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# Economic Viability of Semi-Confined and Confined Milk Production Systems in Free-Stall and Compost Barn

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## Abstract

The objective of this research was to survey the productivity, costs, agricultural income and economic viability of Semi-Confined and confined milk production systems in Free-Stall and Compost Barn in Rio Grande do Sul, Brazil. In order to perform the research, four milk production units were selected in each of the three systems studied. Compared to the others, the Semi-Confined system had greater return of capital invested per year, as well as higher agricultural income per animal and per area, while the confined system in Compost Barn had higher farm incomes per man work unit and total farm incomes due to greater productive scale of properties. The Free-Stall system had the worst economic results. It was not possible to define an ideal system for the state, since the specificities of each property should be analyzed for choosing the system, especially the availability of the factors of production land, capital and labor.

## Keywords

Costs, Decision-Making, Rural Management, Milk

## 1. Introduction

Dairy farming is important in the generation of jobs and income in Brazil. The country has more than 1.3 million properties that develop the activity in which 3.6 million people from the primary sector participate [1]. The production of milk in the Southern Region grows parallel to the nation due to technological, management and organization aspects of the production chain [2]. Rio Grande do Sul (RS) has the highest national productivity, with 3034 liters/cow/year [1].

In Brazil, the dairy farmer needs more professionalization, especially in the management area of costs and viability of new investments. Because farmers prioritize the most urgent activities and formal cost management is not considered as an urgent action, it is rarely carried out [3]. The cost management is fundamental to the viability of the business. The lack of management information on the structure of costs and profitability can trigger losses that are not noticed because they are not measured [4] [5]. Despite its importance, rural accounting is commonly viewed as a complex technique and has a low practical return and, therefore, is one of the least used tools for Brazilian rural producers [6] [7]. Considering the more recurrent market situation, the fact that the farmer has no control over the prices of the product and inputs, he must manage possible variables, essentially reducing production costs [8] [9].

In Brazil and RS there is a plurality of productive systems. Some farmers, seeking greater productivity and production scale, opt for the intensive model, which requires greater consumption of industrial rations and pharmaceuticals, and more productive races. Others select less intensive systems with lower production costs and use of inputs produced in the Milk Production Unit (MPU) [10].

The discussion about the intensification of the milk production system, measured by the relation between the quantity produced and the quantity of the factors of production used (such as land, animals and manpower), is recurrent in the sector. In RS, the search for intensification has aroused the interest of dairy farmers in investing in confinements, especially the compost barn type. This is also due to the predominance of family farming properties, which have less availability of productive area, but wish to increase income or combine activities in this area [11]. Others opt for free-stall confinement, while some remain with semi-confined or extensive systems.

As exposed before, part of the farmers decides which production system to adopt without analyzing the feasibility of the investment. Are these production systems economically viable? What productive system (semi-confined, confined in free-stall or compost barn) presents greater economic return for the RS MPUs? The present research aimed to identify and compare the economic viability of confined milk production systems (free-stall and compost barn) and semi-confined, identifying which production system optimizes the factors of production land, animal and labor.

## 2. Material and Methods

The method employed was a quantitative research with a survey type study. The data used for the survey came from twelve MPUs, representative of the properties of Rio Grande do Sul/Brazil: four in a Semi-Confined (SC) production system and eight in a confined production system in which four have a Free-Stall (FS) production system and four have Compost Barn (CB) systems. The study was developed from April to December 2016. The survey aimed to acquire data and information about characteristics, actions or opinions of a given group indicated as representative of a target population through a research instrument, such as a questionnaire [12]. Table 1 defines the three milk production systems considered and analyzed in this research.

The research considered different steps for data collection and analysis, as follows:

Stage 1 (01/04/16 to 01/05/16)—Survey of the milk producing properties in RS and identification of the MPUs that would participate in the research. These were selected intentionally, based on being representative: four with semi-confined production systems, four with confined production systems with free-stall and four with production systems confined to compost barn. In order to select them, the degree of representativeness of the others was observed, so that they were modal, especially in what corresponds to the number of animals in the property (milking, and heifers), genetic pattern, production standard, managers of the milk production unit.

Stage 2 (01/05/16 to 30/06/16)—Survey of production costs data. Each property was visited with prior scheduling to carry out the collection of data with a semi-structured questionnaire and production costs worksheets developed in Microsoft Excel®. All factors and items of costs necessary for the production of milk during 2016/2017, as well as the necessary investments for the said production systems, were enumerated and quantified. Costing is the basis for subsidizing management decisions; measuring the sustainability of an enterprise; defining the economic viability of an alternative technology; subsidizing proposals or implementing agricultural policies [15]; and it is the minimum value reference that the producer needs to receive in order to enable the activity and how much it has to produce for profitability [3] [9]. The methodology used in this research to analyze production costs was Added Value, a measure of economic value that evaluates the productive activity of the production unit during a year of retroactive work and allows comparing productive activities of distinct production units [16] [17] [18] [19].

Stage 3 (01/07/16 to 30/09/16)—Data tabulation using Microsoft Excel® spreadsheets developed to collect milk production costs and perform the

Table 1. Definition of free-stall, compost barn and semi-confined production systems.

| | | |
|---|---|---|
| **Confined Free-Stall** | Productive animals are confined in covered masonry shed which are open at the sides; food is fully served in the trough; | The temperature is controlled by ventilation and sprinkling; each animal has a single bed; the animal rises to be milked and to eat; |
| **Confined Compost-Barn** | | The temperature is controlled by ventilation; the animals rest in collective spaces, commonly lined with sawdust bed; it has as a principle the composting of this bed; |
| **Semi-confined** | Animals are fed on the trough in a covered shed, where they receive corn silage and concentrate (part of the food), usually after milking. During the interval between milking they are under rotational grazing, usually in cultivated and perennial pastures. | |

Source: Organized by the authors based on reference [13] and reference [14].

following economic analyzes: Production Cost, including Gross Product (GP)—gross value of products and services generated exclusively by the production unit analyzed during one year (milk marketing); Intermediate Consumption (IC)—all goods and services purchased and consumed during the year that were used to produce said GP; Depreciation (D)—fraction of the means of production acquired by the production unit from other agents which are not fully consumed during a production cycle, such as machinery, plant and equipment; Distribution of Value Added (DVA)—taxes, financing, labor, leasing; Gross Value Added (GVA)—GVA = GP-IC; Liquid Value Added (LVA)—LVA = GVA-D; Agricultural Income (AI)—AI = LVA-DVA [19]; analysis of the remuneration of the factors of production land, animals and manpower; participation of the main production costs; Payback and analysis of Return on Invested Capital.

Univariate statistical data analysis and the chi-square test were used by means of the PSPP software.

Stage 4 (01/10/16 to 28/12/16)-Comparative quantitative and qualitative data obtained in the economic analysis of the twelve properties participating in the research.

## 3. Results and Discussion

The properties studied in the three production systems do not differ significantly regarding number of animals, Man Work Unit (MWU) and areas used for the activity, as shown in **Table 2**. The system that presented the highest utilization of area for the production was the system confined by CB. This is characterized, in the RS, to have larger productive scale, more animals and requires larger area for food production such as silage and hay. The demand for MWUs in the activity was similar between the SC and CB systems, being 2.35 and 2.25 MWUs, respectively. The FS demanded 1.83 MWUs. The productivity measured in liters/animal/day and liters/animal/year was higher in the FS, while the productivity measured in liters/MWU/month and liters/ha/year were higher in CB.

**Table 2.** Characteristics of the milk production units of the semi-confined, free-stall and compost barn production systems.

| Zootechnical Indicators | Semi-Confined | Free-Stall | Compost Barn |
|---|---|---|---|
| Useful Surface Area (USAR) (Ha) | 18.67 | 14.83 | 21.17 |
| Number of Animals | 43.33 | 36.00 | 59.67 |
| Animal Husbandry (Cows/Ha) | 3.35 | 3.45 | 4.14 |
| Man Work Unit (MWU)/ Property | 2.40 | 1.80 | 2.3 |
| Productivity (Liters/Animal/Year) | 6846.00 | 8926.00 | 7845.00 |
| Productivity (Liters/Animal/Day) | 22.00 | 29.00 | 26.00 |
| Productivity (Liters/MWU/Month) | 10,631.00 | 13,781.00 | 17,741.00 |
| Productivity (Liters/Hectare/Year) | 17,076.00 | 22,226.00 | 24,256.00 |

From the statistical analyzes carried out, it can be concluded that the behavior presented in this section, for the aforementioned interval, can be determined at the 95% (ninety-five percent) level of confidence, which enables its application in the determination of cost behavior with greater accuracy.

The price received by the producers, production costs and, consequently, the agricultural income of the activity is different between the analyzed production systems (**Table 3**). For confinement in CB the larger productive scale of the properties guaranteed a higher remuneration per liter. This is because in Brazil there is still a system of payment of milk that subsidizes the largest quantity (productive scale) and not the quality.

A lower cost of production was evident at R$ 0.10/liter for the SC production system. When analyzing the feed and depreciation costs, both systems presented similar results, being simultaneously: R$ 0.56 and R $ 0.09/liter of milk in the SC system; R$ 0.59 and R$ 0.09/liter in the FS system; and R$ 0.58 and R$ 0.06/ liter in CB. A lower cost is observed with depreciation in the confinement by CB and Agricultural Income/liter of milk for the productive system SC, followed by CB. The lower income was the FS.

Studies on production costs in milk production systems were conducted at other sites and periods. The results were:

1) Comparative economic analysis between production in free-stall, tie-stall and stable systems concluded that, regardless of the production system analyzed, the properties were not economically viable [9];

2) The economic feasibility study identified a cost of R$ 0.09/liter higher in the free-stall system, compared to the semi-confined system [20];

3) While assessing the profitability and economic viability of the implantation of a free-stall milk production system, the model was economically unfeasible [21];

4) When estimating profitability indicators of the milk production cost center in intensive systems with total confinement with high volume of daily milk production, the main impediments found were: excessive labor and minor expenditure milk sales price [8];

**Table 3.** Remuneration, costs and agricultural income per semi-confined, free-stall and compost barn production system.

| Economic indicators | Semi-Confined | Free-Stall | Compost Barn |
|---|---|---|---|
| Remuneration/litre of milk (R$/Litre) | 1.05 | 1.07 | 1.11 |
| Depreciation costs/litre of milk (R$/Litre) | 0.09 | 0.09 | 0.06 |
| Animal feed costs/litre of milk (R$/Litre) | 0.56 | 0.59 | 0.58 |
| Other costs/litre of milk (R$/Litre) | 0.16 | 0.23 | 0.27 |
| Total costs/litre of milk (R$/Litre) | 0.81 | 0.91 | 0.91 |
| Agricultural Income (RA)/ litre of milk (R$/Litre) | 0.24 | 0.15 | 0.20 |

5) Experiments with Compost for dairy cows have been reported in the US (United States of America), Israel, the Netherlands, Canada and Austria. Compost proved to be economically viable and an alternative dairy facility for farmers who wanted to modernize their facilities or start a new dairy operation. To increase herds, it can be used for all dairy cows or for some cows in particular [22];

6) Construction costs for the Compost Bedded Pack Barns ranged from $33,000 to $300,000, with a cost per cow ranging from $625 to $1750 (only considering the barn, and not the milking parlor). Bedding costs varied from $0.35 to $ 085/cow/day, depending on the sawdust source and the distance it had to be transported. Costs and availability of bedding materials were the main concern of producers [22] [23] [24].

Compost barn is the system that most immobilizes total capital (**Table 3**). If the immobilized capital by area and by MWU involved in the dairy activity is considered, Compost also takes the most resource. However, if the fixed capital per animal is evaluated, the free-stall is the one that demands more capital.

The next update is scheduled for next month, Production Costs and Agricultural Income were also analyzed, based on the three productive factors: land, labor and animal (**Table 3**). Considering the factor of labor production, called the Man Work Unit (MWU), the compost barn production system was the one that paid the most for MWU used. Already considering the productive animal resource, the highest remuneration was obtained in the semi-confined production system. Finally, considering the higher remuneration per area (ha), the semi-confined and compost barn production systems had higher and very close remuneration, while the compost barn was positively highlighted.

The free-stall system did not present itself as the best option from an economic point of view in any of this analysis. The Return on Invested Capital (ROIC) in milk production systems calculates the percentage of return per year per property analyzed and the averages per production system (**Table 4**).

In the average of the systems, the SC system presented return of 7% per year, FS of 3.6% per year and CB of 5.4% per year. The greatest disparity was observed in the FS system, with a difference of about 5% per year between MWUs. This analysis was complemented by Payback (**Table 4**), which calculated how many years it takes to obtain Return on Invested Capital, by MWU studied and the average by production system. The highest payback time is in FS, especially due to the disparity between properties analyzed, which demonstrated the need for 52.42 years to have the investment paid. Next is the CB with 18.6 years and, finally, the semi-confined with the best index of 14.28 years. If these two aspects were analyzed in isolation (Payback and ROIC), the SC system would be the most appropriate, since it remunerated the capital invested more quickly.

## 4. Conclusions

The confined production systems are the result of more recent investments deriving from the intensification of activity, the search for competitive improvements,

Table 4. Gross product, production costs, agricultural income, invested capital, return on invested capital, payback and relationship with the factors of production land, labor and animal in the semi-confined, free-stall and compost barn production systems.

| Economic indicators | Semi-Confined | Free-Stall | Compost Barn |
|---|---|---|---|
| **Total Gross Product (GP) (R$)** | 373,699.35 | 334,583.56 | 594,906.79 |
| *GP/*Cow (R$) | 8623.83 | 9293.99 | 9970.50 |
| *GP/Area* (R$/ha) | 20,019.61 | 22,556.20 | 28,105.83 |
| *GP/*Man Work Unit (MWU) (R$) | 159,021.00 | 182,500.13 | 264,403.02 |
| **Total Cost* (R$)** | 233,118.46 | 265,899.81 | 421,724.00 |
| *Costs/*Cow (R$) | 5552.01 | 7694.92 | 7578.87 |
| *Costs/Area* (R$/ha) | 12,888.60 | 18,675.30 | 21,364.07 |
| *Cost/MWU* (R$) | 102,377.54 | 151,100.15 | 200,980.49 |
| **Total AgriculturalIncome (AI) (R$)** | 133,112.13 | 57,566.62 | 142,700.70 |
| *AI/*Cow (R$) | 3071.82 | 1599.07 | 2391.63 |
| *AI/Area* (R$/ha) | 7131.01 | 3880.90 | 6741.77 |
| *AI/MWU* (R$) | 56,643.46 | 31,399.97 | 63,422.53 |
| **Total Capital Fixed Invested**(R$)** | 1,880,653.6 | 1,740,435.10 | 2,600,684.00 |
| *Capital Fixed Invested/Cow (R$)* | 43,399.68 | 48,345.42 | 43,586.88 |
| *Capital Fixed Invested/Area (R$/ha)* | 100,749.2 | 117,332.7 | 122,867.00 |
| *Capital Fixed Invested/MWU (R$)* | 800,277.70 | 949,328.2 | 1,155,860.00 |
| **Return on Invested Capital (ROIC)** | 7% per year | 3.6% per year | 5.4% per year |
| **Payback** | 14.28 years | 52.42 years | 18.6 years |

*Distribuição do Valor Agregado (DVA) + Consumo Intermediário (CI) + Depreciação (D). **Improvements + Machinery + Land + Animals + Financing + Working capital.

better working conditions for the farmer, as well as a response to the scarcity of MWUs resources (especially labor, land and shade for the animals). Rural properties that work with dairy cattle, represented by those studied in this research, are heterogeneous, either within the same productive system or comparatively between different systems. This hampers conclusions and results that can be generalized.

Each system showed different efficiency, based on the analyzed productive resources: land, labor, animal. For this reason, the farmer should consider the availability of the factors of production land, capital and labor, in the decision and choice between the semi-confined, free-stall and compost barn production systems. The system to be chosen will depend on the production factor that is most limiting in the property. If there is a lack of area and workmanship, the semi-confined system is not ideal at the expense of confined systems, especially the compost barn. If confined systems are chosen, the producer must have a high productive scale to make the activity feasible, since the costs (especially fixed) are higher.

The producer also needs to carry out an investment analysis to identify the viability of the investment. This information will be different for each property, requiring individualized evaluations. The production system is only one factor that affects the success of the property. Therefore, regardless of the system chosen, the farmer needs to be trained and seek competent technical assistance to improve in other aspects that directly impact the profitability of the activity and the longevity of the system. In addition, the decision to confine the animals goes beyond the economic analysis of the activity alone, but opens the space to evaluate the opportunity cost of the land in relation to other activities that could be developed in the areas that are optimized from the confinement. Generally, in RS, extensive milk production is used in areas where land value and competition from grain production areas is lower, reducing the value of land and leases. In contrast, milk production needs to be intensive to be competitive when facing other agricultural activities.

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## References

[1] IBGE—Brazilian Institute of Geography and Statistics (2014) IBGE Indicators—Livestock Production Statistics, June. http://www.ibge.gov.br/Producao_Pecuaria/Fasciculo_Indicadores_IBGE/2016/abate-leite-couro-ovos_201604caderno.pdf

[2] Carvalho, G.R., Oliveira, S.J.D.E.M. and Beskow, W.B. (2017) Changes in Dairy Production in Brazilian Geography: The Advance of the South. *Revista Agropecuária Catarinense*, *Florianópolis*, **30**, No. 2. http://publicacoes.epagri.sc.gov.br/index.php/RAC/article/view/135

[3] Breitenbach, R. (2014) Rural Management in the Context of Agribusiness: Challenges and Limitations. *Desafio Online*, *Campo Grande*, **2**, No. 2. http://seer.ufms.br/index.php/deson/article/view/1160

[4] Sabbag, O.J., Rozales, R.R., Tarsitano, M.A.A. and Silveira, A.N. (2007) Economic Analysis of Tilapia Production (*Oreochromis niloticus*) in a Model of Associative property in IlhaSolteira/SP. *Custos e Agronegócio Online*, *Recife*, **3**, 86-100. http://www.custoseagronegocioonline.com.br/numero2v3/analise%20economica.pdf

[5] Hofer, E., Rauber, A.J., Diesel, A. and Wagner, M. (2006) Cost Management Applied to Agribusiness: Temporary Crops. *Contabilidade Vista & Revista*, **17**, 29-46. http://revistas.face.ufmg.br/index.php/contabilidadevistaerevista/article/view/290

[6] Callado, A.A.C. (Org.) (2008) Agribusiness. 2nd Edition, Atlas, São Paulo, 184.

[7] Callado, A.A.C. and Callado, A.L.C. (2002) Costs in the Decision-Making Process in Rural Enterprises. *Annals of the ANPAD Annual Meeting*, **26**, Salvador, Rio de Janeiro: Metrópole, CCG-1751, CD-ROM.

[8] Santos, G. and Lopes, M.A. (2012) Profitability Indicators of Milk Production Cost Center in Intensive Systems of Production. *Boletim da Indústria Animal*, **69**, 1-11.

(In Portuguese) http://www.iz.sp.gov.br/pdfsbia/1355399581.pdf

[9] De Araújo, A.P. (2001) Comparative Study of Different Systems of Facilities for Production of Type B Milk, with Emphasis on the Indices of Thermal Comfort and the Economic Characterization. Dissertation (Master Degree)—Faculdade de Zootecnia e Engenharia de Alimentos—Universidade de São Paulo, Pirassununga, 69. http://www.usp.br/constrambi/producao_arquivos/estudo_comparativo_de_diferentes.pdf

[10] Norder, L.A.C. (2006) Mercantilization of Agriculture and Territorial Development. In: Schneider, S., Org., *The Diversity of Familyfarming*, UFRGS, Porto Alegre, RS, 57-81.

[11] Neukirchen, L.C., Zanchet, A. and de Paula, G. (2005) Technology Management and Profitability in Small Rural Property—Case Study. *Proceedings of the* 43*rd Congress of the Brazilian Society of Rural Economics and Sociology*, SOBER, Ribeirão Preto, 1 CD-Rom.

[12] Pinsonneault, A. and Kraemer, K.L. (1993) Survey Research Methodology in Management Information System: An Assessment. *Journal of Management Information Systems*, **10**, 75-105. https://doi.org/10.1080/07421222.1993.11518001

[13] EMBRAPA—Brazilian Agricultural Research Corporation (2017) EMBRAPA Information Agency. Agribusiness of Milk. Installations. http://www.agencia.cnptia.embrapa.br/Agencia8/AG01/arvore/AG01_153_21720039244.html

[14] Barberg, A.E., Endres, M.I., Salfer, J.A. and Reneau, J.K. (2007) Performance and Welfare of Dairy Cows in an Alternative Housing System in Minnesota. *Journal of Dairy Sciences*, **90**, 1575-1583. https://doi.org/10.3168/jds.S0022-0302(07)71643-0

[15] Marion, J.C. and Segatti, S. (2006) Cost Management System for Small Dairy Farms. *Custos e Agronegócio Online*, **2**, No. 2. http://189.126.110.61/rbcv/article/view/4070

[16] Neumann, P.S. and Silveira, P.R. (2000) The Reproductive Capacity of Family Farmers in the Region of Santa Maria/RS. *Annals of the World Congress of Rural Sociology*, **38**, 1 CD-Rom.

[17] Defumier, M. (2007) Agricultural Development Projects: Manual for Specialists. EDUFBA, Salvador, 328.

[18] Portela, J.N., Viégas, J., Neumann, P.S., Neto, B.S. and Laurentino, L.D. (2002) Economic Analysis of Production Systems with Milk Cattle from the Central Depression of Rio Grande do Sul. *Ciência Rural*, **32**, 855-861. http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-84782002000500018&lng=en&nrm=iso

[19] de Lima, A.P., Basso, N., Neumann, P.S., dos Santos, A.C. and Müller, A.G. (2001) Administration of the Family Production Unit: Modalities of Work with Farmers. 2nd Edition, UNIJUÍ, Ijuí, 222.

[20] Zanin, A., Favretto, J., Possa, A., Mazzioni, S. and das Zonatto, V.C. (2016) Costing and Economic Result in the Management of Milk Production: A Comparative Analysis between the Traditional System and the Free-Stall System. *Organizações Rurais & Agroindustriais*, **17**, No. 4. http://www.redalyc.org/articulo.oa?id=87844622003

[21] Silveira, I.D.B., Peters, M.D.P., Storch, T., Ziguer, E.A. and Fischer, V. (2011) Simulation of the Profitability and Economic Viability of a Model of Free-Stall Milk Production. *Arquivo Brasileiro de Medicina Veteterinária e Zootecnia*, **63**, No. 2.

[22] Barberg, A.E., Endres, M.I. and Janni, K.A. (2007) Compost Dairy Barns in Minne-

sota: A Descriptive Study. *Applied Engineering in Agriculture*, **23**, 231-238. https://doi.org/10.13031/2013.22606

[23] Endres, M.I. (2009) Compost Bedded Pack Barns—Can They Work For You? *WCDS Advances in Dairy Technology*, **21**, 271-279. http://www.dairyweb.ca/Resources/WCDS2009/Endres.pdf

[24] Endres, M.I. and Barberg, A. (2006) Compost Barns: What Have We Learned So Far? In: *Minnesota Dairy Health Conference*, 115. https://conservancy.umn.edu/bitstream/handle/11299/109615/Endres.pdf?sequence=1&isAllowed=y