Milk-Production in Barns with Compost Bedding and Free Stall: A Profitability Analysis

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Abstract The objective was to analyse, comparatively, the profitability of compost barn and free stall milk-production systems. Data collected from four farms from January to December 2016 were analysed. The cost of milk production was estimated according to the operating cost methodology. Additionally, gross and net margins were estimated as indicators of profitability. The results showed that the average gross and net margins were not influenced by the type of facility; they were positive in both of the production systems. Among the components of the effective operating cost, the proportion of the "medications" item was lower in the compost barn, while the cost of bedding for the cows was lower in the free stall farms. Depreciation and total operating cost were similar in the two systems. Milk sales made up a higher percentage of the revenue in the free stall farms, while the expectations of revenues from wastes were similar in the two production systems. Given that there were no significant economic differences between the types of facilities, it is concluded that ease in management, productivity, reproductive performance, animal health, environmental issues, and availability of water and bedding material should be the motivators for choosing one system over the other.

Keywords Dairy cattle · Cost centers · Production cost · Animal facility

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1 Introduction

In Brazil two intensive systems are used to produce milk from cattle in confinement, based on free stalls or compost bedding. The latter has only recently been introduced into the country. Barberg et al. (2007) reported that the first compost bedded pack barn (CBP) was built in 2001 in Minnesota, while the first CBP in Brazil was realized in 2012 (Brito 2016). This housing system in Brazil rapidly spread due to the high degree of satisfaction of producers worldwide with its functioning.

Various studies have addressed the design of the buildings, including dimensions, installation characteristics and managerial procedures. Other works cite possible advantages of the system in relation to performance, animal health (mastitis, hoof injuries), longevity (Leso et al. 2019). However, no study has reported a profitability analysis of compost barn systems. Additionally, it is known that production costs vary from year to year given that the cost depends on innumerable variables such as the price of inputs, wages, and the technology used at the time. The costs are also influenced by genetics and animal nutrition. Therefore, it is essential to conduct new research on production costs including properties of the free stall system, in order to enable the comparison of compost barn and free stall farms. Few studies adopting the cost centre methodology used in the current study are available in literature (Santos and Lopes 2012).

Thus, due to the lack of studies on economical comparison of compost barn and free stall systems, this study aimed to comparatively analyse the profitability of the two milk production systems.

2 Materials and Methods

Data from four farms were collected from January to December 2016 and analysed. Two of these farms (farms 1 and 2) use the compost barn system, and two (farms 3 and 4) use the free stall system. All the farms have the following characteristics: use of maize silage (*Zea mays*) as the main forage, herds predominantly of the 15/16HG genetic group, milking three times/day, and use of semen from Holstein bulls.

Farm 1 is using the compost barn system since September 2015. The bedding is composed of sawdust with a surface of 9 m^2/cow. The daily milk production in 2016 was 8,459 kg, with an average of 27.3 kg/cow/day and an average of 310 lactating cows. On Farm 2, the coffee husks from the plantations are used as bedding for the cows and complemented with sawdust, providing 10 m^2/cow. In 2016, milking 180 cows, the property produced 5,970 kg of milk per day on average with an average yield of 33.1 kg/cow/day.

On both the farms, the thickness of the bedding layer was 40 cm. The packed bedding was aerated twice a day by means of a cultivator reaching a depth of 30 cm. The quantity of new material added to bedding was 3 m^3/month. The frequency of totally removing and renewing the bedding was 2 years.

In Farm 3 the free stall system has been used since 2006. The bedding consists of sand, and the stocking rate (number of animals/stalls) was 100% during the observation period. Unlike the other three properties, the facility did not have fans and sprinklers, and the animals were only cooled in the waiting room. The farm had a daily milk production of 9,693 kg, with an average of 21.1 kg/cow/day in 2016 with 459 cows milked per day on average. In Farm 4 the cows have been housed in a free stall facility since 2013. Sand is used as bedding, and the stocking rate was 100% during the study period. In 2016, daily production was 8,317 kg of milk, with an average of 23.1 kg/cow/day and an average of 360 lactating cows.

In the present study, the total operating cost (TOC) and effective operating cost (EOC) of milk production were estimated. Additionally, the gross margin and the net margin were calculated as profitability indicators, and analysis and comparison of the proportions of the items that make up the gross revenue, as well as the components of the TOC, were performed in accordance with Lopes et al. (2004).

Using the MS Excel, profitability analysis was conducted and the data were compared via descriptive analyses and grouped into tables with the aim of achieving better comparison, discussion, and presentation of the results (Lopes et al. 2004).

3 Results and Discussion

Table 1 shows the average values for the representativeness of components of Total operating cost and Effective operating cost of milk production in compost barn and free stall production systems. The feeding cost was similar in the two production systems. This occurred because in both facilities the same type of feed can be used, and feed is supplied to the animals in the same way as a total diet using a forage wagon.

The "labour" item was more representative in the farms that adopted the compost barn system. However, apart from the fact that the difference between the values is small, higher expenditure on labour does not seem to be a characteristic of the compost barn system given that the standard deviation of these properties was high (±2.83%) due to the high labour cost at farm 1. The "third-party services" item of this farm (4.91%) was mainly responsible for increasing the proportion of its labour force and, consequently, the average of the two farms that adopted the compost barn system. However, in farm 2, labour costs represented 13.24% of the EOC, indicating lower expenditure than in the two free stall farms, which had values of 13.33% and 14.88%. Thus, the proportion of the cost of production represented by labour costs did not appear to be significantly different in the two types of systems.

Electricity costs represented a lower percentage of the EOC in the free stall properties, but the standard deviation was high (±2.86%). Farm 3 was responsible for this variation because it only had fans in the waiting room, whereas in the other three farms fans were present also in the sheds housing the cows. Because fans are among the items that consume the most energy in dairy farms, in farm 3 the proportion was only 2.71% of the EOC. In farms 1, 2, and 4, electricity represented 5.93%,

Table 1 Representativeness of components of Total operating cost (TOC) and Effective operating cost (EOC) of milk production in compost barn and free stall production systems for the period January to December 2016

Specification	Compost barn[a]		Free stall[a]	
	% EOC	% TOC	% EOC	% TOC
Feed	59.06	54.6	59.37	56.46
Labour	15.24	14.14	14.10	13.46
Energy	7.05	6.50	4.74	4.48
Sanitation	2.80	2.60	6.08	5.78
Milking	3.22	2.97	3.33	3.16
bST	2.67	2.48	2.99	2.85
Reproduction inputs	1.11	1.02	2.75	2.62
Reproduction hormones	0.56	0.52	0.66	0.63
Third-party machine rental	0.18	0.17	0.02	0.02
Miscellaneous expenses	8.10	7.51	5.96	5.66
EOC	100.00	92.50	100.00	95.06
Depreciation	–	7.50	–	4.94
TOC	–	100.00	–	100.00
Milk produced (L/year)[b]	2,558,748		3,193,480	

Source Data from the study (2016)
[a]Information from two properties; bST = bovine somatotropin; sd = standard deviation
[b]Milking period considered = 355 days

8.16%, and 6.76%, respectively, of the EOC. This indicates that the electricity cost proportion in the compost barn farms was close to that of the other free stall farm (farm 4). Therefore, the cost of electricity did not differ significantly between the two systems.

Expenditures for medications comprised a lower percentage of the EOC in the compost barn properties. This difference can be explained primarily by the lower expenditure on intramammary antibiotics for the treatment of mastitis. In farms 1 and 2, the cost of tubes for treating mastitis corresponded to 0.96% and 0.14% of the EOC, respectively, while in farms 3 and 4, the values were 2.30 and 3.07%, respectively. The lower expenditure for this type of medication indicates a lower prevalence of clinical mastitis, and the lower somatic cell counts (SCC) in the farms that adopted the compost barn system.

The proportions of EOC related to the cow bedding were not very significant in either system. However, in the free stall properties, the proportion was lower than in the compost barn farms. Farm 1 had the highest percentage of EOC (2.04%), while farm 2 had 0.93%, a proportion closer to that for the free stall farms (0.10% and 0.75%). This result was expected because the bedding area is smaller in the free stall system than in the compost barn and because in the free stall farms the sand was reutilized with the aid of a sand separator.

The proportion of the TOC represented by depreciation was higher in the compost barn properties than in the free stall properties. However, the standard deviation was high (3.06%). This variation occurred due to the high percentage found for farm 2 (9.66%), which had improvements and idle equipment. For farm 1, depreciation represented 5.33% of the TOC, a value close to that of farms 3 (4.01%) and 4 (5.86%). Thus, there was no significant difference in the production systems. This finding was expected because the patrimony values, which do not take into consideration the land values of the farms with compost barn and free stall facilities, were similar, as the TOC was.

The production of milk per area differed among the studied farms, but no significant difference between the production systems was observed. Farm 1, for example, had production higher than farm 3 but slightly lower than farm 4.

Regarding the operational break-even point (Lopes et al. 2015), it was not affected by the type of facility, given that farms 1 and 2 had values higher than farm 3 but lower than farm 4. This finding was expected because the depreciation also varied widely among the properties. All of the farms not only attained the break-even point but exceeded it (by 85.19%, 82.42%, 92.12%, and 83.96% for properties 1, 2, 3, and 4, respectively), indicating that all were profitable.

As a percentage of the actual revenue, revenue from milk sales was higher in the free stall properties (93.3%) than in the compost barn properties (90.85%). This was due to the higher share of the sale of animals (9.15%) in the composition of the revenues of the compost barn farms, although the standard deviation was very high (10.28%). This variation can occur because the number of animals to be sold depends on the objectives of each farm (e.g., whether the herd is stabilized or in expansion), and it also depends on the wastage rate.

Regarding the revenue from wastes, it is important to note that in the compost barn farms the bedding was not changed prior to this study. Therefore, it was not sold or used in the milk production system itself.

In the free stall properties, the slurry produced cannot be commercialized because its transport is impractical due to the low amount of dry matter. Therefore, it can be used by the fodder production cost centre and is used on the farm itself. The manure produced in these properties had already been used as fertilizer for the maize crops to reduce the cost of bulk feed, which represented 15.24% (±2.83) and 14.10% (±1.09) of the EOC in compost barn and free stall farms, respectively. Therefore, in the present work, expectations of revenue (if sold) from the compost barn bedding and from the free stall manure were presented separately. However, in the farms that adopted the free stall system, there were no estimated gross or net margins because the slurry could not be sold, and the manure was already used for forage production.

When the expected revenue from wastes was included, it was found that this item represented 1.23% (±0.13) and 1.29% (±0.01) of the revenues in the compost barn and free stall properties, respectively. Thus, a fairly similar proportion of total revenue is obtained from wastes in both types of facility, and the proportion of total revenue obtained from wastes per litre of milk was also similar.

When only the actual revenue was considered, the gross margin was higher in the free stall farms. However, the standard deviation was very high for both types of facility (Table 2). This was expected given that the gross margin depends on various factors such as the quality of the milk produced, the price of milk in the region, and the quantity and quality of the animals sold. However, it cannot be concluded that the compost barn properties have a lower gross margin, given that farm 1, for example, had a gross margin higher than farm 4 and very similar to that of farm 3. Farm 2, in turn, had the lowest gross margin among the four due to its smaller production scale and fewer sales of animals.

Additionally, both the compost barn farms and the free stall farms had positive gross margins. This indicates that they are able to produce in the short term, given that they are capable of covering the EOC and still have surpluses.

Considering only the actual revenue, the net margin, similar to the gross margin, was higher in the free stall farms. The standard deviation was very high for both types of facility. This variation was due to the same reasons mentioned in relation to the gross margin and also to the high standard deviation of the depreciation in the

Table 2 Summary of the profitability analysis (in €) of the milk production cost centre in compost barn and free stall production systems located in the state of Minas Gerais, Brazil, for the period January to December 2016

Specification	Compost barn[a]		Free stall[a]	
	Average (€)	sd (€)	Average (€)	sd (€)
[1]Revenue	1,112,663.87	369,261.99	1,298,031.02	207,905.15
Milk	997,170.09	222,846.17	1,209,177.33	170,318.68
Animals	115,493.78	146,415.82	88,853.69	37,586.46
[2]TOC	738,034.98	216,687.87	877,622.03	52,749.67
[3]EOC	686,028.82	223,013.41	834,628.56	61,622.03
Depreciation	52,006.16	6,325.54	42,993.46	8,872.36
[4]Gross margin	426,635.05	146,248.58	463,402.46	146,283.12
Gross margin/ha	4,243.30	1,138.13	4,136.49	316.54
[5]Net margin	374,628.89	152,574.12	420,409.00	155,155.47
Net margin/ha	3,716.53	1,242.88	3,727.50	495.47
Expected revenue from manure	13,412.14	3,130.09	16,673.51	2,568.40
[6]Estimated gross margin[b]	440,047.19	149,378.67	–	–
[7]Estimated net margin[b]	388,041.03	155,704.21	–	–

Source Data from the study (2016)
[a]Information from two properties; [b]No gross or net margins were estimated in the free stall system because the manure had already been used in fertilizing the maize crops in these properties, thus reducing the cost of bulk feed; therefore, it could not be computed again. [1]Revenue = revenue actually received by the producer, coming only from the sale of milk and animals; [2]TOC = total operating cost; [3]EOC = net operating cost; [4]Gross margin = considering only the actual revenue; [5]Net margin = considering only the actual revenue; [6]Estimated gross margin = considering actual revenue and expectation of revenue from wastes; [7]Estimated net margin = considering actual revenue and expectation of revenue from wastes; sd = standard deviation; average exchange rate in 2016: 1 € = R$ 3.858

farms studied and to the differences in production scale, given that a reduction in the product's unit cost can occur when the milk production of a farm is increased (Bressan et al. 2010) due to optimization of the physical structure of the property (Lopes et al. 2006) and keeping costs fixed (Bannock et al. 2003). Additionally, it was verified that farm 1 had a net margin close to that of farm 3, but greater than that of farm 4. Therefore, in the present work, the type of facility had no observable influence on the net margin of the properties.

It is also important to highlight that the net margin was positive in both the compost barn and free stall properties. These results show that the farms are able to produce in the medium term, given that the revenues are sufficient to cover the EOC and to replace the assets after they become worthless through depreciation (Lopes et al. 2004). In relation to the net margin/hectare, similar averages were also seen in the compost barn and free stall properties, with a high standard deviation in the former.

4 Conclusions

The gross and net margins were positive in all the production systems studied, indicating that they are able to produce in the short and medium term. By comparing the components of the TOC of the compost barn and free stall farms, it was concluded that there were differences only in the "medications" item, which constituted a lower proportion of the EOC of the compost barn properties due to the lower percentage expended for intramammary antibiotics for mastitis, and in the "bedding for cows" item, which represented the lowest proportion in the free stall system. In the costs of reproduction inputs and reproductive hormones, there were no significant differences between the farms adopting the different types of facility, although the compost barn farms had better reproductive rates. Additionally, with regard to depreciation, there was no significant difference in the production systems.

Regarding the composition of the revenue, a higher percentage came from the sale of milk in the free stall properties because the compost barn properties sold more animals. In relation to the wastes, the revenue expectations were similar in the two systems.

These results show that the revenues, EOC, depreciation, and the cost of implementing the systems may not be the major determinants in deciding which type of facility to build on a property. Thus, ease of management, productivity, reproductive performance, animal health (hoof injuries and mastitis), water availability, environmental issues, and availability of bedding material (sand, sawdust, coffee husks) should motivate the choice of one installation over the other.

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