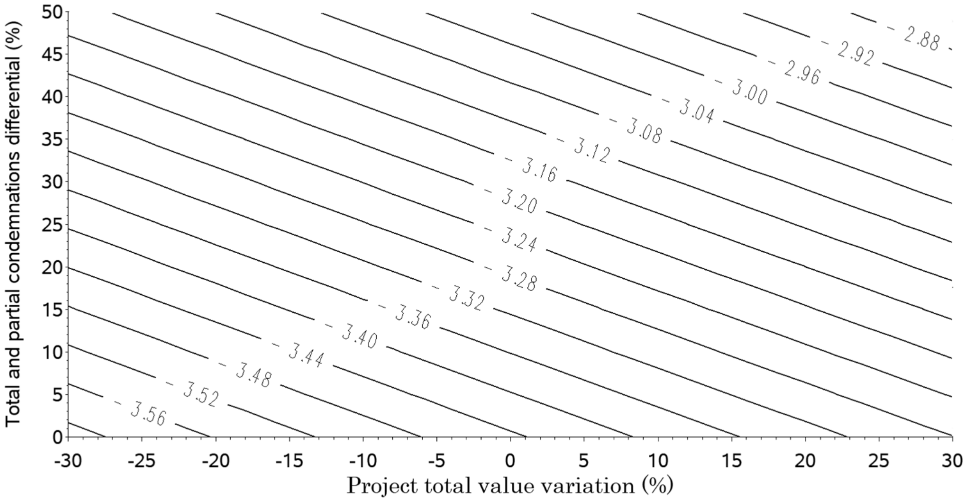

Figure 2. Contours chart of production cost per ton of carcass and offal difference (%) regarding total and partial condemnations differential with the variation of project total value, by comparing fully automated and conventional broiler housing.

Constant monitoring of environmental indicators, such as temperature and emissions inside the house in certain locations, is relevant for broiler welfare (Sans, Vale, et al. 2021). Lima et al. (2021) found that, regarding parameters relating to thermal, air and bed quality, conventional broiler houses, provided the most suitable housing systems for chickens, compared to the fully automated climate control. This could explain the higher percentages in the overall average ($p < 0.05$) of total and partial condemnations in the fully automated broiler housing (Table 4). The causes of these high condemnations require further investigation, as well as the development of strategies to reduce them and to maintain the poultry chain competitiveness.

Facilities with fully automated climate control which are well insulated and with adequate environmental control allows higher density of broiler flocks (Lacy and Czarick 1992). Additionally, their larger floor area compared to the conventional systems brings higher revenues. Through greater profitability, fully automated broiler houses outperform conventional ones, showing that this technology is economically beneficial (Gillespie et al. 2017; Manmeet et al. 2017; Szőllősi et al. 2021).

The FCR was significantly different between the two different types of housing (Table 3), as previously reported by other authors (Manmeet et al. 2017; Mesa et al. 2017; Rodrigues and Yada 2018). Broiler chickens produced in a fully automated climate control house showed statistically higher weight gain and final live weight and lower FCR compared to conventional systems (Farhadi et al. 2016; Szőllősi et al. 2021).

One of the first studies that compared the performance and costs of conventional versus fully automated climate control housing found higher body weight, better FCR, lower mortality and lower production cost of meat when reared under automated housing technology (Lacy and Czarick 1992). Andreazzi et al. (2018) showed that an automated climate control broiler housing was technically and economically viable. It brought benefits, such as labour optimisation and better welfare for broilers. These positive points generate stability and increase profitability, with water, feed, electricity and fuel savings and more production per unit area.

Fully automated climate control broiler houses have been a new source of investment (Kunh et al. 2015). It brings better production and a higher economic returns for both the company and the integrator, despite having a higher construction costs, maintenance, depreciation and a higher consumption of electric energy, compared to conventional houses (Rodrigues and Yada 2018; Szőllősi et al. 2021).

Energy costs for feeding, lighting and maintaining animal thermal comfort has a great impact on production costs (Bueno and Rossi 2006; Curi et al. 2022). In this study, the value of improved broiler performance in the fully automated broiler houses slightly compensated for additional operating costs, such as electricity, which was 27.14% higher than in conventional broiler houses (Table S4).

Conventional broiler housing are still prevalent, representing 65% of the data in this study; facilities, although fully automated control facilities (35%) are increasing fast. Sensitivity analysis exploring the impact of technical indicators and prices variations on the broiler production cost differential gives confidence in the decision-making about each building technology advantages. This analysis showed that lower investment (installations and equipment) and higher feed cost increased production costs in fully automated broiler housing.

The individualised comparison of cost indicators and performance between broiler housing models may not be suitable when determining economic viability (Caldas et al. 2015). Additionally, operational cost, scale of production, technological advantages and these effect on performance indicators should be considered (Talamini and Filho 2020).

The results, based on a wide range of real production data, are important to the broiler production chain, mainly for industry stakeholders, who coordinate the integrated production in Brazil and help in the decision making process regarding investment and expansion models. It is known that there is strong competition in the domestic and international meat markets, so production costs have a key role in the business. Investment in housing facilities affects labour use and animal performance and, consequently, costs and profitability. The use of modern technology and management, together with adequate input supply, will allow product quality and prices, benefiting producers, industry, consumers and all related agencies.

Conclusions

The effect of housing technology was significant for broiler performance variables, (FCR and live weight at slaughter), which were always more favourable in fully automated climate control broiler housing in all geographical regions. For mortality, fully automated broiler housing was lower in regions with hot and humid summer conditions. Despite better results in terms of condemnations, the average from conventional broiler housing, meat cost per ton, excluding losses for condemnations, was lower from fully automated housing. Additionally, all economic sensitivity simulations showed that the differential gain in production was favourable in fully automated housing. Therefore, climate controlled systems allow a reduction in production cost compared to conventional housing, which confirmed greater economic benefits and sustainability in Brazil.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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