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The impact of using technology on the performance of dairy production: traditional management, compost barn and free stall

El impacto del uso de la tecnología en el desempeño de la producción lechera: manejo tradicional, establo de compostaje y puesto libre

O impacto do uso da tecnologia no desempenho da produção leiteira: manejo tradicional, compost barn e free stall

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Abstract

Purpose: This theoretical application seeks to analyze the contribution of the use of differentiated technologies and systems in the formation of the results of the dairy activity of three rural properties, which use different productive systems and are located in the Northwest region of the State of Rio Grande do Sul. Calculation of costs of the three properties using the absorption costing method, in order to know the respective results in each production system analyzed.

Methodology: To achieve the objective of the study, financial control sheets were prepared, based on these data, the management cost indicators for each property were determined,

namely: contribution margin, breakeven point, operational safety margin, income statement and some investment indicators, thus enabling the comparison of results in traditional production, composting granaries and free stalls.

Results: The results indicate that the compost barn method obtained the highest productivity per matrix, the highest average price and the second lowest cost per liter, and, therefore, the highest average profit per liter and per area (hectare) for dairy production among the three properties analyzed, with an average result per liter of R \$ 0.27 and per area (hectare) R \$ 10,030.52. In comparison with other studies carried out in the area, the results indicate that the region under research was a determining factor.

Contributions of the Study: The research made it possible for external users to verify which production method achieved the highest productivity and profitability in the region and in the properties analyzed. In addition, for the producers participating in the research, it was possible to evaluate the return on the activity based on a complete determination of costs, considering that their controls before the development of the study were strongly based on intuition or on previous experiences, without due control. and evaluation.

Keywords: Costs; dairy production; technologies; production systems.

Resumen

Objetivo: Esta aplicación teórica busca analizar el aporte del uso de tecnologías y sistemas diferenciados en la formación de los resultados de la actividad lechera de tres predios rurales, los cuales utilizan diferentes sistemas productivos y se ubican en la región Noroeste del Estado de Rio Grande do Sul. Cálculo de costos de las tres propiedades mediante el método de costo por absorción, con el fin de conocer los resultados respectivos en cada sistema productivo analizado.

Metodología: Para lograr el objetivo del estudio se elaboraron planillas de control financiero, a partir de estos datos se determinaron los indicadores de costo gerencial de cada inmueble, a saber: margen de contribución, punto de equilibrio, margen de seguridad operacional, cuenta de resultados y algunos indicadores de inversión, posibilitando así la comparación de resultados en producción tradicional, granero de compost y puesto libre.

Resultados: Los resultados indican que el método de establo de compostaje obtuvo la mayor productividad por matriz, el precio promedio más alto y el segundo costo más bajo por litro, y, por lo tanto, el beneficio promedio más alto por litro y por área (hectárea) destinada a la producción lechera entre los tres. propiedades analizadas, con un resultado promedio por litro de R \$ 0,27 y por área (hectárea) R \$ 10.030,52. En comparación con otros estudios realizados en la zona, los resultados indican que la región bajo investigación fue un factor determinante.

Contribuciones del Estudio: La investigación permitió a los usuarios externos verificar qué método de producción alcanzó la mayor productividad y rentabilidad en la región y en las propiedades analizadas. Además, para los productores participantes en la investigación, fue posible evaluar el retorno de la actividad en base a una determinación completa de costos, considerando que sus controles antes del desarrollo del estudio estaban fuertemente basados en la intuición o en experiencias previas, sin debido control y evaluación.

Palabras clave: Costos; producción diaria; tecnologías; sistemas de producción.

Resumo

Objetivo: Esta aplicação teórica busca analisar a contribuição do uso de tecnologias e sistemas de produção diferenciados na formação dos resultados da atividade leiteira de três propriedades rurais, que utilizam diferentes sistemas produtivos e estão localizadas na região Noroeste do Estado do Rio Grande do Sul. Utilizou-se para a apuração de custos das três propriedades o método de custeio por absorção e variável, afim de conhecer os respectivos resultados em cada sistema de produção analisado.

Metodologia: Para atingir o objetivo do estudo, foram elaboradas, a partir da coleta de dados planilhas de controle financeiro, e com base nestas, apurou-se os indicadores gerenciais de custos de cada propriedade, sendo eles: margem de contribuição, ponto de equilíbrio, margem de segurança operacional, demonstração do resultado e alguns indicadores de investimentos, possibilitando assim a comparação dos resultados na produção tradicional, *compost barn* e *free stall*.

Resultados: Os resultados indicam que o método *compost barn* obteve a maior produtividade por matriz, o maior preço médio e o segundo menor custo por litro, e, portanto, o maior lucro médio por litro e por área (hectare) destinado a produção leiteira entre as três propriedades analisadas, sendo seu resultado médio por litro de R\$ 0,27 e por área (hectare) R\$ 10.030,52. Em comparação com outros estudos realizados na área, os resultados indicam que a região em pesquisa foi um fator determinante.

Contribuições do Estudo: A pesquisa possibilitou aos usuários externos verificar qual método de produção alcançou maior produtividade e lucratividade na região e nas propriedades analisadas. Além disso, para os produtores participantes da pesquisa, permitiu avaliar o retorno da atividade a partir de uma completa apuração de custos, tendo em vista que seus controles antes do desenvolvimento do estudo eram fortemente baseados na intuição ou em experiências anteriores, sem um devido controle e avaliação.

Palavras-chave: Custos; produção leiteira; tecnologias; sistemas de produção.

1 Introduction

Brazilian agribusiness has made significant advances, becoming relevant for the country's economic development, as it is a dynamic sector of the economy, influencing other sectors and standing out not only in the national market, but also internationally, due to the growth of exports (Callado, 2014; Ministry of Agriculture, Livestock and Supply [MAPA], 2019). In this context, dairy farming stands out for generating employment and being fundamental for economic development (Assis et al., 2017; Josahkian, 2018), as Brazil is the fourth largest producer in the world, second only to the United States, India and China (Rocha, & Carvalho, 2018).

The production chain of dairy production presents good growth prospects, as it is substantial in the production of basic necessities (food), whose consumption is expressive throughout the country and in a large part of the world (Herculano, & Alves, 2014). Producers need to seek for constant improvement, investing in the field, in order to meet the demands of the dairy market and improve the quality of production (Pilatti, 2017).

In this scenario, Pereira and Malagolli (2017) highlight that rural companies have to adapt to a new reality, produce more in less space, to better manage their results. Furthermore, due to the low remuneration of the milk paid to the primary producer, the variation of cents in the revenue or in the unit cost of each liter of the product are decisive factors for the economic efficiency of a milk production system. Thus, cost management in dairy production can help the rural manager in monitoring economic and financial indicators, enabling inferences to improve the profitability of the activity (Zanin, Favretto, Possa, Mazzioni, & Zonatto, 2015).

In addition to it, to remain active in the market, rural properties are having to incorporate in their production processes the use of technologies that provide an increase in the activity's margins and profitability (Rocha, Resende, & Martins, 2018). According to Silvestri et al. (2008), there are currently several technologies used in dairy farming, including: a) milking machines with milk flow meters, blood detector, identification of milk flow obstruction and vacuum regulators; b) genetic improvement of the herd, using artificial insemination and use of sexed semen; c) monthly veterinary and nutritional follow-up, aiming to increase or maintain the productivity of the herd; and d) special treatment for pre-calving cows, using their own feed to reach the maximum productive potential in the next lactation.

Thus, the study question is: How does the application of technologies and the use of different production systems influence the construction of results in the dairy activity? Therefore, the objective was to analyze how the application of technologies and the use of different production systems contribute to the results of the dairy activity of three rural properties that use different production systems.

To achieve the objective of this study, the collected data were systematized in spreadsheets, determining the management cost indicators and comparing them in traditional production/grazing, compost barn and free stall. Based on the indicators found, an interpretive analysis of the results found in the properties surveyed was carried out.

Then, this research is justified by bringing contributions to an outstanding activity of Brazilian agribusiness, which employs a significant number of people, being an important source of income for rural producers. In addition, it will contribute to the sector by showing how technologies are capable of increasing the productivity and profitability of dairy cattle, which, in turn, is an activity with good growth prospects in the country.

It is expected that the research will provide the managers of the researched properties in research and also for other milk producers, information that will help in the management of their business, indicating which method of production system is being more profitable in the region, and consequently how the use of technology can influence the performance of properties, showing that it can be a good ally of field work.

2 Literature Review

2.1 Dairy Production

Dairy cattle raising is an activity of raising animals collectively based on a given milk production system. It is an activity with significant importance for economic development and world agribusiness, both in more remote periods and currently. In Brazil, dairy farming has shown continuous growth, both in terms of production and quality and technologies used in production processes (Domenico, Mazzioni, Kruger, & Bock, 2015; Crepaldi, 2019). For this activity, there is an increase in production costs, caused by the concern with food safety, animal welfare and the impact of farming on the environment. With the reduction of profitability

margins, producers tend to invest in new technologies that allow for the improvement and efficiency of dairy production systems (Pereira, & Malagolli, 2017).

Medeiros and Brum (2015) report that in Rio Grande do Sul state, milk began to be produced since the beginning of the occupation of their territory and the introduction of cattle, however, its more expressive consumption by the population occurred with the arrival of immigrants in the 19th century and the consequent settlement of the State. Since then, Rio Grande do Sul has been following the evolution of dairy farming in Brazil, being, in fact, the second largest milk producer in the country, only behind Minas Gerais and closely followed by the State of Paraná. Thus, despite the difficulties encountered in the milk production chain - high production cost, price fluctuation and low scale of production - the producer is seeing the activity as an important source of income for the family and not only as a complement to it (Medeiros, & Brum, 2015).

Among the production systems there is the traditional management of dairy cattle, which is known as pasture or grazing, (Zanin et al., 2015), used by producers who have a small number of animals, in which the cattle feed on the pasture and only when they are sent for milking do they receive a complementary food in the trough. Rotations may occur in different pastures, or be continuous (Silva, 2006). In rotation, the pasture is divided into parts, called paddocks and in continuous grazing the cattle remain daily in the same place. According to Silva (2006), relatively low costs and greater movement of animals are the main advantages of the traditional system. Among the disadvantages are the lower level of milk production, the need for a larger area for management and the difficulty of quality pastures.

The compost barn consists of a rectangular shed that has a large common area, called the rest area, lined with wood shavings or sawdust and separated from the food corridor by a concrete overhang. In this production system, composting occurs naturally over time through bedding material and organic matter from animal waste (Silano, & Santos, 2012). For Milani and Souza (2010) and Dalchiavon, Heberle, Fank and Zanin (2018), the main advantages of the compost barn system are: animal comfort and well-being, improved herd productivity, ease of daily management, animal longevity, use of bedding as a fertilizer in plantations, reduction of hoof diseases, low maintenance, among other advantages.

In turn, the free stall system comprises a free stall, structured in individual stalls, lined with a bed for resting and a free area for food. With housing in individual pens, the animal tends to move less in pastures, saving energy, increasing production, facilitating the feeding and reproduction of cattle and improving the hygiene of the pens (Zanin et al., 2015). As disadvantages, there is housing in inadequate space for a long period, which can harm the health of the cattle, affecting the level of production and profitability of the activity; in addition to the high cost of equipment and facilities, which for some producers is a limiting factor that ends up making investment impossible (Domenico et al., 2015).

So, production can take place not only through the traditional management system, but also through production structures that are based on animal confinement, which consist of accommodation for dairy cattle aimed at the comfort and health of the animal. free stall differs from compost barn in that it is separated into individual stalls (Zanin, et al., 2015; Pilatti, 2017). Table 1 presents the main characteristics of each research production system, based on the authors used.

Table 1
Characteristics of dairy production systems

	Traditional Production	Compost barn	Free stall
Quantity of Animals	Small number of animals (Silva, 2006)	Generally used in bigger herds (Silva, 2006)	Like <i>compost barn</i> , used in bigger herds (Silva, 2006).
Instalations	The cattle feed and remain daily in the pastures (paddocks or continuous grazing) (Silva, 2006)	Rectangular shed, without dividers, lined with wood shavings or sawdust (Silano, & Santos, 2012) Structured shed with individual stalls, lined with sawdust or rubber bedding (Zanin et al., 2015).	Rectangular shed, without dividers, lined with wood shavings or sawdust (Silano, & Santos, 2012) Structured shed with individual stalls, lined with sawdust or rubber bedding (Zanin et al., 2015).
Advantages	Low cost and lower investment requirement (Silva, 2006)	Animal welfare, and consequent improvement in productivity and longevity, in addition to ease of daily handling (Dalchiavon et al., 2018)	Increased production due to longer rest time. Ease of cleaning the pens, and therefore, the animals are cleaner (Zanin et al., 2015)
Disadvantages	Less milk production, need for a larger area for animal management and difficulty in obtaining good quality pastures (Silva, 2006)	High cost of sawdust to keep the bedding in the desired conditions, in addition to daily management of the bedding, with attention to temperature and humidity (Dalchiavon et al., 2018).	High construction cost, requiring high production to make the costs viable (Domenico et al., 2015).

Source: Silva (2006); Silano, & Santos (2012); Domenico *et al.*, (2015); Zanin *et al.*, (2015); Dalchiavon *et al.*, (2018)

So, rural accounting, centered on cost management, can assist in the management and adoption of strategies capable of enhancing results, subsidizing the manager with information that enables the monitoring of business performance, improving financial and non-financial indicators (Crepaldi, 2019). It is understood that, based on this information, the rural manager can seek production alternatives that allow quick adaptation, in case there are changes in the cost elements of production, or in the product's sales price, which is fixed by the market (Braum, Martini, & Braun, 2013).

Technological evolution and market demands for quality products at attractive prices make rural producers demand economic and financial information that enable assertive inferences, resulting in productive efficiency and maximization of their results (Dal Magro, Domenico, Klann, & Zanin, 2013). In this context, cost management is highlighted in rural activities, being a tool that provides relevant information for management decisions in rural activities and the use of different costing methods allows finding the cost of production, understanding the behavior of these costs and measure the various activities during the production process, identifying those that imply a greater consumption of resources (Quesado, Silva, & Rua, 2018)

Zanin et al., (2015) report that with the desire to increase production, rural managers are investing in the modernization of production processes, causing costs to increase and, consequently, managers demand more control and cost information, seeking alternatives that meet these needs. In dairy farming, there is a tendency to consider aspects inherent to the management of production costs as fundamental information in the decision process, as it

allows the analysis of production structures according to the particular characteristics of each property. (Santos, & Lopes, 2014; Zanin et al., 2015).

2.2 Cost Accounting

Padoveze (2005, p. 5) conceptualizes cost accounting as: “[...] the segment of accounting science specialized in the economic management of the cost and selling prices of products and services offered by companies”. “The term “cost” means collecting, accumulating, organizing, analyzing, interpreting and reporting costs and cost data in order to assist the company's management” (Leone, 2008, p. 234). Thus, costing methods can be conceptualized, according to Padoveze (2005) as the process of identifying the unit cost of a product or service or all products and services of a company.

Absorption costing is the most traditional costing method, it consists of appropriating all production costs to products, directly or indirectly, using apportionment criteria (Wernke, 2008). The direct or variable costing system consists of an appropriation of a managerial nature, that is, only the variable costs of production and marketing of the product as raw material, direct labor and third-party services are applied to the product (Wernke, 2008). In the conception of Santos, Marion and Segatti (2002), the analysis of cost, volume and result is one of the means of getting to know some factors that may be harming the economic profitability of the agricultural activity. Therefore, this analysis makes it possible to diagnose problems through the composition of costs, in order to conclude on the situation of the activity's income.

According to Padoveze (2005) the contribution margin represents the variable profit, that is, it is calculated by the difference between the unit selling price of the product or service and the variable costs and expenses per product or service unit. According to Crepaldi (2012, p. 131) "the expression break-even-point, translated as break-even-point, refers to the level of sale in which there is no profit or loss, that is, where the total costs are equal the total receipts”.

The safety margin is conceptualized by Wernke (2008, p. 62) as: “[...] the sales volume that exceeds the sales calculated at the break-even point. In other words, it represents how much sales can fall without harming the company”. As for the DRE, its main purpose is to portray the formation of the result generated in the year, through the specification of revenues, costs and expenses, until the final net result, being this profit or loss (Braga, 2012).

In the view of Assaf Neto (1992, p. 1) “the investment evaluation study basically refers to decisions to invest capital in projects that promise returns for several consecutive periods.” The profitability index establishes a relationship between the value of the final net profit over the total revenue, with the purpose of verifying the share of the net profit that remained for the company of the total sales value for the period (Basso; Filipin; Enderli, 2015). In turn, profitability is an index that measures, according to Braga (1995, p. 30) “[...] the degree of economic success achieved by a company in relation to the capital invested in it”. The term for return on investment is defined by Assaf Neto (1992, p. 5) as "the method that essentially consists of calculating the time required for the amount of capital expenditure made to be recovered through net cash flows generated by the investment”.

2.3 Previous Studies

Among the studies about the subject, Zanin et al. (2015), studied two rural properties located in the west of Santa Catarina, comparing costs and productivity in the dairy activity based on traditional and free stall production. As a result, it was found that the free stall system

provides a better economic result for the dairy activity, considering the similar production structures of the properties analyzed in the research.

Grespan, Trindade and Breitenbach (2016) aimed to demonstrate and compare the economic viability of semi-confined, free stall and compost barn milk production systems in Passo Fundo Microregion, in order to identify which production system is more profitable. The results were calculated based on the remuneration for labor, per area or per animal. Considering the labor factor of production, the compost barn system paid the most, being R\$ 5,088.75/person. In the animal factor, in turn, the semi-confinement system had the highest capital return of R\$ 3,095.82/cow. Finally, in terms of remuneration per area (ha) the compost barn and semi-confined systems had the best performance, with R\$ 7,223.74/ha in the first and R\$ 7,223.52/ha in the second. It was also found that “[...] on the average of the properties studied, the semi-confined system has the highest return on capital per year (7%), followed by the compost barn (5.4%) and free stall (3.6 %)”.

The study carried out by Adams (2018) evaluated the feasibility of installing a compost barn in a property located in the region of Missões – RS, in a period of four years, considering the traditional system used and the installation of a compost barn system. The results were obtained considering three different scenarios regarding the commercialized value of a milk liter. In the pessimistic scenario, the compost barn system would start with a negative result and would improve over the years with positive results. In the realistic and optimistic scenario, the operating result would be more significant, making the investment viable, that is, in the realistic scenario in 6 years the initial invested resources would be recovered and in the optimistic scenario this time would decrease to 5 years.

Bandeira (2018) aimed to identify the elements that define the economic and financial feasibility of investing in a compost barn system in the milk production of a rural property. As a result, the author found that the project is economically and financially viable, considering that it presented excellent terms for the return on invested capital, which is 2.23 years, in addition to a positive NPV and an IRR higher than the TMA.

Dalchiavon et al. (2018) compared the costs and productivity of milk from the three production systems (traditional, compost barn and free stall). The study was carried out in three rural properties located in the west of Santa Catarina, from June to July 2017, concluding that the free stall management system provides a better economic result for the dairy activity, but with a larger production structure than the other properties analyzed in the study.

It is in this scenario that the relevance of this study is presented, as it seeks to analyze the contribution to the results formation of the technologies application and the use of different production systems in the dairy production process in three properties with different production systems, the research gap, in addition to considering different periods for the costs and result calculations.

3 Methodological procedures

For Marconi and Lakatos (2003, p. 82) “[...] method is the set of systematic and rational activities that, with greater security and economy, allows reaching the objective - valid and true knowledge -, tracing the path to be followed, detecting errors and assisting the scientist's decisions”. According to Zamberlan et al., (2014) researches can be classified according to the characteristics they have in relation to the nature, the way of approaching the problem, levels or objectives and technical procedures.

The study is classified as descriptive, which according to Prodanov and Freitas (2013, p. 52) “[...] only registers and describes the observed facts without interfering with them”. Thus,

in this study, fundamental information about the rural properties under study, such as their investments in the respective production systems, their revenues, costs and expenses, were obtained from the observation and data collection. After collected, the data were described and processed in order to determine some cost management indicators that made it possible to analyze the impacts of the use of technologies on the performance of milk production. Therefore, there were no interferences in the calculated data.

Richardson *et al.* (2012) mentions the qualitative approach does not use statistical instruments for the problem analysis process. For Beuren *et al.*, (2004, p. 92) “in qualitative research, deeper analyzes are conceived in relation to the phenomenon being studied [...]”. Therefore, this study has a qualitative approach, as it does not use statistical bases, but rather, data and information collection in rural properties that use different milk production systems, to answer the research question.

As for the procedures, documentary research and multi-case study were used. For Beuren *et al.*, (2004), documental research uses primary sources, so, information that has not yet undergone an analytical treatment or that can be re-elaborated according to the research objectives, on the other hand, the multi-case study, according to Yin (2015), it is a deeper and more exhaustive analysis of multiple objects, allowing its detailed knowledge. Therefore, the research is classified as documentary, as the data in the documents made available by the owners of the three properties under study were examined; and multi-case study, as three rural milk producing organizations in the Northwest of Rio Grande do Sul were studied, in order to know the costs and results of three rural properties, and, from these data, analyze the contribution of the use of differentiated technologies and systems in the milk production process.

3.1 Data Collection Instruments

The data collection process represents the way in which the necessary data to answer the research problem are obtained (Vergara, 2009). To carry out this study, data were collected from the managers and directors of the surveyed rural properties. The main data collected are related to the technologies used in milk production, the respective revenue from the activity, as well as information regarding their costs and expenses.

Therefore, data collection was carried out through observation, and from this it was possible to know the productive processes of the three rural properties analyzed, with this flowcharts were elaborated depicting how the daily handling of animals is carried out in each system of production of the properties under study. Subsequently, data were collected from documents made available by property managers, optimizing time and avoiding the need to directly request information from the owners that could be verified through the documents.

Finally, interviews were conducted with property managers, which consisted of a conversation between the researcher and property managers, collecting the necessary information to answer the question studied, deepening the search and also answering questions about the documents made available, in order to obtain reliable results. Through the interview carried out with the property managers, all the data necessary for the preparation of the research spreadsheets were collected, in order to identify the costs and results of the properties analyzed and the impact of the technologies used in their production systems, being applied to document and content analysis technique, seeking to meet the proposed objective of the study, requiring more interviews.

4 Results and Analysis

The study is a comparative analysis between the traditional, compost barn and free stall milk production systems in three rural properties in the Northwest region of the State of Rio Grande do Sul, which exclusively use cows of the breed for milk production. Dutch, which makes it possible to compare the production volume between properties based on their respective production systems. The properties were named as A, B and C, and each one has a distinct production structure and uses different technologies in their production processes.

A property uses traditional management/grazing, this method is the most used and known in dairy cattle, in which the cows remain outdoors, feeding on pastures separated by paddocks. After milking, the cows receive an adequate amount of feed, mineral salts and silage in the trough. A property under study has an average of 35 lactating cows and the milking process takes place twice a day, one in the morning and another in the afternoon, with an average monthly production of 28,142 liters.

The property's production process can be summarized as follows: at first, the cows are sent to the milking parlor to then be prepared, with teat cleaning using pre-dipping and teat drying with paper towels, then the first three jets are performed, and then the racket test is performed, which consists of identifying the amount of somatic cells in the milk. After this step, the teat cups are placed to start the milking process, after its completion the teats are sanitized again with post-dipping product, later the cows are released from milking and sent to feed in the troughs and in the pasture.

B property under study uses compost barn as its production method, which is a housing system similar to the free stall system, except for the fact that there are no partitions for each animal separately. Thus, in this system the cows are free to move and can feed at any time of the day, as food is always available. The property has an average of 130 lactating cows and the milking process takes place three times a day, with an average monthly production of 124,378 liters.

The property's production process starts with the transfer to the waiting room for milking batch 1 (cows with daily average production above 30 liters) and after batch 2 (cows with daily production of 10 to 30 liters). The milking process occurs according to the batches, and as in A property, it starts with the milking preparation, cleaning the teats with pre-dipping, drying the teats with paper towels, carrying out the first three jets, followed by the test of the racket. Once the preparation process is finished, the teat cups are placed and the milking process is then carried out, afterwards the teats are sanitized with post-dipping and the cows are released from milking and then sent to the compost barn, where the cows are free to rest and eat, and your food is available 24 hours a day.

Finally, C property uses the free stall, which consists of a large fenced area, where one part is destined for food and exercise and the other part is divided into individual stalls that are lined with a bed for the animals to rest. C property has an average of 150 lactating cows and the milking process takes place three times a day, the average monthly production of the property is 126,622 liters.

The production process of C property is very similar to B property, so, the cows are separated into lots and sent for milking, in which all preparation takes place as described in the processes of the other properties, after the end of milking the cows are taken to the free stall housing, being free to feed and go alone to a free stall to rest.

The production and yield data of animals from properties A, B and C are summarized in table 2.

Table 2*Property data under research*

PROPERTIES DATA	PROPERTIES		
	A - Grazing	B - Compost Barn	C - Free stall
N° of cows in production	35	130	150
Total Average Production per month	28.142	124.378	126.622
Average production per day per cow	26,8 liters	31,89 liters	28,14 liters
Average price per liter sold	R\$ 1,38	R\$ 1,60	R\$ 1,58
No. of hectares used for dairy production	14	40	55
No. of own hectares	14	40	25
No. of leased hectares	-	-	30

Source: *Survey data (2019).*

After the characterization of the productive processes of the properties under study, the research results were investigated and analyzed, in order to answer the proposed question. The period for calculating the survey data comprised the months of August/2018 to July/2019. Data collection was aimed at knowing the total cost of a liter of milk from each of the properties under study.

The direct costs of the properties involve the costs of animal feed, such as corn silage, hay, oat silage, summer and winter pasture, feed and mineral salt. Direct costs also include the costs of drugs and vaccines for routine animals, depreciation of lactating cows and the costs of labor involved in production. On the other hand, indirect costs include the feeding of heifers, depreciation of machinery, equipment and buildings, depreciation of heifers and dry cows, cleaning material used in the milking process, monthly veterinary services, electricity, water, meter, sawdust in the case of compost barn and free stall, *pro-labore*, semen used in artificial insemination and fuel for daily management of the properties. With this, the total cost of the liter of milk produced from the properties was calculated from the cost of absorption and variable cost.

Table 3 describes the monthly averages of the direct and indirect costs of the dairy activity on the properties.

Table 3*Total cost of the dairy activity*

Variable direct costs	Average Monthly Property A	Average Monthly Property B	Average Monthly Property C
Corn silage	1.775,34	12.477,43	16.151,12
Food	12.403,01	53.424,75	65.362,50
Winter pasture	395,57	0,00	0,00
Summer pasture	384,73	0,00	0,00
Hay	149,69	0,00	415,65
Mineral salt	1.617,00	0,00	480,00
Routine Medicines and Vaccines	1.669,67	9.000,00	14.000,00
Employees	3.600,00	8.000,00	18.000,00
Depreciation cows in production	1.400,00	6.933,33	8.000,00
Total Variable Direct Cost	23.395,01	89.835,51	122.409,27
Monthly production/liters	28.142	124.378	126.622
Variable Direct Cost per Liter	0,83	0,72	0,97
Fixed overhead costs	Average Monthly Property A	Average Monthly Property B	Average Monthly Property C

Machine, equipment and buildings depreciation	1.590,11	8.646,33	7.457,83
Water	180,00	30,00	0,00
Accountant/Consulting	0,00	0,00	750,00
Lime for cleaning the beds	0,00	0,00	1.000,00
Pro Labore	0,00	18.000,00	10.000,00
Total Fixed Costs	1.770,11	26.676,33	19.207,83
Liter Production/Month	28.142	124.378	126.622
Fixed Indirect Cost per Liter	0,0629	0,2145	0,1517
Variable overhead costs	Average Monthly Property A	Average Monthly Property B	Average Monthly Property C
Boots	60,00	80,00	200,00
Powdered milk for calves	0,00	0,00	1.500,00
Consume of calves milk and discarded milk	493,33	6.750,00	0,00
Electricity	341,25	3.737,50	5.000,00
Sponge/Mop/ Glove / Kitchen detergent	10,00	200,00	220,00
milk filter	60,00	72,00	100,00
Milking and other maintenance	247,50	1.100,00	800,00
Nitrogen	37,50	75,00	100,00
Paper towel	65,00	500,00	370,00
Pre-dipping/post-dipping/acid and alkaline chlorinated detergent and sanitizing chemicals	816,00	2.833,33	1.100,00
Heifer Ration	1.414,51	2.880,00	4.083,33
Calves Ration	428,12	950,00	864,00
Shavings	0,00	0,00	100,00
Sawdust	0,00	3.500,00	0,00
Mineral salt, heifers and oxen	400,00	1.350,00	924,00
Semen	583,33	1.451,04	1.200,00
Pre-partum food	524,00	3.000,00	2.193,33
Fuel	217,00	2.720,00	1.017,70
Silage corn calves, heifers, dry cows, oxen	760,86	5.997,39	4.679,89
Silage oats calves, heifers, dry cows and oxen	0,00	0,00	3.750,96
Hay, calves, heifers, dry cows and oxen	128,31	0,00	443,35
Depreciation of dry heifers and cows	1.200,00	7.733,33	6.866,67
Equipment maintenance	0,00	0,00	500,00
Professional assistance	457,50	1.000,00	700,00
Total Month	8.244,22	45.929,60	36.713,24
Average monthly production/liters	28.142	124.378	126.622
Variable Indirect Cost per Liter	0,29	0,37	0,29

Source: Survey data (2019).

Next, Figure 1 presents a graphic comparison of the total costs per liter of milk from the three properties.

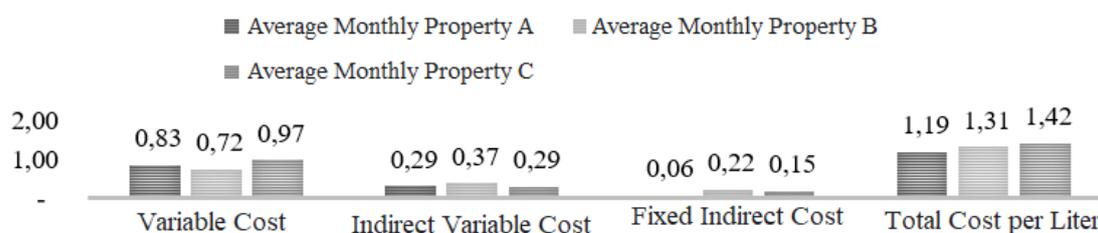


Figure 1 Total cost of properties by Absorption Costing

Source: Survey data (2019).

Based on Figure 1, it was found that C property had the highest total cost per liter, being R\$ 1.42, while in A and B properties the total cost per liter is R\$ 1.19 and R\$ 1.31, respectively. The higher cost per liter of C property is due to the fact that its direct costs are significant, that is, R\$ 0.25 higher than those of B A property and R\$ 0.14 higher than those of A property. In Figure 2 the total costs per liter of the three properties analyzed are presented, based on the variable costing.

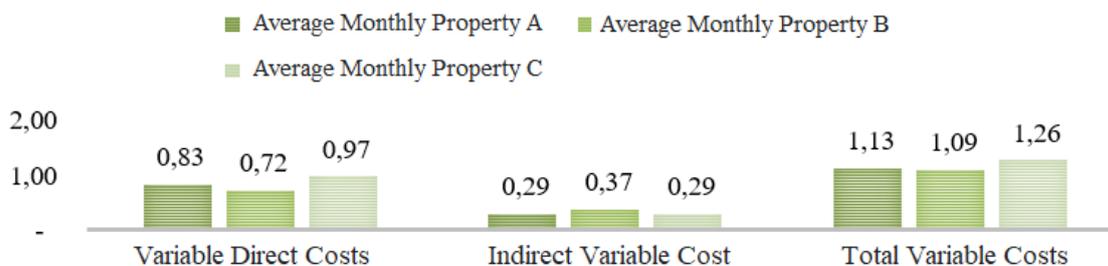


Figure 2 Total cost of properties by Variable Costing

Source: Survey data (2019).

From Figure 2, it was verified that C property had the highest total cost per liter, from the variable cost, which was R\$ 1.26. This is mainly explained by its higher feed cost, the fact that it uses soybean meal in the feed mixture, which is not used in other properties, higher cost of silage, in view of the annual cost of leasing and also outsourced fungicide applications, employees, because they are better paid and cost more in medicines, which is a result of cows that became susceptible to diseases and also the value of lactoprim used to increase the productivity of the herd. Thus, while these more significant costs add up to a disbursement per liter of R\$ 0.69 in A property and in property R\$ 0.67, in C property this disbursement per liter is R\$ 0.90, interfering with considerably its total cost per liter of milk produced.

Based on the total cost information through variable costing, some managerial cost indicators were calculated, so, contribution margin, break-even point, operational safety margin, income statement and some investment indicators, such as profitability, profitability and period for return on investment. After the calculation of these indicators, it was possible to analyze the situation of the income of the dairy activity in the properties. The management indicators of C property costs are described in Table 4.

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Table 4*Contribution margin, break-even point and property safety margin*

Contribution Margin	Average Monthly Property A	Average Monthly Property B	Average Monthly Property C
Recipes	38.558,00	198.934,79	198.966,62
Variable costs	31.639,23	135.765,11	159.122,50
Variable Expense - Funrural/Fundesa	595,18	3.058,29	3.060,00
Total Contribution Margin	6.323,59	60.111,39	36.784,12
Unit Contribution Margin	0,2247	0,4833	0,2905
breakeven point	Average Monthly Property A	Average Monthly Property B	Average Monthly Property C
Total Fixed Cost	1.770,11	26.676,33	19.207,83
Unit Contribution Margin	0,2247	0,4833	0,2905
Break-even point in liters	7.878	55.196	66.120
Average price received per liter of milk	1,37	1,60	1,58
Breakeven point in reais	10.792,39	88.313,94	104.469,44
Operational safety margin	Average Monthly Property A	Average Monthly Property B	Average Monthly Property C
Quantity sold/month	28.142	124.378	126.622
Quantity in PE	7.878	55.196	66.120
MSO	20.264	69.182	60.502
MSO %	72%	56%	48%

Source: Survey data (2019).

As for the contribution margin, that is, the difference between the price per liter and the variable costs and expenses, it can be seen from Table 4 that B property achieved the highest contribution per liter, that is, R\$ 0.48, followed by C property, whose contribution margin per liter was R\$ 0.29, and A property, which was R\$ 0.22. This result is because B property has the lowest variable average cost per liter, which is BRL 1.09, while in properties A and C it is BRL 1.13 and BRL 1.26, respectively. In addition, B property has the highest average price per liter among the properties being researched, followed by C property, which has the second best average price per liter.

On the other hand, the break-even point (PE), which indicates the amount of liters that must be produced so that there is no profit or loss, as shown in Table 4, C property has the highest break-even point in liters and also in reais, that is, the property needs a greater volume of production to cover its fixed and variable costs, and, therefore, only from a production of 66,120 liters, the property starts to make a profit. Thus, even if its average total fixed cost is lower than that of B property, its average contribution margin is also relatively smaller, and, therefore, it has the highest balance point among the properties analyzed.

As for the operational safety margin, that is, the production volume that exceeds the amount established at the break-even point, it appears that A property had the highest operational safety margin in liters and as a percentage of the period, and, therefore, even if production decreases by 72%, the property will not enter the area of loss. Although properties B and C have presented lower safety margins than A property, their MSO indices are satisfactory, working well beyond the number of liters defined at the equilibrium point.

The income statement for the properties under study is shown in Table 5. At first, the average gross operating revenue (ROB) was listed, that is, the sales of milk and discarded animals. Then, the amount referring to 1.5% of the operation's FUNRURAL was deducted from the gross revenue value, as well as the FUNDESA, which is equivalent to a value per liter, which is readjusted each year. The result of this operation gives rise to the average net operating

revenue, from which all expenses related to the survey period are deducted, regardless of whether they were paid or not, thus forming the final average result of the properties.

Table 5*Income statement of properties*

Description/Properties	Total Year A Prop.	Average Month A Prop.	Total Year B Prop.	Average Month B Prop.	Total Year C Prop.	Average Month C Prop.
1 - Gross Operating Revenue	480.018,00	40.001,50	2.462.217,48	205.184,79	2.420.899,41	201.741,62
2 - Deductions from Revenue	7.401,97	616,83	37.824,51	3.152,04	37.219,45	3.101,62
3 - Operating Revenue net	472.616,03	39.384,67	2.424.392,97	202.032,75	2.383.679,96	198.640,00
4 - Variable Costs	379.670,72	31.639,23	1.629.181,28	135.765,11	1.909.470,05	159.122,50
Total Contribution Margin	92.945,31	7.745,44	795.211,70	66.267,64	474.209,91	39.517,49
Fixed Costs	21.241,30	1.770,11	320.116,00	26.676,33	230.494,00	19.207,83
Final result	71.704,01	5.975,33	475.095,70	39.591,31	243.715,91	20.309,66
Result/Gross Revenue	14,94%	14,94%	19,30%	19,30%	10,07%	10,07%
MC in relation to revenue	19,36%	19,36%	32,30%	32,30%	19,59%	19,59%

Source: Survey data (2019).

From Table 5, it can be seen that B property achieved the highest result in relation to gross revenue and also the highest contribution margin in relation to revenue. This is due to the fact that B property had the highest average revenue per liter, R\$1.60 and the second lowest total cost per liter, which was R\$1.31. From the results of the statement of the exercise of the properties, some investment indicators of the properties in research were determined, which were: profitability, profitability and time for return on investment. Profitability indicates when the property turned into profit of its total income, profitability shows how much the investments made by the owners have yielded, while the period for return on investment indicates the time that is necessary for the owner to recover the investment made. Table 6 describes the investment indicators of the three properties under study.

Table 6*Property investment indicators*

	Profitability Indicator	Profitability Indicator	Deadline for return on investment/Years
Property A	14.94%	13.36%	7.5 Years
Property B	19.30%	17.61%	5.7 Years
Property C	10.07%	10.81%	9.3 Years

Source: Survey data (2019).

Analyzing Table 6, it was found that B property obtained the best indicators of profitability, profitability and time for return on investment, which were, respectively, 19.30%, 17.61% and 5.7 years. Thus, in view of the good profitability in relation to gross revenue and the considerable profitability of the investments of B property, its period for return on investment is notably shorter than that of other properties.

Finally, the production and profitability of the three properties surveyed were compared, from their respective production systems, in order to conclude on the contribution of the use of different technologies and systems in the formation of the results of the dairy activity. Table 7 summarizes the main information related to the cost of properties, revenue received per liter sold and also the profits from their respective production systems.

Table 7

Synthesis of costs by absorption costing and property results

	Property A (Grazing)	Property A (Compost Barn)	Property A (Free stall)
Average monthly production	28.142	124.378	126.622
Average daily production per matrix	26,8	31,89	28,14
Average cost per liter (BRL)	1,1896	1,3079	1,4171
Average price per liter (BRL)	1,37	1,60	1,58
Average profit per liter (BRL)	0,16	0,27	0,14
Annual final result of the property	54.641,88	401.220,72	210.915,36
Area used in the dairy activity (hectare/year)	14	40	55
Profit per hectare per year	3.902,99	10.030,52	3.834,83

Source: Survey data (2019).

From Table 7 it was found that the compost barn method, used by B property, was the most efficient among the three production systems analyzed, then, it had the highest average productivity per matrix, which was 31.89 liters per day, the highest average price per liter, this being R\$ 1.60 and the second lowest cost per liter, which was R\$ 1.31, and therefore its profit per liter of R\$ 0.27 is the highest among the three production methods in research. In addition, B property also presented the highest profit per hectare, R\$ 10,030.52 per hectare, with the area used in milk production being 40 hectares.

Thus, the result obtained by compost barn is 68.75% higher than in the traditional or grazing production method and 92.85% higher than in the free stall production system. A property had the lowest cost per liter produced, considering that its fixed cost per liter is significantly lower, however, as its production volume is smaller, the property ends up receiving a lower revenue per liter than that received in properties B and C, but even so, its result per liter and per hectare surpasses the results of the free stall production method.

Thus, from the investment indicators presented (profitability, profitability and time for return on investment) it is possible to infer that B property is able, through good owner management, to pay all the investment costs of the compost barn production system, even in a relatively shorter period than that contracted for the financing. In addition, its profit is greater than 10% of revenue, and, therefore, exceeds what would be acceptable by the capital market. Thus, the compost barn promoted an increase in the daily productivity in the property under research, which was enough to cover its costs and still generate a considerable return on the capital invested by the owners.

As for the impact of the use of technologies, it was found that their use influenced the production of the properties under research, considering that the three properties are well advanced in terms of existing technologies in the dairy market and apply many of them in their production processes, thus achieving good results and profitability above 10% of gross revenue obtained. This finding confirms the research by Carvalho, Ramos and Lopes (2009), who concluded the use of viable technologies provided a better system response to several factors of production.

Among the technologies applied by the properties in their production processes, one can list reproduction from artificial insemination and sexed semen, which guarantees 90% of reproduction in female offspring, thus following mating programs aimed at obtaining high quality genetic standards; monthly veterinarian monitoring to verify that the animals are following expected standards, including gestational monitoring of cows and heifers. In addition to it, the properties have nutritional monitoring, in which the nutritionist prepares diets according to the quality of the silage, hay and pasture, thus determining the type of feed to be used and its complements, in order to increase or maintain the productivity of the herd. The properties also use pre-partum food, which consists of a ration suitable for the gestational period before childbirth, in order to prevent the occurrence of metabolic disorders and regenerate the mammary gland for the next lactation. In addition, milking machines with milk flow meters, measuring time of milking, vacuum regulators, slip and drop identifiers of the teat cups are used, in order to optimize the production process of the activity as much as possible.

Such results contradict the findings of Zanin *et al.* (2015) and Dalchiavon *et al.* (2018) who found that the free stall management system provides a better economic result for the dairy activity. On the other hand, comparing the results of this study with the research by Bandeira (2018) and Grespan, Trindade and Breitenbach (2016), the results are confirmed, which concluded that the compost barn was the most profitable method, and in the case of the research de Bandeira (2018) was viable in the analyzed property. Thus, it was found that the region under study was decisive for the results of the study, and the researches carried out in Santa Catarina found the free stall method as the most profitable and the researches carried out in the Northwest of Rio Grande do Sul found that the compost barn method achieved the most considerable results.

5 Final considerations

This study aimed to analyze the contribution of different technologies use and systems in the results formation of the dairy activity. It was verified from the results that for the organizations participating in the study, it was possible to verify the return of the dairy production activity, identifying the productive structure that provided better productivity and better return among the analyzed properties.

The findings allow us to verify that with the application of new technologies, the properties observed an improvement and efficiency in their production processes, and, thus, the benefits obtained from these investments in technologies were sufficient to pay their costs and still generate a considerable profit, which in the case of properties under research, was above 10% of their gross revenue. Thus, the owners became aware that the applications of technologies contribute to obtaining good financial results in a market with narrow margins and high production costs.

Therefore, answers were obtained for the problem established by the research, and, therefore, the objective was met, the findings indicate that the compost barn system had the best financial result, and proved to be the most effective method among the three production systems

and properties analyzed. In this method, the average net result per liter was R\$ 0.27 and per hectare for milk production R\$ 10,030.52, in addition to it, the most satisfactory indicators of profitability, profitability and time for return on investment were observed, thus proving to be the most efficient method among productive systems in research.

From the results, it was found that the net result of the properties in the period under research was above 10% of revenue, however, it is noteworthy that some factors had an influence on the results obtained, such as the prices received per liter of milk sold by the properties. In B and C properties, which use the compost barn and free stall methods, prices were considerably higher than in the property that uses the traditional/grazing system, which is mainly due to the production volume of the properties. Another factor that should be emphasized is that the properties being researched sell to different dairies, and although they are very close in terms of location, the policies used by dairies are usually different and this can influence the results obtained. Therefore, it is suggested that further research be carried out to analyze this factor.

Thus, it is verified how much accounting and cost management is of significant importance for the control and decision-making processes of rural properties, which use the information generated by cost management in order to know the total cost of the activity, and from it its margins and results (Crepaldi, 2019). In addition to it, for the producers participating in the research and also for those who will have access to the results of this study, the prospect of increases in the results will make them look more closely at the technologies and innovations that are emerging in the dairy market, making with producers to assess the possibility of making these investments in their properties, thus improving their production processes and thus ensuring the continuity of this activity, which is so important for the Brazilian economy and for global agribusiness.

As limitations of the study, three properties analyzed are not of same size, the area destined for milk production and the number of animals is different. This is due to the fact that the free stall analyzed in the study was the only one found in the region, on the other hand, no traditional management/grazing property was found that had a close number of lactating cows such as the compost barn and free stall.

It is suggested for future research to continue the study in later periods and in properties of equal size and number of animals. It is also indicated to carry out researches considering other regions, in order to extend the existing knowledge on this subject, consolidating or opposing, totally or partially, the results obtained in this study.

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