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An Analysis of Life Cycle on Dairy Farms with Grasslands Having Different Botanical Compositions

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ABSTRACT

Aim. To analyze the life cycle (LC) on dairy farms with rotational grass management, depending on its botanical composition. **Materials and methods:** The study compared dairy farms in Cotopaxi, 2800--3590 meters above sea level. Farm 1: livestock load 1 and 1.2 AU/ha, on 50% ribwort plantain (*Plantago lanceolata*), 50% white clover *(Trifolium repens)*. Farm 2: Farm 1: stocking rate 1 and 1.2 AU/ha, on 85% Ryegrass (*Lolium perenne*)-15% white clover (*Trifolium repens*). Farm 3: Farm 1: stocking rate 1 and 2.1 AU/ha, on 33% Ryegrass (Lolium perenne)-33% ribwort plantain-34% de Trébol blanco. The land was fertilized, with balanced feeds and crossbred, New Zealand, and American Holstein animals, including grazing rest. **Results:** There were differences in land use, as in farms 1 and 3, as to household labor. In farm 1, resting was 15-28 days, and NDF was 47.38, at 28.03, and 1.96, 2.45 Mcal of energy, whereas farm 3 showed 1.99 metabolizable energy at 40 days, and 2.11 at 35 days, less milk/cow than No. 3 and over No.1. As to milk production per ha, farms 1 and 3 were higher (24 kg vs 19 kg.). This data was positive for the farms. A potential was observed for converting more energy from the system into products. **Conclusion:** The analysis showed similar results to other dairy production systems, nitrogen and energy balances, and their relationships to the environment and emissions, though it can be more efficient through managing improvements and no excess input.

Keywords: botanical composition, efficiency, income, grasslands, cost-effectiveness, nutritional value (*Source*: *AGROVOC*)

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INTRODUCTION

Grass-based cattle raising depends largely on the availability of dry matter and nutritional quality of the supply; the animal potential that consumes it and turns it into nutrients included in the milk and/or animal tissue; and how the cattle system deals with the resources of the dairy system, which will determine animal productivity (Bywater, 2010; Ruiz and Guevara, 2021; Herron *et al*., 2022). This type of analysis is a referent to backup strategies for grazing cattle herds (Herron *et al.*, 2022). The analysis type showed the need to understand interactions among the different technical, production, and economic elements (Jiang and Sharp, 2014; Guevara *et al*., 2020), and the possible recommendations for improvements in various ecosystems (Arcos *et al*., 2021).

Herron *et al.* (2022) pointed out that to overcome environmental challenges in the world□s grass-based dairy sector and to ensure economic feasibility, milk farmers must enhance the system□s efficiency and set up reference points to evaluate the efficacy of handling practices and the mitigation strategies recommended, achieve higher technical and scale up efficiency, cut down costs of milk kg, and improve LCA, which coincides with several analyses based on dairy strategies (Bywater, 2010; Guevara *et al*., 2020).

Accordingly, this study aims to analyze the life cycle of animals on dairy farms with grass having different botanical compositions, and based on conventional rotational grazing.

MATERIALS AND METHODS

Description of the farm studied

Farm 01 (G01): It is located in Area 3, province of Tungurahua, Canton Pillaro, at 1^0 8´ 49,47¨, south latitude and 78^0 32´ 50,13¨ west longitude, 2853.3 meters above sea level and a temperature of 15 ^{0}C, covering 30 ha of grasslands, and New Zealand, American, and crossbred Holstein animals, as well as areas with grains and leafy crops. The animals□ stocking rate was between 1 and 1.2 AU/ha, on 50% ribwort plantain (*Plantago lanceolata*), and 50% white clover *(Trifolium repens)*, daily. The commercial feed used included 2.7 kg/cow/day for production herds, though there were differences as to each animal□s production, at 460 g/cow/d from the 7th kg of milk. The locations used organic and mineral fertilization, and irrigation by sprinkling every 21 days.

Farm 02 (G02): Province of Cotopaxi, located in Cumbijin community, San Miguel Parrish, canton Salcedo, 3200 meters above sea level, with a temperature of 12.4 °C. Some communities have a 6-8 °C average, occasionally below 5 °C. Precipitations average 718 mm, located at 1^0 8´ 49,47¨ south latitude and 78^0 32´ 50,13¨ west longitude, covering 60-70 ha. It has grassland for dairy cattle (New Zealand Holstein, and American and crossbred Holstein animals). The farm also has areas for grains and leafy crops. The grass was used under 1 and 1.2 AU/ha, rotational, on 85% Ryegrass (*Lolium perenne*)- 15% white clover (*Trifolium repens*). The commercial feed intake was 1.6 kg/cow/day. The locations included organic and mineral fertilization, along with irrigation by sprinkling. Comparatively, farm No. 02 is the most common referent in the area, according to the names of farming systems approach due to the presence and proportion of species and cattle activity in the area.

Farm 03 (G03): It is located in Potrerillos, canton Latacunga, province of Cotopaxi. At 1^0 1´ 50,28□ south latitude and 78°28' 51.36□ west longitude, 3492.5 meters above sea level, covering 30 ha of grasslands. The animals are New Zealand Holstein and American and crossbred Holstein. The animal stocking rate was between 1 and 2 AU/ha, rotational, on 33 % de Ryegrass (*Lolium perenne*)- 33% ribwort plantain (*Plantago lanceolata*), and 34% de white clover (*Trifolium repens*), according to samplings made twice a year (Corbea and García Trujillo, 1982). The commercial feed used included 3.6 kg/cow/day for production herds, though there were differences as to each animal□s production. The locations included organic and mineral fertilization, along with irrigation by sprinkling. Data was collected from the record of production indicators of the farm and the other two farms between 2019 and 2022.

The grasslands of the three farms were sampled twice a year to check the proximal bromatological composition, whereas the dry matter, crude protein, ME, NDF, and ADF values were analyzed as well, along with the feeds included. The yearly data containing the milk weight values from each farm/month were recorded and the milk/cow/day production indicators per ha/year and total annual production were calculated. Instant feed balances (BAI) were performed according to the Pérez Infante (2010) technique, which included the nutritional requirements of a cow, on average, at the time (NRC, 2010), and the nutritional contribution was calculated for each feed type, particularly metabolizable energy and grass intake. The balance was set up depending on the differences between needs and contributions. The economic indicators of expenses, income, and cost-effectiveness were collected from the farm□s records, and the net income and cost-effectiveness were estimated by the Luening (2010) technique.

A life cycle analysis of every production system using contrasting grass was performed on each farm, according to the method described by IPCC (2019). Opinions were collected from nutritional balance studies for the life cycle and urinary excretion. Then the data were used to calculate their main indexes, using known parameters like milk production, and estimates like total energy balance. The global warming potential, overall energy balance, and agro-environmental sustainability indicators, like methane and N_2 balances, were calculated (Guevara, 1999), including energy and land for milk production through the IPCC methods (2019). The CH4 emissions were calculated with the emission coefficient of CO2-Eq/kg of milk equal to 1.2. The information provided by the farms containing data between 2019 and 2022 was gathered, particularly data about milk production, costs, and income, along with other indicators of the herd (IPCC, 2019). Comparisons of live cycle analysis indicators were performed, which resulted in numeric differences among the farms.

RESULTS AND DISCUSSION

Table 1 shows the data about land use in the farms whose fieldwork was evaluated. The total area was between 30 ha on farms 01 and 03, whereas farm 02 covered 60 ha. This criterion for land use was very significant in evaluating efficiency and the life cycle, including the grazing and cropping areas, which may bring differences in terms of land use efficiency and productivity (Jiang and Sharp, 2014; Batalla, 2022; Herron *et al*., 2022), where the space for cattle raising and grass production on farms 1 and 3 showed similar values, very common in these types of farms in Latin America, just like forest areas. Labor is one of the most significant factors producing economic results, with an important effect on family participation in the three farms, similar to the reports by Ma *et al.* (2019) on New Zealand dairy farms; Herron *et al*. (2022), for dairy farms in the USA; and Bywater (2010), who monitored, in the milk conglomerate in south Chile, more than 400 family-held farms, and defined highly relevant indicators in these farms, as to area, number of cows, production, reproduction, and similar household activities with a variable intensification. The minimum area ensuring cost-effectiveness for a farming company held by a household, which allows for favorable evolution, is a fundamental criterion for sustainability. The farming household can be considered as a contribution to work and is being studied in Chile, Argentina, and Ecuador. So far the results show several criteria, such as productivity, cost-effectiveness, and even technical and scale cost-effectiveness (Bywater, 2010; Hargreaves *et al*., 2021; Batalla, 2022; Guevara *et al*., 2022).

Taufiq *et al*. (2016) took part in a study that analyzed the life cycle to measure the impact of these activities as triggering global warming (PCA), acidification potential (AP), and eutrophication potential (PE) on specialized and diversified cattle farms, which generated fewer negative impacts on these indexes, though the diversified farms with broader cropping areas percentages of the farm surface, were more sustainable.

Table 1. Land use in the cattle systems evaluated

Indicators	G01	G02	G03
Ryegrass area in the cattle surface (%)	----	85	33
White clover **area in the cattle surface (%)**	50	15	34
Ribwort plantain **area in the cattle surface (%)**	50	----	33
Cropping area in the cattle surface (%)	2.1	2.8	3.3
Forest area in the cattle surface (%)	0.5	1.1	0.8
Road and infrastructure area in the cattle surface (%)	1.2	1.6	1.3

On farm No. 1 (Table 2), grass resting occurred between 15 and 28 days; NDF, 47.38 and 28.03; and 1.96 at 2.45 Mcal of energy. Then 20-28 days were used for grazing. Farm 2, with grazing between 25 and 40 days, an NDF between 32 and 50.88%, and energy between 1.33 and 2.21, regularly, showed more use in 25 days with better ME level, and lower NDF, whereas farm 3 showed metabolizable energy values (ME) of ME1.99, at 40 days of grass intake rest, and between 2.11 and 35 days.

Table 2. Utilization of grass fields (occupation/year), rest time (days), NDF (%), and metabolizable energy (ME) of grass on the farms

	Days	Grass field utilization	NDF	ME (Mcal/kg)
Farm 1	28	7	47.38	1.96
	15	11	28.03	2.32
	20	7	34.01	2.45
Farm 2	40	5	50.88	1.33
	25	7	32.68	2.21
	35	5	38.59	1.99
Farm 3	50	4	50.55	1.40
	35	6	44.02	2.11
	40	5	45.31	1.99

Farm No. 3 showed normal rotation management, between 35 and 50 days (Table 2), with 50.55% NDF, and 1.40 Mcal/kg of metabolizable energy. It was remarkably deficient for animals in a 35-day study and 2.1 Mcal/kg metabolizable energy, with more efficient management parameters. Research shows that frequent defoliation produced leaves with higher crude protein and metabolizable energy contents, and less soluble carbohydrate content, NDF, and ANF. Accordingly, the response of the soluble carbohydrate response matches the grass NDF-energy-intake ratio, which has been shown in this study, provided that the availability of dry matter supplied to the animals from the grass is not a limiting factor (Pérez Infante, 2010; Ruíz and Guevara, 2021). It entails maintaining cost-effectiveness and low operational costs with lower costs/kg of milk/cow (Guevara, 1999; Pérez Infante, 2010). Among the determining factors needed for sustainability, according to Bywater (2010), the most productive cow types with lower energy and other nutrient needs due to their live weight, have a decisive role in achieving cost-effectiveness and efficiency of grazing systems, while others point out it may be achieved steadily in different dairy areas of the world (Coffey *et al*., 2018; Ruiz and Guevara, 2021; Down, 2022).

Table 3. Physical characteristics of dairy farms, according to productive indicators and labor (mean values in 2019-2022)

Indicators	**G01**	**G02**	**G03**	**SE ±**	**VC (%)**
Stocking rate (AU/ha)	1.5	1.5	2.1	0.02	14.3
Total cows (#)	48	72	56	1.19	11.6
Milking cows (%)	28	27	32	0.03	13.1
Milk production/cow/day (kg)	16.93	13.27	11.81	0.16	14.3
Milk production/ha/day $(kg)^{-1}$	25.40	19.91	24.81	0.05	12.1
Total labor (#WU)	3	3	5	0.02	7.6
Total labor outside families (#WU)	----	2	----	0.04	18.2

These results are similar to the reports by Rotz *et al*. (2020) when comparing the results from Farm 2, to the traditional performance using Ryegrass-Trébol, with lower production of milk/cow on Farm 3 than on Farm 1. The indicators of milk production per ha, farms 01 and 03 were higher (24 kg vs 19 kg.) than the values observed on farm 2. It is a positive sign of LCA for the two farms, with differences between the overall stocking rate (0.6 AU/ha), and favorable results in other studies made on dairy farms, such as Jiang and Sharp (2014) in New Zealand, and by Rotz *et al.* (2020), in representative dairy farms in various areas of the USA. Greater land productivity was observed in a study by Berton *et al.* (2020), on dairy systems in Italy, with a significant inclusion of grass intake and grass production/area in terms of land use by dairy cattle, also reported by Herron *et al.* (2022), who cited fodder production/ha and its conversion into dairy yields, as one of the main indicators.

Table 3 shows the indicators of the overall system□s stocking rate, total cows, and the percentage of milking cows. It is related to the determining effect of family labor on each farm, which is similar to the behavior found by Jiang and Sharp (2014) and Ma *et al.* (2019) on dairy farms in New Zealand, though in larger surfaces and more cows, with similar family labor characteristics and greater intensification. The high level reached by household labor on these farms in the south mountain range of Ecuador is remarkable (Hargreaves *et al*., 2021; Batalla, 2022; Down, 2022).

The criteria for improved grassland, household labor and/or hired staff, overall stocking rate, and the percentage of milking cows are determinants, coinciding with Coffey *et al.* (2018); Herron *et al.* (2022), in which the indexes can explain the positive and relevant efficiency and carbon emissions from these dairy systems.

Berton *et al.* (2020) and Drews *et al.* (2020) demonstrated the need to study the influence of the type of production system, the handling strategies, technology, more intensive grazing land use, and the geographical surface. Morone *et al*. 2023) claimed that the sustainability and superiority needed for an economy based on fossil fuels should be tested rigorously, using biological-based processes. USDA (2020) and Santos Carvalho *et al.* (2022), said that methane and nitrogen emissions, along with inputs for animal nutrition, were the main contributors to impacts observed in milk production in most categories. Milk yields (Tables 3 and 4) were very similar to the ones achieved in the grazing system with the inclusion of other grass species, such as Kikuyo grass, as well as other improved species, like Rye-Grass English and Italian, Dactylo, Festuca, and Leguminosae like the white and red clover, and ribwort plantain (*Plantago lanceolata*), which made a particular contribution, reaching between 5 and 15 kg/cow/day, and between 9 and 28 kg/ha/day, as reported by Batalla (2022) and Down (2022) on the Sierra Region, in Ecuador, with values between 2500-6000 kg of milk/ha/day, and average lactation adjusted to somewhat more than 240 days, which coincided with the values observed in other areas in Argentina, Europe, the

United States, Australia, New Zealand, and some locations in Latin America (Jiang and Sharp, 2014; Berton *et al.,* 2020; USDA, 2020).

It coincides with (Table 4) Finnegan and Goggins (2021) and Herron *et al.* (2022), who conducted studies to estimate the environmental impact of crude milk production. The fat and protein productions (Table 5), are related to industrial analysis values (3.5 and 3.2%, respectively), indicating a higher percentage of acetic acid for fat and amino acids and dairy protein (Orskov, 2005; Ruiz and Guevara, 2021; Herron *et al*., 2022).

Table 4. Milk production indicators by area, less Diesel use, commercial feeds, energy and fertilizers, and age of leading farmers (2019-2022)

Indicators	G01	G02	G03	SE (±)	VC (%)
Milk production (kg/ha/year)$^{-1}$	6197	4857	7609	214	16.5
Age of owner (years)	53	58	52	2.6	14.6
Less fertilizer use (%)	22.53	14.85	7.16	1.23	18.2
Less commercial feed use (%)	6.25	6.78	7.11	1.52	11.5
Less energy/milk kg produced (%)	26.02	21.37	19.41	3.17	8.3

[1]Milk production kg/ha/year, adjusted to 244 days of lactation on average/group, multiplied by production/cow/day and the mean stocking rate on each farm

The nitrogen/ha/year balances (14.33 kg/ha) were favorable for G01, with lower values for G02 and G03, respectively, less efficient in terms of this nutrient and the lowest value for Efficiency in the Utilization of Nitrogen to produce milk (0.79 kg/1000 kg). Herron *et al.* (2022) reported similar results by physical factors, farming diversity, less fertilizer use, less commercial feed use, less energy intake/kg milk, and the size of the farm.

Table 5. Indicators for fat and protein production by surface area on dairy farms, N_2 balance, and Efficiency in the utilization of N_2 on Dairy Farms

INDEXES	G01	G02	G03
Production/fat/ha/year (kg)[1]	31.63	24.32	25.11
Production/protein/ha/year (kg)[2]	26.42	21.03	22.09
N_2 balance/ha/year (kg)	14.33	11.38	7.65
Efficiency in N_2 use (kg/1000kg milk).	0.79	0.91	1.06

[1,2]Production of fat and protein calculated with coefficients 3.5% and 3.2% fat and dairy protein.

Similar results have been reported in several grazing experiments in temperate areas, using mid-high-performance cows (Coffey *et al.,* 2018; Berton *et al.,* 2020; Herron *et al.*, 2022) in dairy systems in Argentina, England, and France. These values were calculated by Batallas (2022) and Down (2022) on dairy farms in the mid-north Sierra of Ecuador.

Table 6 also shows indexes like energy balance and energy intake per kg of milk for every 1000 kg of milk produced, accounting for 1008 Mcal in G01, and almost 35% of the energy needed to produce 15-20 kg of milk, as recorded on this farm, which was over the rest. In all the cases, it coincides with the reports from American dairy farms and research done by Jiang and Sharp (2014) in the USA, and Ma *et al.* (2019) on dairy farms with different levels of intensification and animals with a high genetic potential in New Zealand. Taufiq *et al*. (2016) said that they found on the local farms with diversification, the LCA was 2.34 kg CO2 eq/kg milk FCM, whereas the impact of modern specialized farms was 1.52 kg LCA, CO2 eq/kg FCM of milk. Emissions were higher in the treatments with Ryegrass (85 and 33% on farms 2 and 3, respectively), and the LCA values were higher on farm 01, less efficient in their digestion, with a higher production of methane and CO_2.

Table 6. Indicators of agro-environmental aspects, in terms of endurance and sustainability of the system (2019-2022)

INDEXES (2019-2022)	Values for the three farms		
	G01	G02	G03
Energy balance of all the systems in the LC (UCE = 10 000 MJ)[3]	1055	1177	1297
Energy intake by the herd/1000 kg of milk (Mcal)[2]	1080	1145	1242
Mortality and rejection of cows and adults (%)	0.7	1.6	1.03
Mortality of progeny as an indicator of herd endurance in time (%)	0.3	0.5	1.2
Increase in adult herd in this period (%)	17.2	10.8	8.3
Potential methane emission (kg CO2 eq. /10 000kg milk)[3]	10889	20108	21135
Global warming potential by GEI (EqCO2(1.2) /UCE)[3]	5.18	7.66	9.52

[1]The Ca and P balances were only for lactating cows. [2]This index was calculated for production and maintenance requirements [2]UCE=Energy converted Units, equal to 10 000 MJ.

As reported in several studies, such as Jiang and Sharp (2014) in New Zealand, on dairy farms in the USA (Berton *et al*., 2020) and Herron *et al.* (2022), a comparative study showed that more diversified farms were more efficient than specialized farms. As to energy indicators like energy balance, there is still a potential to convert more energy entering the system into more exit beneficial products at reasonable values, along with proper energy intake per 1000 milk kg. Efficient dairy systems produce less greenhouse gases per milk unit than the previous (less than 10 800 kg CO2-eq/10 000 kg of milk) (Berton *et al.,* 2020; Herron *et al.,* 2022).

According to IPCC (2019), Berton, *et al.* (2020), Carvalho *et al.* (2018) emissions derived from milk production in developed dairy regions are estimated between 1.2 and 1.4 kg of CO_2/kg, respectively. It is below the international mean (2.5 kg of CO_2 per milk kg, in terms of fat and protein, by grazing, including grazing on 80% of the land surface (Charlton *et al.,* 2019; FAO, 2021).

Concerning the contribution of methane and its CO_2 equivalence, the estimates could be reduced through proper systems, depending on the resources available to maximize its use, cut down on commercial feeds, and include species that enhance the ruminal environment, reducing ruminal methane, such as ribwort plantain (Batalla, 2022). It was demonstrated by the results of the study, investments on farms G01 and G03 including ribwort plantain (*Plantago lanceolata*), which is nutritionally favorable to the rumen, reduces digestive disorders like timpanisms and poisoning by oxalates and nitrates present in graminaceous under organic-mineral fertilizers, or their associations (Pérez Infante, 2010; Charlton *et al.,* 2019; Ruiz and Guevara, 2021; Batalla, 2022; Down, 2022). Various authors noted that milk production efficiency entails cost-effectiveness (Guevara, 1999; Pérez Infante, 2010; Charlton *et al.,* 2019; Ruiz and Guevara, 2021). Among the determining requisites for sustainability, according to Arcos *et al.* (2021), the most productive cow types with lower energy and other nutrient needs due to their low live weight, have a decisive role in achieving cost-effectiveness and efficiency of grazing systems.

Coinciding with our results, Herron *et al.* (2022) pointed out that by evaluating two types of pastures on different farms (1) an average updated dairy system based on spring parturition grass, and (2) a dairy system based on spring parturition grass that met the yielding goals set up for dairy systems (objectives), which used criteria like kilogram of milk corrected in fat and protein (MCFP) and by hectare. They found that the global warming potential was even more reduced (in 16.4%). Besides, the change from an updated dairy system to an objective system could reduce the environmental impact of FPCM kilogram (Ruiz and Guevara, 2021; Herron *et al.,* 2022).

In IDF (2015), they have shown adjustments to the LCA in the dairy sector. The LCA is now emerging faster, looking to make the Overall Standard of the Carbon Fingerprint of IDF for the Dairy Sector, become more updated and relevant. This site will serve as a place to gather relevant data to make IDF orientation more dynamic in terms of LCA and the Carbon Fingerprint. Recently, LCA studies have been conducted in Brazil, on milk and dairy products from buffalo cows and goats (Cabral *et al.*, 2020). Moreover, Ruviaro *et al.* (2020) used the life cycle perspective to evaluate the costs of production systems in the south of Brazil. The value found in the present study for a semi-intensive system led to animal enclosures for the supply of commercial feeds, was relatively lower than the ones found by González-Quintero *et al.* (2021), whose emissions ranged between 2.1 and 4.2 kg CO_2-eq, using a feeding strategy based on grazing. These authors observed that on farms with different feeding systems, the amount of CO_2-eq was significantly higher in the pure grazing systems than in enclosed systems.

On the contrary, the value was higher than the reports of Rotz *et al.* (2020), between 0.86 and 1.17 kg of CO_2-eq by FPCM kilogram, on representative farms in different regions of Pennsylvania, USA. The land needs were lower than in the study done by Berton *et al.* (2020), found in Italian dairy systems. The significant inclusion of pastures in the land was also reported by Rotz *et al.* (2020); Herron *et al.* (2022), who cited fodder production as a contributing flow.

Management to mitigate farm methane emissions could be reduced even more through diet strategies practices using other forage plants (Llantén, Achicoria, Colza, Nabo, and Morera).

In Scotland and Europe, the cattle industry needs to reduce greenhouse emissions urgently, to meet the ambitious political goals of climate change (Orskov, 2005; IPCC, 2019; Finnegan and Goggins, 2021). Carvalho *et al.* (2018); IPCC (2019); Berton *et al.* (2020), and Finnegan and Goggins (2021), reported that emissions derived from milk production in developed dairy regions, such as the United Kingdom and Continental Europe are estimated between 1.2 and 1.4 kg of CO_2/kg, (Berton *et al*., 2020). Finnegan and Goggins, (2021); Carvalho *et al.* (2018); Charlton *et al.* (2019), and Drews *et al.* (2020) suggested the establishment of a system with less CO_2 emissions per unit or management type, where diet digestibility is related to the chemical composition of the feed and water intake (Charlton *et al.,* 2019; Drews *et al.,* 2020).

Table 7 shows the total costs and variables per farm, income, and cost-effectiveness. Greater milk/cow volumes on farm G01 increased the amount of milk per farm and their cost-effectiveness. Farm G01 reached cost-effectiveness (almost 36%), higher than G02 and G03. The latter, with the lowest value, (close to 20%), due to better use of the grassland (ribwort plantain), with greater nutritional value, less NDF, and more energy (Orskov, 2005; Arcos *et al.,* 2021; Ruíz and Guevara, 2021; Batalla, 2022).

Table 7. Expenses, income (USD), and cost-effectiveness (%) on each farm during the four years (mean values adjusted to the 2019-2022 period

Indexes (2019-2022)	G01	G02	G03
Total farm expenses[1]	20 415	18176	19 425
Farm variable expenses[2]	19 118	17279	19 129
Total farm income[3]	27 273	23 814	23 201
Net income[4]	6858	5638	3776
Cost-effectiveness (%)[5]	35.91	32.63	19.74

[1,2,3]**The overall expenses, variables, and overall annual incomes (USD) were collected from farmer communications, in their records and accounting books, through cattle consulting.** [4,5]The net income and cost-effectiveness were calculated according to **Luening (2010).**

CONCLUSION

Several aspects of the life cycle analysis matched indicators from more specialized dairy systems, such as yields, nitrogen, energy, and mineral balances, and their relations with milk production, the environment, and global warming emissions. However, some indexes offer a space to recover efficiency through improved management with no need to use extra supplies on the farms.

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AUTHOR CONTRIBUTION STATEMENT

Research conception and design: CSTI, GEGV, RVGV, PJLA, JSFR, CNAA; data analysis and interpretation: CSTI, GEGV, RVGV, PJLA, JSFR, CNAA; redaction of the manuscript: CSTI, GEGV, RVGV, PJLA, JSFR, CNAA.

CONFLICT OF INTEREST STATEMENT

The authors state there are no conflicts of interest whatsoever.