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Determination of Competitiveness of a Dairy Production System in Family Farming by Management Systematization as an Extension Practice

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Abstract

Through a case study, the goals of this paper were: First, to provide whether the technical and financial results were adequate to determine the competitiveness of family farming unit to response for enhancing its dairy production system. Second, to propose an alternative analysis methodology titled concentrate rationing to measure the financial performance of the dairy cows. Third, to provide a method to analyze the performance of technical assistance and rural extension. Data were collected by control spreadsheets on family farming unit in Alegre, Espírito Santo, Brazil. Indicators related to income and production costs were analyzed by Excel® software spreadsheets as well the concentrate rationing tool. Financial analysis evidenced that the intensification process resulted in an income increase of 92.5% in dairy sales and a reduction of 38% in the total cost of dairy production; however, the scale of production can be an obstacle for farmers to meet their business opportunities. The best financial results were achieved with the cows that showed the highest milk production and were fed the highest amount of concentrate, implying that the concentrate feeding can be an ally for the family farmer. The intensification process demonstrated be positive in meeting the production costs requirements provided that there is scale; the concentrate rationing tool sets a new perspective for the financial evaluation of a dairy farm; and the interaction between the extension technician and the farmer should bring knowledge so that the family farming becomes the main character in the production structure of the dairy supply chain.

Keywords: technical assistance and agricultural extension, production cost, cost rationing, productivity

1. Introduction

Between now and 2027, the demand for dairy products is expected to increase at a rate of approximately 2% per year due to population growth, world income, and changes in international eating habits (OECD & FAO, 2017). To benefit from this growth in international demand, Milanez et al. (2018) state that countries with farmers who present more competitive prices in dairy production will be given an advantage in the dispute over their participation in global exports.

Sorio (2018), on the other hand, pointed out that the competitive structure of buying markets in Brazil, has its influence in forcing prices to fall in the national dairy market, bargaining for better quality of the milk bought

from farmers, transferring services from industry to them, promoting an undesirable competition among the industry buyers and consequently, transferring this influence over the entire supply chain to the farmers, the least organized link in this chain. This situation demands a solid organizational structure of each link in the supply chain, mainly of the farmers link, the primary sector, in the way that all the involved can meet the market requirements. Pires et al. (2018), analyzed the sustainability of the dairy production system in small farms in the state of Pará, and stated that this category is characterized by a lack of organization, capital, and information; as a result, family farmers are at greater risk of exclusion from the dairy sector in Brazil.

Brazilian economic advances, in terms of productivity and knowledge, depend on the implementation of a cycle of productivity growth, high added-value activities, and increased quality of life (Vilela & Portugal, 2012). Generating knowledge and techniques to improve the efficiency and results of agricultural economic activities, using tools that work since the problem diagnosis, ordering the weak points according to their severity, urgency, and tendency to worsen, was essential to assist farmers and extension workers in the implementation of a solid planning (Lopes et al., 2016).

Ongoing changes in competitive environments lead companies to seek new strategies to guarantee their remaining in the market at a distinct level (Ribeiro et al., 2017). According to Godinho and Carvalho (2009), in order to adapt to market uncertainties, the planning of a farm should be based on decision making based on the analysis of facts, data, and information from internal and external environments, at all levels of the organization, as well as to meet the needs and strategies of the organization, providing reliable information on processes and results.

Similarly, Lopes et al. (2007) stated the knowledge of the relationships between production and cost and its implementation in the rural business management would enable better competitiveness of agricultural products; in addition, the study of scale economies would provide information on the efficiency with which the production resources are allocated.

Hence, the choose of a production system that is focused on the efficient allocation of the productive resources and manpower, as well suitable for the best land occupation, directly affects production costs, which, combined with the productivity of the productive resources, set attractive prices internationally (Milanez et al., 2018). On this basis, Campos et al. (2012) linked the feasibility of production systems with nutritional management, given that feeding the herd is one of the most significant items in the cost composition of animal products.

Vilela et al. (2018) highlighted that the rotational grazing combined with soil correction and fertilization as a readily-available technology for dairy farmers, is able to improve both animal and land productivity levels and minimize the economic and environmental losses caused by the effects of extensive grazing. Production and management techniques that have been practiced for many years are still not applied in most Brazilian dairy farms, either because of the lack of adequate training of available technical assistance, or because of the lack of support for development work aimed at generating income (Rezende, 2015). The research conducted by Silva and Fiist (2015) should be emphasized so as to stress the importance of accounting for small farmers, this being used as a management tool. The authors identified that 84% of the interviewees did not do bookkeeping, stating a lack of knowledge, difficulty in doing it, or by considering hiring an experienced professional to be an inaccessible factor. This limits the analysis of real gains in productivity and also the success in family livestock.

To revert this scenario, developing and implementing public policies to encourage productive recovery in areas with low productivity, with continued technical assistance acquainted with the suitable technologies for each situation, is of utmost significance (Vilela et al., 2018). Ribeiro et al. (2017) considered the identification and use of proper tools and methodologies were essential to manage the flow of knowledge within the organization and guide it, enabling a positive environment for its creation, sharing, dissemination, application, and control, making effective the processes of organizational management and precise and responsible decision making.

As Pires (2018) said, the complexity of the Brazilian agronomic system, dichotomized into an agribusiness linked to the globalized market, and, at the same time, the organically disarticulated familly farming (FF), with an enormous lack of infrastructure, capital, knowledge in production and marketing fields, are expression of the need to propose more inclusive and democratic alternative social practices in rural areas. This issue, in the author's view, possibly implies that cooperativism and the technical assistance and rural extension (TARE) take on new dimensions and incorporate new meanings to ensure that agricultural policies are delivered to farmers.

Considering the need to adapt FF to the market forces and the contribution to the Brazilian economic advances by income generation and social inclusion, this article intends to answer the following research question: Can the rural extension action provide conditions for dairy production activity become financially viable in FF?

Through a case study, the goals of this paper were: First, to provide whether the technical and financial results were adequate to determine the competitiveness of family farming unit to response for enhancing its dairy production system. Second, to propose an alternative analysis methodology titled concentrate rationing to measure the financial performance of the dairy cows. Third, to provide a method to analyze the performance of technical assistance and rural extension.

2. Method

2.1 Location

The case study refers to a typical farm on FF placed in the municipality of Alegre, state of Espírito Santo, Brazil, with the following geographical coordinates: 20º37′48.6″ south latitude and 41º32′51.9″ west longitude, where the principal activity is dairy farming. Data were collected over 42 months, in two production cycles, from February 2011 to March 2012 and January to December 2013, when there was a technological transition from a production model with low adoption of appropriate technology for the activity, considered traditional in the region, to a production model with intensified adoption of the productive resources.

2.2 Model Production and Performance Indicators

It should be highlighted that the intensification process was based on the production of pasture with irrigated tropical grass in management under intermittent stocking constituting the nutritional basis of the dairy cows diet. The irrigation provided regularity in the supply and quality of forage consumed by the animals during the whole period. Table 1 depicts the evolution of the main technical performance indicators of the system and compares it with means obtained from Vilela et al. (2018) as reference, proving that, technically, the adoption of technology led to a more efficient animal response in production and reproduction as well.

Table 1. Technical performance indicators in a family farm dairy production system before and after adopting intermittent rotational management technology in watered tropical pasture, compared to similar production systems in Brazil

Indicator	Period		Reference * (Vilela et al., 2018)
	2011/2012 (12 months)	2013 (12 months)	
Volume of milk marketed (liters year^{-1})	43,851	84,423	-
Dairy cows (nº)	11.2	16.6	-
Dairy cows (%)	70	75	-
Animal productivity (liters cow^{-1} day^{-1})	11.1	14.2	7.0 to 10.4
Management (cow ha^{-1})	-	17 to 23	1.8 to 5.0
Productivity (liters ha^{-1} day^{-1})	-	219 to 351	17.4 to 47.8

Note. *Performance of crossbred, Holstein and zebu cows in different pastures and nitrogen fertilization in rainy season.

Source: Research data.

The extension practice should conduct the financial analysis after technical results so that the competitiveness determination of the production system is based on a systematization of decision making that minimizes the specific risks of the activity. To this end, financial analysis of the production cycles before and after the intensification process was executed. Chart 1 depicts the financial indicators adopted to evaluate the effects of the technology transition on property monitored by the TARE service. Nominal values were deflated in the two production cycles to real values, in May 2019, by the general market price index (IGP-M), to eliminate the effects of inflation in the comparative analysis of data. Milk prices were standardized in both periods in accordance with the market quotation, in May 2019, so as to avoid a bias in milk income regarding situational issues of dairy market prices very different. The monetary amounts were converted from the Brazilian real currency to the United States dollar at the exchange rate prevailing on May 2, 2019 (BANCO CENTRAL DO BRASIL, 2019).

Indicator	Description
Investment (US$)	Sum of capital, in dollars, invested in productive resources in order to obtain profit or benefits, within the production cycle.
Milk income (US$)	Gross value, in dollars, of total milk production sold to the market in the production cycle.
Average milk price (US$ liter^{-1})	Value, in dollars, of the total production of milk sold to the market divided by the amount of milk produced in the production cycle.
Animal income (US$)	Gross value, in dollars, of the sale of herd animals in the production cycle.
Cash flow (US$)	Gross value, in dollars, of the operating result between what was obtained with the total income (milk and animals) subtracted from the operational cost in the production cycle.
Operational cost/Income (%)	Relationship between operational cost and total income, in percent, in the production cycle.
Result (US$)	Gross value, in dollars, derived from subtracting total income and total cost in the production cycle. The result can be set as "profit" or "loss".
Total cost (US$.liter^{-1})	Value achieved by dividing the sum of the expenses of costing, depreciation of machinery and facilities, and return on capital invested in animals and land, by the quantity of milk produced.

Chart 1. Financial indicators, units and description of the calculation used to evaluate the performance of intensive dairy production on a farm of FF, in the municipality of Alegre, Espírito Santo State, Brazil, in two production cycles

2.3 Concentrate Rationing Management Tool

In an effort to enhance the efficiency in the use of productive resources, a strategy for evaluating the supply of concentrate feed based on the financial return of the amount offered daily, was developed. To do so, a technique identified as concentrate rationing (CR) was applied to evaluate the performance of the dairy cows. The criterion for the supply of concentrate was determined by the amount of milk production and the stage of lactation at each dairy control; so each cow was given 1.0 kg of concentrate to 3.0 kg of milk produced, which could be adjusted in specific situations immediately after dairy control, that is, addition of concentrate demanded by the cow to achieve higher levels of production or reduction when there was no animal response within the expectations.

The CR consists of rationing, monthly or after each dairy control, the fixed (FC) and variable costs, except for concentrate feed (VC-cf), among the dairy cows in the herd. Ration only among dairy cows is explained by the fact that this group is responsible for generating income on the farm; thus, each cow must "pay", with the milk produced, its respective portion of ration added to the concentrate feed it has consumed. As such, the "Result" means the measurement of the financial return of each cow, or a batch of cows, according to the concentrate consumed. This indicator shows a marginal analysis of the profitability of the project beyond what is already established by the indicators previously presented, it measures the extent to which the additional unit of the activity carried out has brought more benefit than it has cost to develop it. Moreover, it allows analyzing the financial effects of variations in the herd structure, in other words, measuring the impact on the change in the relationship between dairy cows and dry cows. Hence, CR is presented as an alternative tool for financial analysis of animal performance, besides trying to demystify, among farmers and extension workers, the adoption of concentrate feed as an unviable input from the financial point of view in small dairy production systems, typical in FF.

3. Results

3.1 Financial Performance Indicators

Table 2 shows the financial results of gains in efficiency of the productive resources on the farm, due to the adoption of management with rotational capacity in a watered tropical pasture.

Table 2. Financial performance indicators in two production cycles. Nominal values were deflated to real values, in May 2019, by the Brazilian general market price index (IGP-M). Milk prices were standardized according to quoted market prices. The dollar exchange rate, on May 2, was 3,965 Brazilian *reais*

Indicator	Period	
	2011/2012 (12 months)	2013 (12 months)
Investment (US$ year^{-1})	1,151.31	4,978.39
Milk income* (US$)	15,372.73	29,595.96
Average milk price** (US$ liter^{-1})	0.35	0.35
Cash flow (US$)	1,994.28	7,052.06
Operational cost/Income (%)	87%	59%
Result (US$)	-5,419.17	4,897.17
Total cost*** (US$ liter^{-1})	0.47	0.29

Note. * Only considered commercialized volumes of 43,851 and 84,423 liters, respectively. ** Milk quotation paid to farmers, in May 2019, for April production, with no freight (Scot Consultoria, 2019). *** It includes family labor remuneration.

3.2 Concentrate Rationing Management Tool

Table 3 shows the measurement of production and consumption of concentrate feed, calculation of income generated, ration expenses plus the consumption of concentrate, and the result of each production unit (cow). As an example, based on the month of August 2013, the CR was applied after dairy control, when there were 19 dairy cows and five dry cows, that is, 79% were in lactation stage. The milk price received by the farmer was US$ 0.27 and the value of the concentrate feed was US$ 0.17 per kilogram, composed of the value of the ingredients. The calculated CF and CV-cr were US$ 440.71 and US$ 1,019.85 per month, respectively. The sum of these values was rationed among the 19 dairy cows, the ones responsible for generating income at that time, resulting in a "quota" of US$ 2.48 per day for each cow to "pay" added to the respective value of concentrate feed consumed according to the production. The daily financial result of each cow results from the subtraction of the value of its milk production and the value of its respective expense (quota and concentrate), thus being possible to measure financially the animal response limited by genetics and/or lactation stage.

Table 3. Daily result referring to the Concentrate Rationing of a 19-cow herd in different dairy stages that received concentrate according to the production in August 2013

Cow	Production (Liters of milk)	Concentrate (Kg)	Income (US$)	Expenses Ration + Concentrate (US$)
1	25.0	8	6.75	3.83
2	24.0	8	6.48	3.83
3	24.0	8	6.48	3.83
4	23.5	8	6.34	3.83
5	23.5	8	6.34	3.83
6	21.5	8	5.80	3.83
7	21.1	7	5.69	3.66
8	20.5	7	5.53	3.66
9	20.1	7	5.42	3.66
10	18.0	6	4.86	3.49
11	17.0	5	4.59	3.32
12	16.0	5	4.32	3.32
13	15.0	4	4.05	3.16
14	13.5	4	3.64	3.16
15	13.1	4	3.54	3.16
16	13.0	4	3.51	3.16
17	12.0	4	3.24	3.16
18	11.0	4	2.97	3.16
19	5.0	0	1.35	2.48
Total	336.80	109.0	90.90	65.52
Mean	17.7	5.7	4.78	3.29
SD*	6.7	4.7	5.76	0.36

Note. *SD: Standard Deviation.

Source: Prepared by the authors based on the research data.

4. Discussion

Proper nutrition of dairy cows led to an increase in production volume and, consequently, an increase of 92.5% in income from milk sales. A study conducted by Bassotto et al. (2018) on FF units showed that the volume of production was a key component in the continuity of the dairy activity, given that projections indicated that the financial results could be reduced in the long term as a result of reduced milk production and increased production costs. Achieving a production scale to meet the needs of FF farmers may be an obstacle considering the physical limitations of the property or for adding more cost than income, in view that the growth of the production structure requires more entrepreneurial management, for which this type of producer is probably not technically qualified.

4.1 Investment Efficiency

During the first period of analysis, 87% of the income was used in operating costs, which was not enough to amortize the total fixed costs for the depreciation of machinery and facilities and remuneration of capital tied up in animals and land, which led to a negative result of US$ 5,419.17. The cash flow of only US$ 1,994.28 was not enough to remunerate family labor with a current minimum wage, representing the decapitalization of the farmer and threatening the sustainability of the activity even in the short term (Table 2).

For the second period of analysis, after investments in the intensification of the productive resources, organization, and control of the productive and reproductive indexes of the herd, it was possible to measure the animal performance, plan the development of the herd, and select the animals for a more adequate quantity according to the size of the property and the productive resources availability. The performance indicator operational cost/income relationship measured the effects of enhancing the efficiency of the production system; in other words, 59% of the income generated by the milk sales were used to cover the operational cost, providing adequate margin to amortize assets and return on the capital invested, which generated US$ 4.897.17 for the year (Table 2), corresponding to 19.5 minimum wages in Brazil according to Decree No. 9,661 of 2019 (Diário

Oficial da União, 2019). This result is in line with the findings of Bezerra & Schlindwein (2017), who emphasized the importance of no longer understanding FF as 'subsistence agriculture' but rather seeing its potential for the market insertion, in a context of local or regional development.

When analyzing the financial results of a FF unit, account should be taken of the evolution of the income and remuneration of the family labor. Considering the low influence of farmers on the milk price, they should aim that the increase in income, arising from the increase in production volume, has to proportionally generate higher results than the minimum wage readjustments. This mitigates the impacts of milk price instability so that its profitability, over time, is attractive and does not exert its opportunity cost on its remuneration, leaving the activity.

The total cost per liter of milk, including the remuneration of family labor, decreased 38% (Table 2), which would be satisfactory, but still above the total costs of typical farms in countries, such as Brazil, Argentina, and Uruguay, identified by the International Farm Comparison Network (Milanez et al., 2018). Traditional countries in dairy exports and competitors in consumer markets, such as New Zealand, have activity costs below the one provided by the production system in question but have strong physical restrictions to expand their production (MILANEZ et al., 2018). In this way, FF is technically prepared to compete in foreign markets if there is a process of remodeling this link in the supply chain in order to achieve gains in efficiency and scale. According to Engel et al. (2017), organizing in cooperatives can be a strategy for survival and growth that FF has to adapt to new formats, especially taking into account the globalized and competitive market that is currently in place. Leite and Batalha (2016), however, detected significant limitations concerning to the role of cooperatives, especially the small number of technicians in the field; limited conduction of studies in commercial areas; lack of specific policies for the subject; and absence of a particular marketing policy.

4.2 Concentrate Rationing Management Tool

The development of the CR tool attempts to assist the systematization of the farm management and to create, with the family farmers and rural extension technicians, a broader and clearer view of the effects of the technologies adopted in the intensification of the production process. The CR tool also considers the inputs on zootechnical and financial returns, to develop a greater critical sense for the evaluation of the production system by all the protagonists of the process.

Through the CR tool, the best financial returns were verified for the cows that reached the highest milk production and that consumed the highest amount of concentrate, indicating that the rational adoption of concentrate in the daily diet of the cows can be an ally of family farmers, assuming its technical and financial effects are assessed (Table 3). These findings are in line with those of Silva et al. (2015), who asserted that supplementation provides long and short-term effects on dairy production systems based on tropical forage; among others, the increase in individual milk production, increase in the capacity rate of pastures, increase in fertility, increase in dry matter consumption per area, increase in lactation duration, and increase in milk production per area.

In the study of the performance indicators that determined profitability in 159 farms in western Minas Gerais, Resende et al. (2016) noted the best results were linked to the efficient use of labor, which was related to the use of concentrate feed, determining higher productivity per cow. As such, achieving a gain in production per cow can be a reasonable zootechnical goal to direct the gain in profitability.

In all of this, the analysis is directly linked to the market price of a liter of milk and a kilo of concentrate. The ratio between the milk and concentrate prices is an index that indicates the amount of feed (kg of concentrates) a farmer can buy after selling a liter of milk. In this way, this relation can be considered favorable when this index is higher than 1.5. In other words, the higher the proportion, the more economic it is to fed concentrates (IFCN, 2017). However, in view of the wide variation in the milk and concentrate prices, a characteristic of agricultural markets and a source of great economic stress in the industrial and primary sectors, it is fundamental for rural extension technicians and family farmers to assess the effects of these price fluctuations so as to create more security in interventions in production systems. In this respect, the CR tool makes possible to measure the financial impact of the concentrate feeding, allowing a complementary and more in-depth discussion of the financial analyses in any intensive dairy production system, mainly in the FF systems.

It is perceived in the Table 3 that the cow with lower production, even not fed concentrate, showed negative financial results. This is because, even at a lower cost, the low-production or temporarily unproductive animals (dry cows) do not generate sufficient income or simply do not generate income by milk sales to contribute to the maintenance of the system. Such fact leads to another effect that this tool can evaluate, that is, the herd structure; the negative financial effects of an unstructured herd increase in proportion to the increase in the number of

unproductive animals in the herd. That is to say, the greater the number of dry cows, besides the 17% characterizing reproductive inefficiency, and the greater the number of breeding and rearing animals, it can be inferred, by means of the CR, that the entire production system feels the effects of administrative inefficiency when the number of cows in conditions to generate income decreases regarding the total number of herd animals.

Hence, there is an understanding of the importance for farmers to implement techniques and management to achieve the ideal zootechnical index of 83% of dairy cows (Bergamaschi et al., 2010). It is worth mentioning, however, the relevance of the strategic offering of the concentrate in pre-natal care in order to establish optimal physiological conditions for delivery. This was verified by Teixeira Júnior et al. (2016), who related the pre-natal management with the concentrate feeding to the increase of economic and financial results and improvement of profitability of a dairy production system.

The CR tool amplifies the discussion about reproductive management in dairy production systems when relating the reproductive condition of the herd with its financial effects, confirming the information of Resende et al. (2016), who pointed out that herds with a greater proportion of animals in production have higher profitability, being as such more efficient.

4.3 Diffusionist View of TARE and the Consequences

In this way, FF is technically prepared to compete in foreign markets if there is a process of remodeling this link in the supply chain in order to achieve gains in efficiency and production scale. According to Engel et al. (2017), organization in cooperatives can be a strategy for survival and growth that FF has to adapt to new formats, especially taking into account the globalized and competitive market that is currently in place. Leite & Batalha (2016), however, detected significant limitations concerning to the role of dairy cooperatives, especially the small number of rural extension technicians working on them; few studies in the commercial areas; lack of specific policies for the dairy business; and absence of a particular marketing policy.

Historically, the insistence in a diffusionist viewing of TARE is directly linked to the fact that farmers usually resist, somehow, to the implementation of technologies in their farms (Landini, 2014). With the aim to increase the effectiveness of the TARE evaluation as a strategy that subsidizes decisions, Bressan et al. (2009) emphasized that these services should be thought about. First, forecasting their interventions and, second, separating their effects and verifying whether there is an interaction among the different interventions, especially those in which TARE is not implicated, such as the market dynamics effects on the decision making of the techniques adopted.

It is important to note, however, that determining FF competitiveness in Brazil not only depends on the efficient use of farm production resources, by implementing a production system consistent with the farmers' reality, but also on a structural organization process involving the external environment, by strengthening TARE programs and cooperativism.

As Pires (2018) puts it, cooperativism represents an important resource of rural extension for bringing agricultural policies to farmers. Furthermore, cooperatives have the power to unite farmers towards common interests; enable them to generate work and income; and, given their territorial anchorage, promote local dynamism.

5. Conclusions

Investments in the intensification process, by using intermittent grazing in irrigated tropical pasture, proved rewarding when analyzed by financial performance indicators. The financial analysis of the intensified production system demonstrated to be promising in attending to the demands on production costs in international markets, as long as there is enough scale.

The concentrate rationing tool is effective for measuring the financial results of production units (cows), in addition to creating a perspective of financial evaluation by the herd structure in a dairy production system.

The rural extension technicians and family farmers interaction should combine knowledge produced by educational and research institutions, be guided by market demands, and catalyzed by cooperative ideals, for family farming to become a protagonist in the productive arrangement of dairy supply chains.

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