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# Effect of husbandry system on the technical and economic performance of dairy cattle

# Efeito do sistema de criação no desempenho técnico e econômico de rebanhos leiteiros

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## Abstract

This study aimed to investigate the effects of husbandry system on the technical and economic performance of dairy farming. Samples included data from 61 dairy farms from the State of Minas Gerais, Brazil, which were collected between 2002 and 2011. Farms were categorized by type-pasture-based (PB), semi-confinement (SC), and confinement (C)-and technical and economic indexes were compared. In general, the results indicated indexes that are higher than the average for Brazilian farms but lower than those in other countries or technological farms in other Brazilian regions. Milk production was mainly determined by farm size rather than by productivity indexes. Components of the total and effective operational costs that were most significant were feeding followed by labor. The comparative analysis indicated that, although C systems have technical indexes that are superior to those of the PB and SC systems, economic performance was independent of the intensification level. Thus, pasture systems are potentially competitive, provided that the producers are efficient.
**Key words:** Indexes. Profitability. Husbandry system. Farm management. Dairy farming.

## Resumo

Objetivou-se com este estudo investigar o efeito do sistema de criação sobre o desempenho técnico e econômico da atividade leiteira. A amostra incluiu dados reais de 61 rebanhos leiteiros localizados no estado de Minas Gerais, Brasil, durante os anos de 2002 a 2011. As fazendas foram agrupadas em função do nível de intensificação em pasto (PAST), semiconfinamento (SEMI) ou confinamento (CONF) e os índices técnicos e econômicos foram comparados. De forma geral, os resultados mostraram índices técnicos maiores do que a média de fazendas brasileiras, porém inferiores a índices internacionais ou de fazendas tecnificadas de outras regiões do Brasil. A produção de leite foi mais determinada pelo tamanho da fazenda do que pelos índices de produtividade e os itens do custo total e operacional efetivo que tiveram maiores representatividades foram, em ordem decrescente, alimentação e mão de obra. A análise comparativa mostrou que, embora sistemas CONF apresentaram índices técnicos superiores a PAST e SEMI, o desempenho econômico independeu do nível de intensificação. Portanto, sistemas a pasto são potencialmente competitivos, desde que os produtores sejam eficientes.
**Palavras-chave:** Índices. Lucratividade. Sistema de criação. Gestão rural. Pecuária de leite.

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## Introduction

The current economic conditions of Brazilian dairy farming require producers to find alternatives to improve the profitability and competitiveness of the sector. Strategic decisions such as choice of animal shelter system and forage production and collection are particularly important, because they have a long-term impact on the business. With the tendency toward specialization of the dairy farming sector, there has been a rapid expansion of intensive milk production systems during the past few years, particularly in the southern and southeastern regions of Brazil, where animals with high genetic potential are maintained in confinement (C) systems and fed through feeding troughs. There is, however, an increasing interest in pasture-based (PB) systems owing to several factors, including low financial requirements (SILVEIRA et al., 2011), better conditions for animal health and reproduction (GREEN et al., 2007; HERNANDEZ-MENDO et al., 2007; RIBEIRO et al., 2013), increased pressure from environmental regulatory agencies to reduce central accumulation of animal production waste (ROTZ et al., 2010), and better quality of life for farmers (GLOY et al., 2002).

There have been various discussions regarding the type of husbandry systems used. The considerable heterogeneity in the Brazilian production chain, its presence in the entire country, and the dynamic essence inherent to the environment (OLIVEIRA et al., 2007) have led to the development of a variety of production systems. Comparison of PB and C systems enables an increased production is achieved using confined dairy cows rather than dairy cows bred in pastures. Despite lower milk production, American PB systems have lower production cost, higher profit per dairy cow, and similar labor efficiency, than do other C systems (WHITE et al., 2002; FONTANELI et al., 2005).

In the present study, the exploitation model for milk adopted by producers, be it traditional or intensive, is referred to as a “husbandry system.” Because there are significant technological and financial differences between PB and C systems, these systems may influence feasibility. Within this context, in PB systems, animals replace the equipment for forage collection, and therefore investments in machinery and infrastructure are reduced (GLOY et al., 2002). However, other factors affect PB milk production such as the wide variation in the nutritional value of forage during the year and impaired diet balancing, due to the difficulty in quantifying the amount of ingested forage, heat stress, and the need for a large area for forage production (FONTANELI et al., 2005).

Technical and economic indexes are essential management tools for analyzing the operating and economic feasibility of farms, and provide accurate information for decision-making. Several researchers have focused on technical aspects (MANCIO et al., 1999; GONÇALVES et al., 2008) and milk production cost estimates (MANCIO et al., 1999; MORAES et al., 2004) in different Brazilian regions. However, these studies have assumed that all farmers have adopted the same husbandry system. The producers included in a given sample use distinct husbandry systems, and thus, adopting a single model may introduce a profound bias in the analysis, because it does not take heterogeneity into consideration. Therefore, this study represents a more robust analysis of the effects of husbandry systems on the technical and economic results of dairy farming. This approach has major practical implications, as it provides reliable data for technicians and producers, and allows the use of such information to develop plans, evaluate results, and assist in decision-making.

This study evaluated the effects of husbandry system on the technical and economic performances of dairy farms and identified the most significant components of the total operational costs (TOC) and effective operational costs (EOC).

## Materials and Methods

*Experimental area*

We collected data on the size, technological, and economic indexes for 61 dairy farms located in the central, southern, and southwestern regions of the State of Minas Gerais, Brazil, between January 2002 and December 2011. Data collection for production, costs, and profit was performed monthly using field notepads specifically prepared for this purpose. A non-probability sampling was designed based on the availability and consent of producers who accepted to participate in this study without a financial incentive. Three farms were excluded from the initial sample due to lack of data. The experimental area is characterized by an average altitude of 937 m above sea level (780-1,800 m) and tropical climatic conditions. Average rainfall varies between 650 and 2,100 mm, peaking during summer, and the average temperature is 22 °C. These climatic conditions enable grazing during the entire year. Thus, PB husbandry systems are common in this experimental region.

*Sample description*

Farms were categorized by husbandry system type (considering feeding and dairy animal management). Husbandry systems were categorized into three intensification levels to enhance the accuracy of the comparison and interpretation of results: pasture-based (PB), semi-confinement (SC), and confinement (C). PB included traditional farms composed of crossbred animals (Holstein × Zebu), which performed low-intensity grazing; dairy cows grazed during the entire year. During the rainy season (October to March), dairy cows were supplemented with 1 kg concentrate per 3-4 kg milk, and forage was composed of *Brachiaria* and/or native grass. During the dry season, dairy cows were fed with feed concentrate with similar proportions and with limited amounts of forage, which was composed of corn silage (*Zea mays* L.), sugar cane (*Saccharum officinarum* L.), or elephant grass (*Pennisetum purpureum* Schum.). During this period, pastures were severely impaired, with almost no food availability.

SC systems are improved systems composed of crossbred animals (Holstein × Zebu) with access to plots containing *Brachiaria, Panicum,* and/or *Cynodon* during the rainy season; the plots provided sufficient food of a sufficiently high quality to prevent overgrazing. Dairy cows' forage mainly originated from intensive grazing, with supplementation during, or subsequent to, milking, using 1 kg commercial corn and soybean-based concentrates per 3 kg of milk produced. During the dry season, dairy cows received concentrate during trough feeding in the same proportion, in addition to forage composed of corn or sugar cane silage. Furthermore, dairy cows were only allowed to graze during the night during this period. The difference between PB and SC systems was the increased productive process intensification in SC, particularly during winter.

Large and modern C systems were composed of dairy cows (Pure Holstein) stocked in free-stall structures. These animals were not allowed to graze at any time of the year, and received total diets with 1 kg concentrate per 3 kg milk. Forage was composed of corn silage.

*Indexes and calculation methodology*

The size, technological, and economic indexes used are described in Table 1. These indexes were selected considering data availability and relevance. Costs were estimated in accordance with the method of operational (MATSUNAGA et al., 1976) and total (LOPES et al., 2007) costs. The following criteria were considered in the calculation of production cost: 6% return on capital per year, which approximately corresponds to the rate of savings; linear depreciation method to represent the cost of substituting the goods due to physical or economic wear: $D = \frac{P_c - S_v}{U_l}$ , where D = Annual depreciation value, = Purchase cost (new asset), = Salvage value, and = Useful life (HOFFMANN, 1987); and the grouping of items that contribute to the operational costs of milk, such as feeding, labor, health, reproduction, milking, fixed taxes, energy, and other expenses (LOPES et al., 2007). Expenses related to the use of recombinant bovine somatotropin were allocated to health, whereas machinery rental was allocated to other expenses. The representation of these items in relation to TOC and EOC, expressed as percentages, was also calculated. The method proposed by Lopes et al. (2011) was used to calculate profitability and return on capital. All calculations were performed using MS Excel® electronic sheets (Microsoft Corp., Redmond, WA, USA).

**Table 1.** Index descriptions, abbreviations, equations, and units.

| Index | Abbreviations | Equation | Unit |
|---|---|---|---|
| Size indexes | | | |
| Daily milk production | DMP | --- | L day$^{-1}$ |
| Area stocked with dairy cows | Ar | --- | ha |
| Contractor labor | CL | --- | wd |
| Family labor | FL | --- | wd |
| Dairy cow number | DCN | --- | head |
| Technical indexes | | | |
| Dairy cow stocking rate | DCSR | Number of dairy cows/area | head ha$^{-1}$ |
| Milk production per dairy cow | DMP/DCN | Daily milk production/Dairy cow number | L year$^{-1}$ |
| Dairy cows per worker day | DCN/L | Dairy cow number/Total annual labor | head wd$^{-1}$ |
| Yearly milk production by labor | YMP/L | Yearly milk production/Total annual labor | L wd$^{-1}$ |
| Yearly milk production by area | YMP/A | Yearly milk production/farm area | L ha year$^{-1}$ |
| Economic indexes | | | |
| Milk gross profit (MGR) by total gross profit (TGR) | MGR/TGR | MGR/TGR × 100 | % |
| Operational expenses excl. depreciation (EOC) by TGR | EOC/TGR | (EOC/TGR) × 100 | % |
| Operational expenses (TOC) by TGR | TOC/TGR | (TOC/TGR) × 100 | % |
| Unitary EOC by milk price (MP) | EOCun/MP | (EOCun/MP) × 100 | % |
| Unitary TOC by milk price | TOCun/MP | (TOCun/MP) × 100 | % |
| Total unitary cost by milk price | TCun/MP | (TCun/MP) × 100 | % |
| Ratio of fixed cost by total cost | FC/TC | (FC/TC) × 100 (%) | % |
| Depreciation by TOC | D/TOC | (D/TOC) × 100 | % |
| Profitability 1 | P 1 | (Profit/profit) × 100 | % |
| Profitability 2 | P 2 | (Net profit/profit) × 100 | % |
| Return on capital 1 | R 1 | (Profit/invested capital) × 100 | % |
| Return on capital 2 | R 2 | (Net profit/invested capital) × 100 | % |

*Statistical analysis*

The parametric assumptions were assessed using the Levene (homoscedasticity) and Kolmogorov-Smirnov (normality) tests. Results were expressed as the mean ± standard error, and comparisons were performed using an ANOVA test, complemented by the least significant difference (LSD) test for multiple comparisons when data showed a normal distribution (PETRIE; WATSON, 2006). Results are expressed as medians and interquartile range, and group comparisons were assessed using the Kruskal-Wallis test, also complemented by LSD tests for multiple comparisons between ranked means of variables (PETRIE; WATSON, 2006). Differences were considered significant at $P < 0.05$.

The Pearson's correlation coefficient was used for testing the relationship between certain variables. The results are presented as correlation coefficients, and differences were considered significant when $P < 0.05$. To investigate the effect of husbandry system on profitability (binary variable, where positive profitability = 1 and negative profitability = 0), we created a generalized linear model, using a logistic regression function. The relationship between husbandry system and production scale (categorical data) was evaluated using the correspondence analysis method. Farms were categorized by production scale as follows: small scale, <200 kg milk per day; medium scale, 201-1,000 kg milk per day; and large scale >1,001 kg milk per day. All statistical analyses were performed using R software 2.15.2v (The R Foundation for Statistical Computing, Vienna, Austria; http://www.r-project.org/).

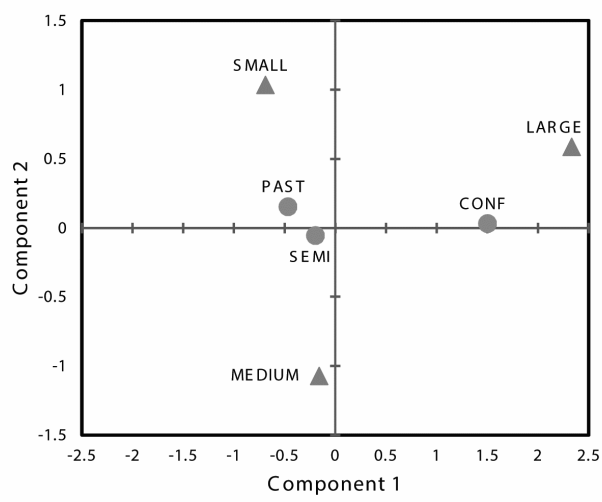
## Results and Discussion

During the last decades, increases in the price of food and fluctuations in the price of milk have led to structural changes in the dairy production chain (HEMME et al., 2014). Farm production intensification has positively contributed to the performance of dairy farming, which represents a competitive strategy for the producers. However, special attention has been given to PB systems, given the different cost and environmental impact and animal well-being, real or perceived, associated with C systems. Although several factors contribute to the success of dairy farming (GLOY et al., 2002; TAUER; MISHRA, 2006; CABRERA et al., 2010), the comparison of the technical and economic indexes performed for the farms included in this study revealed that husbandry systems do not seem to influence the economic results, but rather the efficiency level. Thus, PB systems may potentially be competitive if milk producers are efficient.

Data were collected from typical farms from the State of Minas Gerais, Brazil, and although they do not represent all dairy farms, their data is real and provide evidence of the effects of husbandry systems on technical and economic results. Evaluations were performed for 12 (19.7%) PB farms, 40 (65.6%) SC farms, and 9 (14.8%) C farms. There was no difference ($P > 0.05$) between size and technical indexes among PB and SC husbandry systems (Table 2), which may be explained by the heterogeneity of the sample and, hence, the increased standard deviations. Therefore, herds from both groups had similar characteristics of size and technical performance, indicating that farm stratification per husbandry system may not be relevant for comparisons between distinct groups of producers, and that other criteria may be adopted, as will be described.

To better investigate the relationship between husbandry system and production scale, we performed a correspondence analysis (Figure 1). The results indicated that the husbandry system significantly affected the production scale. Farms with C systems were mainly associated with higher production scales (>1,001 kg $day^{-1}$), which results from production intensification. However, SC and PB farms were not clearly distinguished and were categorized as medium (201-1,000 kg $day^{-1}$) and small (<200 kg $day^{-1}$) (production scales), representing a more heterogeneous group of producers. Therefore, although the husbandry system is a sufficient criterion for comparisons of the technical and economic results, production scale is more easily obtained, and probably more accurate. PB systems are also more commonly observed in North American small herds (TAUER; MISHRA, 2006), and may be chosen owing to high costs associated with C systems (SILVEIRA et al., 2011).

**Figure 1.** Correspondence analysis among husbandry systems (●) and production scales (▲) of 61 dairy farms.




The median for daily milk production (DMP) was 191.6, 236.4, and 1,487.2 L in PB, SC, and C, respectively, and significant differences ($P < 0.05$) were detected for C husbandry systems (Table 1). The higher volume of milk produced in C systems may be explained by the larger number of dairy cows per herd and area, in addition to higher productivity per cow, which corroborates the results obtained by Hanson et al. (2013). To clarify this, a Pearson's correlation test was performed and we observed that DMP was more highly correlated with the number of lactating cows ($r = 0.96$) and area ($r = 0.83$) than with productivity per cow per year ($r = 0.46$). This intriguing result suggests that, within the analyzed herds, the volume of milk produced daily was determined by farm size, rather than by productivity indexes.

The median farm area was 17.0, 30.0, and 113.0 ha for PB, SC, and C, respectively, and significantly larger ($P < 0.05$) for C husbandry systems. The median stock rate varied from 0.8 to 1.2 heads $ha^{-1}$, and there was no significant difference ($P > 0.05$) among the husbandry systems (Table 2). Although C systems can stock more animals than any PB system (GLOY et al., 2002), these results indicate that large areas were necessary when forage production

**Table 2.** Effects of husbandry system on the size and technical indexes of 61 dairy farms.

| Index | Husbandry system | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pasture-based | | | Semi-confinement | | | Confinement | | |
| | Mean ± SD | Median | 95% CI | Mean ± SD | Median | 95% CI | Mean ± SD | Median | 95% CI |
| DMP† | 238.0 ± 201.8 | 191.6[a] | 88.6-343.1 | 719.5 ± 2,100.0 | 236.4[a] | 114.3-366.6 | 2,807.0 ± 3,050.2 | 1,487.2[b] | 471.9-5,272.5 |
| Ar† | 43.1 ± 53.7 | 17.0[a] | 7.5-83.8 | 55.0 ± 66.1 | 30.0[a] | 10.0-78.3 | 141.1 ± 81.7 | 113.0[b] | 89.0-218.6 |
| CL† | 1.4 ± 0.5 | 1.0[a] | 1.0-2.0 | 2.3 ± 2.3 | 2.0[a] | 1.0-2.0 | 7.1 ± 3.9 | 6.0[b] | 4.0-8.5 |
| FL† | 0.5 ± 0.4 | 0.5[a] | 0.0-1.0 | 0.7 ± 0.5 | 1.0[a] | 0.0-1.0 | 0.0 ± 0.0 | 0.0[b] | 0.0-0.0 |
| DCN† | 22.5 ± 11.0 | 21.0[a] | 15.1-30.0 | 56.9 ± 156.0 | 26.7[ab] | 11.6-33.8 | 143.7 ± 125.4 | 107.0[b] | 50.0-230.0 |
| DCSR† | 1.3 ± 0.9 | 1.2[a] | 0.5-1.6 | 1.5 ± 2.1 | 0.8[a] | 0.4-1.7 | 1.0 ± 0.5 | 1.2[a] | 0.6-1.3 |
| DMP/VCN‡ | 3,561.9 ± 1,566.5[a] | 3,089.8 | 2,195.8-5,120.2 | 4,016.1 ± 1,165.4[a] | 3,822.2 | 3,239.6-4,911.7 | 6,240.0 ± 2,812.2[b] | 5,099.1 | 4,043.6-8,534.7 |
| DCN/L† | 11.8 ± 5.8 | 10.0[a] | 7.7-16.3 | 13.0 ± 11.9 | 10.9[a] | 5.4-13.7 | 19.0 ± 12.6 | 15.0[a] | 11.6-22.7 |
| YMP/L† | 124.4 ± 105.5 | 85.9[a] | 54.2-181.8 | 148.1 ± 173.9 | 107.3[a] | 50.7-155.0 | 335.9 ± 294.9 | 247.9[b] | 134.6-424.3 |
| YMP/A† | 4,556.9 ± 2,423.5 | 4,556.9[a] | 1,873.8-5,577.5 | 6,662.1 ± 11,722.0 | 2,497.8[a] | 1,535.2-7,646.2 | 6,345.4 ± 4,012.6 | 6,100.0[a] | 2,285.3-10,319.1 |

† Kruskal-Wallis test; ‡ ANOVA test; SD = Standard deviation; CI = Confidence interval; Different letters in the same row indicate a statistically significant difference ($P < 0.05$)

areas were considered. The absence of stocking rate differences corroborate the results obtained by Nascimento et al. (2012), who investigated 875 dairy farms in the State of Minas Gerais with average areas of 56.6 ha, and concluded that area did not contribute to efficiency increases.

Annual milk production per dairy cow was 3,561.9, 4,016.1, and 6,240.0 L for PB, SC, and C systems, respectively. As expected, the more intensive husbandry systems (C) had significantly higher milk production ($P < 0.05$; Table 2). These results corroborate those reported by Bargo et al. (2002), who showed that dairy cows fed on a complete diet produced 25.19% more milk than grazing and concentrate-supplemented cows (38.1 *versus* 28.5 kg day$^{-1}$). Kolver et al. (2000) and White et al. (2002) also recorded 34.07% and 11.00% increases, respectively, under a complete diet, when compared with pasture + concentrate systems. Milk production differences may be explained by genetic differences between herds (crossbred Holstein × Zebu *versus* Pure Holstein) and by the energy expenses associated with grazing. In PB systems, dry matter ingestion is the main limiting factor (BARGO et al., 2002) and animals expend more energy grazing (AGNEW; YAN, 2000), in addition to the lower energetic efficiency due to higher methane production, when compared with animals fed with higher concentrate-content diets (LANA; RUSSUELL, 2001). Furthermore, because the grazing cows spend the majority of their time exposed to solar radiation and do not benefit from fans and sprinklers – common to free-stall structures – they are more susceptible to heat stress effects (COLLIER et al., 2006; GARNER et al., 2016), although crossbred cows commonly used in pasture-based systems are more adapted to heat (COSTA et al., 2015). Values obtained in this study were higher than the average production in the State of Minas Gerais [2,956.5 L (FAEMG, 2006)] and lower than those reported by Silva et al. (2006) for the State of Paraná (between 5,829.1 and 10,201.8 L). A favorable climate for excellent quality forage production, increased genetic merit of the herd, adaption of appropriate management practices, and regional cattle breeding traditions are factors that may explain the superior indexes observed in Southern Brazil.

We found that the median labor productivity (liters per worker-day, L wd$^{-1}$) was significantly higher ($P < 0.05$) for C (247.9 L wd$^{-1}$) than for PB (85.9 L wd$^{-1}$) and SC (107.3 L wd$^{-1}$) (Table 2). This result indicates the higher labor efficiency in more intensive systems. Intensive technology use may positively contribute to productivity improvement (KOMPAS; CHU, 2006; ALVAREZ et al., 2008), whereas low modern capital use in family farming explains low productivity and is a limiting factor for production improvements. However, these results were lower than those of more technologically advanced farms in other Brazilian regions, where values varied between 310 and 832 L wd$^{-1}$ (SILVA et al., 2006), or those from overseas farms where average production is greater than 1,605.6 L wd$^{-1}$ (STEPHENSON, 2000).

A competitive advantage of the Brazilian livestock industry is related to the large pasture area available for animal breeding. However, less intensive production practices are adopted countrywide (FAEMG, 2006). Median milk production per area was 4,556.9, 2,497.8, and 6,100.0 L ha year$^{-1}$ for PB, SC, and C, respectively, showing no significant difference ($P > 0.05$) between groups (Table 2). These values were lower than those recorded by Silva et al. (2006) in the State of Paraná, which varied between 7,366 and 22,129 L ha year$^{-1}$. Low milk productivity per area combined with the smaller number of dairy cows per hectare obtained in this study indicates that the majority of farmers were underusing their fields. The main consequences of this practice are total cost (TC) increases when the opportunity cost is considered, lack of field usage for other profitable crops, and negative effects on other productivity indexes. Furthermore, although continued technological innovations will determine productivity per food unit in the future (SHALLOO et al., 2004), lower area availability will impair milk production (O'DONNELL et al., 2008), and is thus a critical factor to be considered.

The contribution of EOC to total gross profit (61.7%, 54.4%, and 96.5% for PB, SC, and C, respectively) was significantly different ($P < 0.05$) among the husbandry systems. Participation in TOC was different ($P < 0.05$) among SC (74.7%) and C (100.4%; Table 3). Both index values (EOC/GR and TOC/GR) were higher for C systems, which indicates that cost increases are directly associated with milk production increases and production intensification. This result was expected and corroborates the observation that operating expenses increase for each increment in milk per cow production reported by Alvarez et al. (2008). Factors that contributed to higher costs were increased feeding, reproduction, and health expenses incurred by C systems. Cost increases may be explained by the higher nutrient ingestion required for higher dairy cow productivity (WASHBURN et al., 2002), and by the increased reproductive (DEMETRIO et al., 2007) and health (WINDIG et al., 2005) problems observed in C systems. However, additional C system costs may be compensated for by a higher profit.

**Table 3.** Effect of husbandry system on economic indexes of 61 dairy farms.

| Index | Husbandry system | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pasture-based | | | Semi-confinement | | | Confinement | | |
| | Mean ± SD | Median | 95% CI | Mean ± SD | Median | 95% CI | Mean ± SD | Median | 95% CI |
| MGR/TGR† | 82.1 ± 14.3 | 86.1$^{a}$ | 68.6-94.5 | 88.0 ± 11.0 | 91.0$^{a}$ | 82.3-97.9 | 90.6 ± 9.5 | 93.5$^{a}$ | 82.9-97.5 |
| EOC/TGR† | 67.6 ± 19.8 | 61.7$^{a}$ | 51.8-88.4 | 57.6 ± 12.4 | 54.4$^{b}$ | 47.5-66.0 | 91.2 ± 19.0 | 96.5$^{c}$ | 75.9-101.0 |
| TOC/TGR† | 82.1 ± 25.0 | 78.5$^{ab}$ | 62.7-96.2 | 75.3 ± 13.6 | 74.7$^{a}$ | 63.4-84.2 | 96.5 ± 20.0 | 100.4$^{b}$ | 81.4-108.4 |
| EOCun/MP‡ | 82.5 ± 19.9$^{a}$ | 86.1 | 62.3-97.2 | 65.9 ± 13.3$^{b}$ | 64.7 | 53.6-78.5 | 101.2 ± 22.0$^{c}$ | 99.7 | 86.8-119.0 |
| TOCun/MP† | 100.8 ± 28.0 | 95.1$^{a}$ | 77.5-120.7 | 86.3 ± 15.0 | 86.0$^{b}$ | 72.9-101.7 | 107.3 ± 23.9 | 103.8$^{a}$ | 90.7-127.0 |
| TCun/MP† | 132.2 ± 53.0 | 110.9$^{a}$ | 104.0-149.7 | 114.8 ± 24.0 | 112.7$^{a}$ | 94.0-128.6 | 121.8 ± 28.9 | 112.2$^{a}$ | 102.7-140.7 |
| FC/TC‡ | 28.0 ± 14.4$^{a}$ | 29.5 | 19.0-35.6 | 31.9 ± 11.6$^{a}$ | 30.6 | 24.4-37.7 | 15.4 ± 5.5$^{b}$ | 15.0 | 10.0-19.7 |
| D/TOC‡ | 10.9 ± 7.4$^{a}$ | 10.5 | 5.4-16.8 | 13.0 ± 5.5$^{a}$ | 12.1 | 10.3-15.6 | 5.6 ± 2.1$^{b}$ | 4.8 | 3.9-6.8 |
| P 1† | -0.8 ± 43.4 | -2.6$^{a}$ | -13.9-24.2 | -0.3 ± 21.7 | 2.6$^{a}$ | -12.0-16.1 | -9.0 ± 20.6 | -8.5$^{a}$ | -23.27-3.8 |
| P 2† | 18.0 ± 25.0 | 21.5$^{ab}$ | 3.8-37.3 | 24.7 ± 13.6 | 25.4$^{a}$ | 15.8-36.6 | 3.5 ± 20.0 | -0.4$^{b}$ | -8.4-18.6 |
| R 1† | 1.7 ± 13.2 | -0.7$^{a}$ | -5.3-14.6 | 1.8 ± 7.5 | 0.6$^{a}$ | -3.7-7.0 | -0.8 ± 7.5 | -2.2$^{a}$ | -5.2-1.3 |
| R 2‡ | 9.7 ± 13.2$^{a}$ | 6.3 | 1.4-21.0 | 10.2 ± 8.3$^{a}$ | 7.9 | 3.6-14.6 | 4.5 ± 9.5$^{a}$ | -0.3 | -2.5-10.2 |

† Kruskal-Wallis test; ‡ ANOVA test; SD = Standard deviation; CI = Confidence interval; Different letters in the same row indicate a statistically significant difference ($P < 0.05$)

Profitability is a percentage index for describing the ratio of profit-by-profit. It is used to compare similar activities to define which one is more profitable. There was no significant difference ($P > 0.05$) in profitability 1 among husbandry systems (-2.6%, 2.6%, and –8.5% for PB, SC, and C, respectively). Other metrics may be more appropriate to compare the economic performance of different activities. Return on capital measures the capability of profit generation by available capital, describing a percentage ratio of profit by capital. Similarly, return on capital did not show any significant differences ($P > 0.05$) among the husbandry systems (-0.7%, 0.6%, and –2.2% for PB, SC, and C, respectively; Table 3).

Activity results are considered for profitability 1 and return on capital 1 calculations; the opportunity cost of capital and land are already included. Analysis of results considering profitability 2 and return on capital 2 indexes use net profit (Profit, TOC) instead of profit (LOPES et al., 2011), and provide results that are closer to reality, and thus decision-making criteria are improved. By considering net margin, values may be compared with, for example, savings or other investments, thereby providing better comparison capability. Profitability 2 was significantly higher (P < 0.05) for SC systems (21.5%, 25.4%, and –0.4% for PB, SC and C, respectively), whereas no significant differences (P > 0.05) in the return on capital 2 were observed (9.7%, 10.2%, and 4.5% for PB, SC and C, respectively; Table 3), suggesting that there is a large variation on return capital of each farm (GILLESPIE et al., 2009). Although PB systems are technically less productive, they are more economically competitive. Thus, PB milk production is capable of reducing costs (HOFFMAN et al., 1993; TAUER, 2001; SILVA et al., 2008; ALVAREZ et al., 2008), mainly because of lower expenses associated with concentrate feeding, and lower requirements for labor, machinery and equipment, and structural investments, such as animal shelters. Differences found between SC and PB may be explained by the management efficiency of SC systems, with better productive and pasture usage conditions and supplementation using concentrates. However, although profitability 2 was slightly higher for SC, production scale is inefficient in conventional systems (SC and PB). More intensive systems frequently maximize milk production per cow and produce small profit margins per milk unit, but with a significant net profit (WINSTEN et al., 2010). These systems require increased management capacity for the various dairy farming areas to succeed, which includes management of animal, agricultural, human, and financial aspects. In the current study, a large proportion of C farmers (66.7%) were inefficient, although logistic regression analysis indicated that the rate of husbandry systems by profitability was similar (P > 0.05; Table 4). In fact, selecting an appropriate husbandry system strongly depends on the prevailing economic scenario, as well as on limiting factors (e.g., area). Within a low-milk-price scenario, pasture husbandry systems may be favored because of their low production expenses. In contrast, C systems eliminate seasonal pasture production restrictions and may be more attractive, depending on profit per additional milk production (PATTON et al., 2012). Furthermore, other factors such as geographic location, climate, and herd size, may also affect the choice of husbandry system (GLOY et al., 2002).

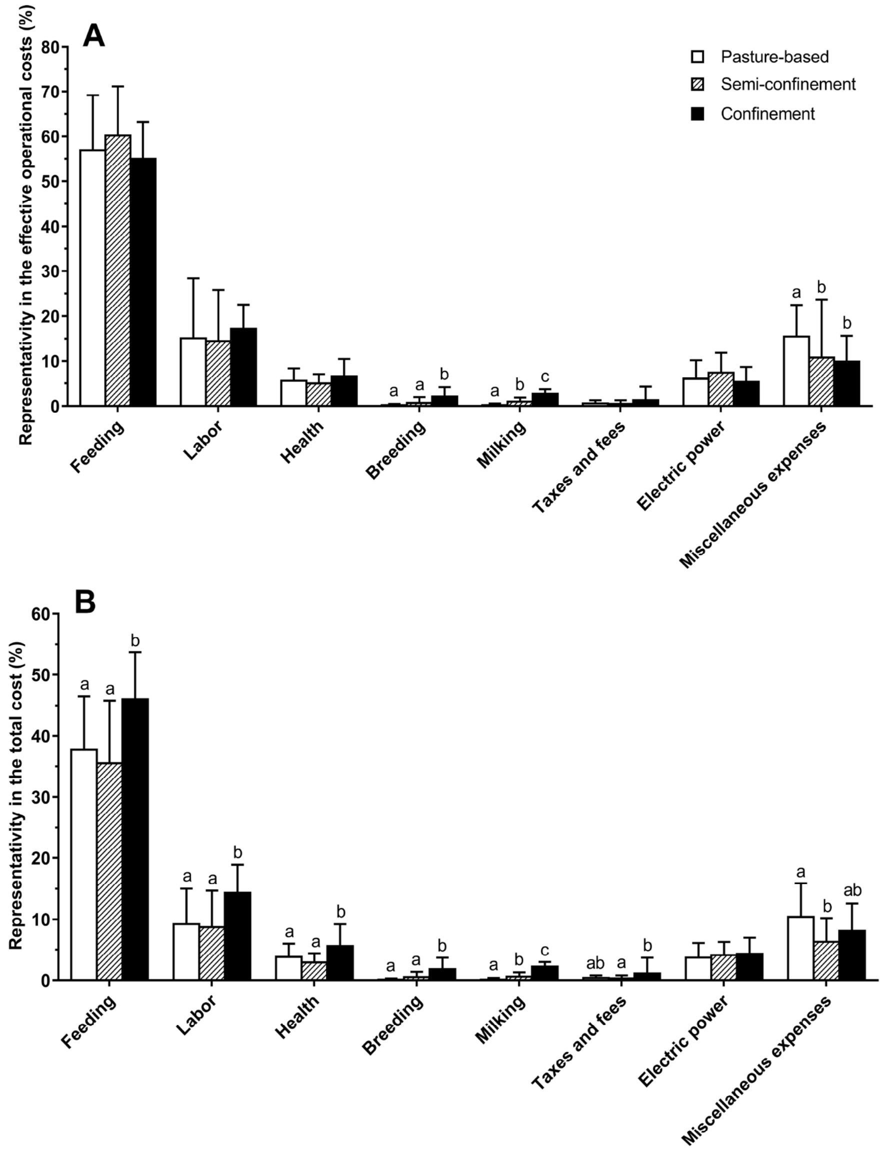
**Table 4.** Effect of husbandry system on the profitability of 61 dairy farms.

| Husbandry system | Profitability | | | |
|---|---|---|---|---|
| | Positive Number (%) | | Negative Number (%) | |
| Pasture-based | 5[a] | (41.7) | 7[a] | (58.3) |
| Semi-confinement | 23[a] | (57.5) | 17[a] | (42.5) |
| Confinement | 3[a] | (33.3) | 6[a] | (66.7) |
| Total | 31 | (50.8) | 30 | (49.2) |

Different letters in the same row indicate a statistically significant difference (P < 0.05)

Expense grouping enables expense surveillance, thereby assisting technicians and farmers with an overall economic analysis. In the present study, feeding was the most significant factor contributing to TOC and EOC, followed by labor. These results corroborate those reported by Hemme et al. (2014), who analyzed the overall milk production cost and suggested that farmers must pay special attention to these items. Feeding represented a significantly higher (P < 0.05) proportion of the TC of C systems (37.7%, 35.5%, and 46.0% for PB, SC, and C, respectively; Figure 2). Similarly, labor also made a significantly higher (P < 0.05) relative contribution to TC in C systems (9.2%, 8.7%, and 14.3% for PB, SC, and C, respectively; Figure 2). C systems have higher feeding costs (WHITE et al., 2002; FONTANELI et al., 2005), and a proportion of the variability in results and lack of a significant difference (P > 0.05) in TOC (excluding depreciation) found in the present study can probably be explained by the low stocking and productive efficiency of PB and SC systems, e.g., a high concentrate content in the diet, which is the most expensive feeding component. Furthermore, dairy farms require intensive labor because of their twice-daily milking needs, as well as fieldwork. An advantage of conventional systems (PB and SC) is labor reduction, related to the need for less crop production and stall-cleaning activities, which results in significantly lower labor costs (HANSON et al., 2013).

**Figure 2.** Effects of husbandry system on the representation (%) ± SD of components of total effective operational cost (A) and total cost (B) of 61 dairy farms.



Health, reproduction, and milking expenses were significantly higher ($P < 0.05$) in C (Figure 2), possibly because of increased health control requirements, and the use of artificial insemination and milking machines. However, these expenses made a smaller contribution to TOC, excluding depreciation, which indicates that there is no need for substantial technological and management efforts to reduce these costs, and even less need to reduce the use of important inputs such as animal health products, which would significantly affect productivity and would lead to minimal cost reductions.

## Conclusions

In conclusion, the comparison of technical and economical indexes of dairy herds under different husbandry systems provides evidence that intensification is not a determinant of the economic results, but the efficiency level of the farmers. PB systems may be potentially competitive, and thus technicians and producers must analyze which method is appropriate based on limiting factors and economic scenarios.

The methodology used in the present study supports the comparison of performance indexes based on common factors among farms, aiming to generate more robust reference data. However, the stratification of farms according to husbandry system may not be a good criterion for comparisons between distinct groups of producers.

The sample used in the present study showed high technical indexes in comparison with Brazilian farm averages. However, these values are inferior when compared with worldwide indexes, or those observed for technological farms in other Brazilian regions, which emphasizes the need for regional studies and the existence of opportunities to improve technical and possibly economic efficiencies. Feeding followed by labor were the most significant components of TOC and EOC.

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