R. Bras. Zootec., 51:e20210106, 2022
https://doi.org/10.37496/rbz5120210106

Animal production systems and agribusiness
Full-length research article

Revista Brasileira de Zootecnia

Brazilian Journal of Animal Science
e-ISSN 1806-9290
www.rbz.org.br

Socioeconomic and investment profile of environment control in a swine integration system

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ABSTRACT - The objective of this study was to characterize and understand the investment profile towards technologies for control and automation of climate control on swine farms, focused on integrated producers on the same integration system. A structured questionnaire including open, dichotomic, or multiple-choice questions was responded by 190 integrated producers classified as nursery (28,300 swines), wean-to-finish (WTF; 144,388 swines), or finishing unit (FU; 164,185 swines) farms. Data were described and categorized according to the type of integrated producer (nursery, WTF, and FU) and income history during a 24-month interval. The most predominant farmer profile was of a 44.5-year-old man, with incomplete secondary education. Furthermore, the majority of the farms had family-based labor with an average area of 43.6±65.5 ha and ~2.4 economic activities developed. Overall, a reduced labor availability was observed, although the integrated producers declared to be satisfied with the activities. Interestingly, integrated producers with a better income history declared a longer working (high = 37; average = 31; regular = 31; low = 28 min). The investment profile in automation technologies is conservative; however, potential improvements in pig performance were the most popular justification for potential investments. Furthermore, high costs, knowledge in technologies, interest rates, and quality of the available material are the limiting factors for investing in environment control. A total of 74% of the integrated producers considered the activity as economically profitable. Lastly, the uptake of environmental control technologies is strongly associated with the average income received by farmers.

Keywords: automation technology, pig production, pig farming innovation, smart farming, structured survey

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Received: June 3, 2021
Accepted: July 6, 2022

How to cite: Beker, F. M.; França, I.; Tomas, J.; Siqueira, H. A.; Lima, G. F. R.; Rizzoto, G.; Peripolli, V. and Bianchi, I. 2022. Socioeconomic and investment profile of environment control in a swine integration system. Revista Brasileira de Zootecnia 51:e20210106. https://doi.org/10.37496/rbz5120210106

1. Introduction

The swine production in Brazil has improved significantly throughout the years, with advances focused on nutrition, genetics, and health. However, investments in technology and environment control have been adopted less intensively when compared with other livestock areas. Among the increasing

investments in this segment, improvements in climate control and automation are observed, such as digital management technologies in the swine production system (Machado and Nantes, 2011).

Farm automation (such as feeding and environment control) and data management (known as Big Data) are likely to become even more frequent on swine farms (Hoste et al., 2017). Although Brazil is not a leading country in investments in this segment, the adoption of such technologies has been more intense in breeding systems and gradually on wean-to-finish (WTF) farms. Notably, the major limiting factors regarding a wider adoption of such technologies is the initial investment, material quality, and coverage of internet signal on the farms (Beker et al., 2020).

The understanding of the socioeconomic profile and the characterization of the reality for decision making of the implementation of new technologies is still sparse in the Brazilian swine industry. With the consolidation of the Agro 4.0 era (Massruhá and Leite, 2017) the knowledge of the profile of the farmers becomes an important way to understand the technological and economic issues for the farmers.

In this context, two questions were proposed to enhance the discussion on this subject: Is there a difference between the socioeconomic profile of pig producers on the different types of farms (nursery, WTF, and finishing)? How is the profile of investment and adoption of environmental control technologies by swine farmers of different types of farms? Therefore, the objective of this study was to characterize the socioeconomic profile as well as the capacity and disposition for investment of the farmers associated to a swine integration system in the South of Brazil, focusing on implementation of environment control automation on pig farms.

2. Material and Methods

This study was carried out according to the institutional Ethics Committee for Human Studies (reference number 4.085.137/2020). To characterize the swine production units, qualitative and quantitative data collection was performed through a digital survey (Google Forms, Google LLC, 2020). Our methodology was similar to that of Marcílio et al. (2022).

The structured questionnaire was composed of 34 questions, including open, dichotomic, or multiple-choice questions (with absolute and relative frequency answers). The classification of the farms (nursery, WTF, and finishing) followed the parameters indicated by the Associação Brasileira dos Criadores de Suínos (ABCS, 2016). The questions addressed aspects such as the type of farm, physical and economical characterization of the farm, employee profiles, perspective into the adoption of automation technologies, as well as the overall profile into decision making, regarding monitoring and investment in environment control on pig farms. A previous consent form was signed by participants.

The access link to the survey form was sent to all the participants (n = 281), from nursery, WTF, and finishing, integrated to a swine production agroindustry in the Itajaí Valley, Santa Catarina, Brazil (27°14'26.77" S and 49°41'07.18" W). All farms included in this study belonged to the same integration system (in accordance to the Federal Law 13.288 of May 16th, 2016) comprising a group of 23 municipalities. The reply period lasted from September to October 2020.

A total of 190 replies were received, representing 67.6% of the total of farms pertaining to the integration system. The nursery, finishing, and WTF units corresponded to 2.1% (n = 4), 61.1% (n = 116), and 36.8% (n = 70) of the replies, respectively. The average income history (R$/pig delivered) was considered on a 24-month basis, which preceded the survey. Based on that, the different farm types were initially grouped and then divided into four distinct income groups (high, average, regular, and low), each with 25% of the participants. The four new groups were used to arrange the answers regarding innovation and investment in environment control.

The daily labor time was calculated by the sum of number of workers and hours of work per day, and the result was converted in time (min) as a common ground for every 100 animals (Miele et al., 2011; Heinemann, 2013). Data were evaluated through descriptive statistics, which produced absolute and relative frequencies through the software Excel (Microsoft®) and Minitab 18®.

3. Results

3.1. Socioeconomical characterization, configuration, and quality of workforce

The questionary responses were mostly given by farm owners (95.8%), while only 4.2% was provided by employees. The average age of the participants was 39.7 (±10.6), 42.4 (±12.6), and 45.9 (±11.9) years old for the nursery owners, WTF, and finishing farms, respectively. Most of the participants completed primary education; however, a high percentage did not hold a secondary education degree (Table 1).

The average property size was of 43.69 (±65.5) ha (Table 2). The major portion of the farms (85.9%) also have other economic activities aside pig farming. On average, the properties had 2.4 (±0.8) activities with relative economic importance (maximum of six and minimum of 0, in addition to pig farming). The other activities developed in the farms were crop production (39.2%), beef and dairy cattle farming (35.8 and 29.7%, respectively), and fish farming (7.3%).

On WTF and finishing farms, family workforce was predominant; however, on nursery farms, due to the higher number of animals and volume of work required, the family is assisted by employees (Table 3). Regarding the perception of the skill of employees, WTF and finishing farmers mentioned, respectively, that, 37.1 and 38.8% were of "optimal quality", 57.1 and 55.2% were of "good quality", and 5.7 and 6.0% of "regular" or "lacking quality". Regarding the pig nursery systems, all farmers indicated the

Table 1 - Educational level of the participants in the survey (%)

Educational level	Nursery (n = 4)	Wean-to-finish (n = 70)	Finishing (n = 116)
Primary education (incomplete)	25.0	24.3	29.3
Primary education (complete)	25.0	20.0	19.0
Secondary education (incomplete)	25.0	2.9	6.9
Secondary education (complete)	0.0	32.9	32.8
Technical degree (incomplete)	0.0	4.3	2.6
Technical degree (complete)	0.0	1.4	1.7
Bachelor's degree (complete)	25.0	2.9	2.6
Bachelor's degree (incomplete)	0.0	11.4	5.2

Table 2 - Characterization of the work force on the pig farms (mean ± SD)

Item/type of farm	Nursery (n = 4)	Wean-to-finish (n = 70)	Finishing (n = 116)
Property area (ha)	35.8±39.5	35.2±31.4	49.5±81.0
Number of activities performed	1.8±0.6	2.5±0.8	2.3±0.9
Age of production unit (years)	7.8±5.9	7.3±4.4	12.2±6.1
Animal allocation capacity	7,075±1,738	2,062±679	1,414±627
Number of employees	3.8±0.50	2.6±0.94	2.3±0.96
Hours of work per day[1]	25.0±12.9	8.2±5.3	8.2±6.0

[1] Sum of hours of all the employees; provided by the employer.

Table 3 - Labour type on the pig farms (%)

Composition of work force	Nursery (n = 4)	Wean-to-finish (n = 70)	Finishing (n = 116)
Family	0.0	90.0	77.6
Family + temporary workers	25.0	8.6	7.8
Family + hired workers	75.0	1.4	9.5
Only hired workers	0.0	0.0	5.2

ability of employees as being "good". Interestingly, when asked to grade their work ability on a 0-10 scale, the results were 6.3, 7.9, and 7.3 for the nursery, WTF, and finishing, respectively. Moreover, when questioned about the availability of work force for hiring, only 55.8% of the participants answered the questions. Of these, 9.4% considered it as "abundant", while 43.4 and 47.2% considered it as "sparse" or of "low availability", respectively.

3.2. Characterization of electricity supply and internet access

Usually, the electricity supply is two-phase or three-phase power in 47.9 and 52.1% of the farms, respectively. Solar energy and the energy generated by tractor engine are the main supplementary sources of electricity (Table 4). Roughly, 62% of the property owners indicated that the inadequate power supply is a risk for the farm activity and 32.9% declared that the instability of the power supply is rather frequent on the farms. A specific question regarding the frequency of power blackouts in the properties indicated that 82.9% of the participants experienced it one to three times per month; 12.2%, four to five times per month, and 4.9% more than five times per month.

Internet access is available on all nursery farms, while in WTF and FU, it is available in 90.0 and 85.34%, respectively. Internet radio connection is the most common way to access internet on the farms (Table 5). Cellphones/smartphones are present on 100% of the farms, while notebooks and desktops were available on only 19.47 and 3.68% of the farms, respectively. Lastly, landline phones and radio communicators were listed as communication devices in 11.6 and 2.6% of the farms, respectively.

Table 4 - Major electricity sources and alternative/supplement sources[1] for power generation in the properties studied

Item/type of farm	Nursery (n = 4)	Wean-to-finish (n = 70)	Finishing (n = 116)
Dual voltage – 220v	50.0	51.4	45.7
Triphasic	50.0	48.6	54.3
Solar energy	0.0	17.1	10.3
Power generated by a tractor engine	50.0	11.4	10.3
Diesel generator	0.0	12.9	4.3
Gasoline generator	0.0	4.3	5.2

[1] Value corresponding to the percentage of properties in each category that has one or more alternative/supplementary energy source.

Table 5 - Internet connection sources in the farms (%)

Connection source	Nursery (n = 4)	Wean-to-finish (n = 63)	Finishing (n = 99)
Via radio	100.0	69.8	61.6
Via smartphone	25.0	38.1	45.5
Via landline phone system	0.0	7.9	16.2
Optic fiber	0.0	11.1	6.1

3.3. Characterization of farmers regarding the average hours of work and environment control

For each type of farm, the properties were categorized by the stratification of income history of pigs delivered into "high", "average", "regular", and "low-income". It was observed that in all farm categories, the farmers with a high-income history also reported a high average of daily work time (25, 28, and 43 min/days for every 100 animals housed on the nursery, WTF, and finishing farms) (Table 6). The work time average observed was 21.0±7.5 min/days for every 100 animals for nursery units, 24.0±13.8 for WTF units, and 37.0±28.4 for finishing farms.

The environment control actions performed on the farms contrasted with the daily work time dedicated to the property. One third of the farmers (32.5%) do not perform any monitoring, and roughly 60% do not record any of the observed information (Table 7). Only 18.1% of the farmers stated that they record the temperature and humidity on the farm; of this total, 32.3% have an automated recording system. Unfortunately, it was not possible to relate the income history to the monitoring routine or recording the temperature and humidity indexes. The farmers from each farm type were questioned about the number of times they perform the opening/closing of curtains daily (Table 8). Only 8% of the farms have an automated control system to open or close the curtains.

The participants were questioned about which was the most important environmental factor for a good animal performance in their production systems. The most important factors listed were temperature and air quality, which represented 50.0 and 44.2%, respectively (Table 9). The air quality was the indicator most cited by nursery (66.7%) and WTF (68.6%) farmers, whereas room temperature was mentioned by 62.6% of the farmers on the finishing farms.

Table 6 - Average work time (min/days) for every 100 animals housed on nursery, wean-to-finish, and finishing farms

Type of farm/income history	Min/day[1]
Nursery unit (n = 4)	
Regular	13±0.0
High	25±1.9
Wean-to-finish unit (n = 70)	
Low	22±16.5
Regular	25±16.0
Average	22±9.3
High	28±12.9
Finishing unit (n = 116)	
Low	32±14.2
Regular	36±34.0
Average	35±19.8
High	43±34.9
Overall total	32±25.0

[1] The daily labor time was calculated by the sum of number of workers and work hours per day, and the result was converted into minutes.

Table 7 - Indexes of temperature and relative humidity control inside farms segmented by the income history (%)

Type of farm/income history	Non-recorded	Only temperature	Temperature and humidity
Nursery unit (n = 4)			
Regular	0.0	100.0	0.0
High	0.0	100.0	0.0
Wean-to-finish unit (n = 70)			
Low	28.6	71.4	0.0
Regular	30.0	70.0	0.0
Average	38.9	44.4	16.7
High	33.3	55.6	11.1
Finishing unit (n = 116)			
Low	35.3	64.7	0.0
Regular	40.7	48.2	11.1
Average	44.1	55.9	0.0
High	16.2	81.1	2.7
Overall total	32.5	62.8	4.8

Table 8 - Curtain opening/closing method and number of times of manual activity performance on non-automated farms, according to each production system and income history of the farmer

Type of farm/income history	Non-automatic (%)	Automatic system (%)	Daily activity performance (n)[1]
Nursery unit (n = 4)			
Regular	100.0	0.0	5.0
High	0.0	100.0	-
Wean-to-finish unit (n = 70)			
Low	100.0	0.0	4.0
Regular	85.0	15.0	3.4
Average	88.9	11.1	3.4
High	77.8	22.2	4.8
Finishing unit (n = 116)			
Low	94.1	5.9	3.4
Regular	0.0	0.0	3.4
Average	0.0	0.0	3.9
High	91.9	8.1	3.4
Overall total	92.0	8.0	

[1] Averages compared only between farmers that perform the curtain handling manually.

Table 9 - Farmer opinion regarding the most important environmental indicators with potential to impact animal performance, in accordance with type of farm and income history (%)

Type of farm/income history	Absence of wind	Air quality	Environment temperature	Relative humidity
Nursery unit (n = 4)				
Regular	0.0	0.0	100.0	0.0
High	0.0	100.0	0.0	0.0
Wean-to-finish unit (n = 70)				
Low	0.0	71.4	21.4	7.1
Regular	0.0	65.0	35.0	0.0
Average	0.0	72.2	27.8	0.0
High	0.0	66.7	33.3	0.0
Finishing unit (n = 116)				
Low	0.0	35.3	64.7	0.0
Regular	18.5	29.6	44.4	7.4
Average	5.9	20.6	70.6	2.9
High	0.0	32.4	67.6	0.0
Overall total	3.7	44.2	50.0	2.1

3.4. Characterization of the farmers with respect to the investment profile

To understand the profile of investment and innovation, the farmers were questioned about their perception on the profitability of the activity that they performed. The farmers were asked about their acceptance of investment in new technologies (Table 10). Fifteen percent of the participants were in favor of the prompt implementation of new technologies.

Interestingly, even with a conservative approach regarding new technologies, 15.9% of the participants declared that they never performed repairs or improvements on their farms. On the other hand, the investments in such areas were performed three or more times since the beginning of the activity on 26.6% of the farms.

Notably, only 7.5% of the farmers declared they were not in favor of investing or adopting technologies to control the environment within the farm. A high percentage of farmers stated that the adoption of environment control technologies is economically viable for farmers of high- and average-income history in the finishing stage. Furthermore, 57.5% considered that investing in technologies for environment control can improve animal performance, even though the investment is costly and economically impracticable. Interestingly, most of the farmers that indicated that the investment would be profitable were those with low-income history from WTF (57.1%) and finishing farms (52.9%).

The most important reason to invest in environment control automation was the perspective of improvement in animal performance, which was indicated by 68.6% of the participants from all types of farms, especially for WTF systems (74.3%). They also mentioned the perspective of reducing the cost with workforce (18.6% of the overall farmers), particularly for finishing farmers, which represented most of the responses (22.6%). Lastly, the farmers mentioned the importance of adequation to the integration industry and to acquire knowledge on technologies available in the market, indicated as important by 12.8% of the participants.

On the other hand, cost was considered as the most important limiting (78.4%) factor for adoption of environment control automation, based on the overall responses. Other important limiting factors indicated were interest rates for financing (25.8%), knowledge on technologies available (19.5%), quality of the material employed in automation (11.6%), and likelihood of family inheritance (6.8%). Only 5.2% of the participants considered they had no limitations with respect to this type of investment.

Regarding the perspective of profitability of the activity, most of the participants (73.9%) considered pig farming as a profitable activity. A small proportion of the farmers (3.2%) wanted to leave the activities in their farms. Regardless of the income history, farmers of WTF (61.4%) and finishing farms (61.7%) have a similar perspective concerning the profitability of their production system (Table 11).

Table 10 - Investment profile of pig farmers for novel technologies for swine facilities and management of the environment

Type of farm/income history	Favorable, but doubtful of potential (%)	Favorable, if already tested by other farmers (%)	Favorable and willing to adopt immediately (%)	Conservative approach (%)
Nursery unit (n = 4)				
Regular	0.0	0.0	0.0	100.0
High	50.0	50.0	0.0	0.0
Wean-to-finish unit (n = 70)				
Low	20.0	50.0	20.0	10.0
Regular	22.2	27.8	16.7	33.3
Average	50.0	22.2	11.1	16.7
High	21.4	50.0	28.6	0.0
Finishing unit (n = 116)				
Low	18.5	44.4	14.8	22.2
Regular	43.2	27.0	10.8	18.9
Average	20.6	35.3	11.8	32.4
High	23.5	47.1	17.6	11.8
Overall total (%)	28.2	36.7	14.9	20.2

Table 11 - Profitability perspective of pig farming, in accordance to type of farm and income history of the farmer (%)

Type of farm/income history	Profitable	Less profitable	Profitable but not willing to invest in it	Willing to leave the activity
Nursery unit (n = 4)				
Regular	100.0	0.0	0.0	0.0
High	100.0	0.0	0.0	0.0
Wean-to-finish unit (n = 70)				
Low	50.0	50.0	0.0	0.0
Regular	75.0	15.0	5.0	5.0
Average	66.7	16.7	16.7	0.0
High	50.0	33.3	5.6	11.1
Finishing unit (n = 116)				
Low	64.7	23.5	11.8	0.0
Regular	59.3	14.8	18.5	7.4
Average	61.8	20.6	14.7	2.9
High	62.2	24.3	13.5	0.0
Overall total	62.2	22.9	11.7	3.2

4. Discussion

The socioeconomic and investment profiles are the main characteristics to respond the interaction between factors such as region, culture, and economic relevance of the most important activity of the area of the study. This study aimed to understand the profile of the pig farmers in the Itajaí Valley, a countryside of Santa Catarina, Brazil. The studied region has a high human development index (HDI).

The average profile of the pig farmer is of middle-aged men (44.5 years old), with a primary education degree although a study carried out by Hoelscher (2018) indicated that the pig farmers from the South of Brazil have a higher educational level, with at least a secondary education degree or a bachelor's degree. However, the author interviewed farmers that were in the activity for a longer time when compared with the present study. Additionally, another study observed that farmers within a similar age range had a heterogeneous educational level when compared with pig farmers with family and industrial activities (Kumar et al., 2014). Lastly, a similar pattern was also observed in Central Africa (Motsa'a et al., 2018).

The average housing capacity of the nursery, WTF, and finishing units in the State of Santa Catarina are 1,921, 1,660, and 649, respectively (ABCS, 2016), lower than the capacities observed in the present study. Similarly, the overall housing capacity on nursery and finishing farms in Brazil are also lower than those obtained in this study. However, the WTF farms have an average housing capacity of 2,651 animals/farm (ABCS, 2016), higher than observed in the present study. Lastly, the housing capacity of pig farms in Paraná, Brazil, another southern state, are smaller (669±340 animals) compared with the present study.

The demand for employees in WTF and finishing were quite similar, although there are important differences regarding the type of activities required for each production system. Furthermore, there is a good perception regarding the quality of farm employees, although the reduced possibilities of hiring may become a limiting factor in the future, especially on the farms that do not have a perspective of family inheritance, which in this study was of around 25%. This scenario indicates a good perspective regarding the maintenance of the activities on the farm. Moreover, profitability is the most important factor related to the permanence in the farm activity (Kruger et al., 2018). Moreover, the guarantee of a satisfactory income is fundamental for new generations to remain in the production industry in the countryside.

The number of workers involved in pig farming was similar to the described in a previous study (Horwat, 2019), which investigated the metropolitan region of Curitiba, Paraná, Brazil, which employed 2.2±1.2 workers on average. The author also reported a great participation of family workforce in pig farming as well as other economical enterprises within the farm such as crop, cattle, and poultry production. The great importance of the family workforce was also reported by Silva et al. (2017) who observed about 75% of the workforce of this type in productive swine farms in the southern region of Brazil.

The energy supply and internet signal are satisfactory. However, there are constant interruptions due to the recurrent power blackouts, roughly, in one third of the farms. A small fraction of the properties relies on alternative power sources. Moreover, the quality of the energy production must be in consonance with legal regulations with respect to animal welfare applied to pig farms (MAPA, 2020), which demands supplementary power sources on farms with automated systems, and therefore requires a contingency plan to guarantee the welfare and health of the animals during power blackouts or interruptions.

The internet signal reaches about 85% of the properties, and the access is mostly performed via smartphones, which were present on all farms. A study carried out by SEBRAE (2017) indicated that 92.6% of the rural farmers from Santa Catarina State (Brazil) used smartphones in their properties. However, when asked about the quality of internet coverage in the countryside, the farmers ranked it as 6.2 (in a 0-10 range). Therefore, the internet signal quality can be a limiting factor when farmers adopt an online automation/control system that requires a livestream data exchange.

Farms with better income history per pig delivered for slaughter, regardless of the housing capacity of the property, declared they work for longer periods. Furthermore, data from the InterPig Network, which contains information of the most well ranked countries in pig farming, indicates that the required time spent per animal by an employee in the finishing systems in Santa Catarina is 49 min, whereas the world average is 22 min (Miele, 2019). In our study, the average work time per animal was 43 min for the finishing farms, considering a total of 116 days of housing. Besides, this value can be explained by the low demand of human labor in automated systems, which is most common in countries such as United States, Denmark, and France, that are part of the InterPig Network (Miele et al., 2011; Heinemann, 2013).

One third of the properties did not perform any control of the environment indicators within the farm. In addition, two thirds of the farmers that monitor these indicators did not have records of the temperature and relative humidity. It is important to indicate that the automation strategies are sparse in the reality observed in this study. Additionally, the manual handling of curtains is an important management tool for pig production systems with positive/natural pressure (Santos et al., 2018; Beker et al., 2020). In this study, the handwork is more predominant when compared with automated systems. Therefore, the average number of times that workers had to manually open or close the curtains may also be related to animal performance.

A conservative investment profile, with respect to automation technology and environment control, was predominant among the farmers, even after indicating that they consider the pig farming as a profitable activity. The perception of profit in WTF and finishing farms based on the data of this study is different from the observed in another study (Piva and Gonçalves, 2014), which indicated that the WTF systems in Brazil require more investments in infrastructure and manpower training and, therefore, have the lowest profitability on a short or average term. A study of Consoni et al. (2015) indicated that the WTF system have a good economic viability in the Brazilian perspective, mostly due to the increase in average daily weight gain and average weight at slaughter, in comparison with pigs raised in the traditional growing and finishing systems.

Farmers with a lower income history are less conservative regarding their investments in environment control. The assumption is that the decision making into improving is likely to increase the animal performance. Lastly, the high cost and interest rate over financing as well as the lack of knowledge regarding up-to-date technologies and availability of material of good quality were the main limiting

factors that may explain the low investment rates in strategies for automation and environment control on the farms studied.

5. Conclusions

The socioeconomic profile of the swine farmers participating in our study was homogeneous, probably because all swine farmers were part of the same integration system. Several factors were identified as key points for investments towards technologies for control and automation of climate on swine farms. The perception of the farmers is that the types of swine farms included in the study have good profitability, considering a productive scenario by the expressive family production system with diversification in the activities on the farm and positive expectation towards family inheritance of the farm. Besides, the performance of the animals may have a positive association with the number of daily hours of work. The adoption in higher scale of automation of environment control by the farmers is strictly related to the reduction of the initial investment, interest over loans, and diffusion of knowledge regarding the available state-of-the-art technologies as well as availability of good-quality materials for performing such improvements.

Author Contributions

Conceptualization: F.M. Beker, I. França and I. Bianchi. Data curation: F.M. Beker, I. França and J. Tomas. Formal analysis: F.M. Beker and I. França. Funding acquisition: F.M. Beker and I. Bianchi. Investigation: F.M. Beker, I. França, J. Tomas and H. A. Siqueira. Methodology: F.M. Beker, I. França, G.F.R. Lima and I. Bianchi. Project administration: F.M. Beker and I. Bianchi. Supervision: V. Peripolli and I. Bianchi. Validation: F.M. Beker and I. França. Visualization: F.M. Beker and I. França. Writing – original draft: F.M. Beker, I. França and G. Rizzoto. Writing – review & editing: G.F.R. Lima, G. Rizzoto and I. Bianchi.

Acknowledgments

The authors acknowledge Pamplona Alimentos SA for the authorization of the data collection within the integrated producer base of the company. Furthermore, we would like to thank the Núcleo de Inovação Tecnológica from the Instituto Federal Catarinense (call notice NIT 70/2019 IFC) for the financial support of the research project. We also acknowledge all the producers that provided de data used in our study.

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