REUNIR:
Magazine of Administration, Accounting and Sustainability
www.reunir.revistas.ufcg.edu.br
ISSN: 2237-3667

ORIGINAL ARTICLE: Submitted in: 11.28.2022. Validated on: 02.25.2024. Apt for publication in: 03.30.2024. Responsible Organization: UFCG.

Organic cow milk: impacts on environmental sustainability

Leite orgânico de vaca: impactos na sustentabilidade ambiental

Leche de vaca ecológica: impactos en la sostenibilidad Ambiental

Carlos Candidoda Silva Cyrne
Universidade do Vale do Taquari – Univates
Av. Avelino Talini, 171 – Universitário – Lajeado – RS
https://orcid.org/0000-0002-1025-1685
cyrne@univates.br

Júlia Elisabete Barden
Universidade do Vale do Taquari – Univates
Av. Avelino Talini, 171 – Universitário – Lajeado – RS
https://orcid.org/0000-0002-9818-1844
jbarden@univates.br

Fernanda Cristina Wiebusch Sindelar
Universidade do Vale do Taquari – Univates
Av. Avelino Talini, 171 – Universitário – Lajeado – RS
https://orcid.org/0000-0003-3138-7386
fernanda@univates.br

Rafaela Danieli
Universidade do Vale do Taquari – Univates
Av. Avelino Talini, 171 – Universitário – Lajeado – RS
https://orcid.org/0000-0002-9061-7252
rafaela.danieli@universo.univates.br

KEYWORDS
Cow. Dairy products
Sustainable.

Abstract: Livestock is recognized as one of the industries that contribute to environmental degradation, prompting exploration of alternative production methods such as organic, ecological, or biological approaches. This study aims to identify the environmental impacts resulting of organic cow milk production compared to conventional methods. Methodologically, it adopts an exploratory and descriptive approach through systematic literature review, utilizing defined and systematized search methods. The search was conducted on the Journal Portal of the Coordination for the Improvement of Higher Education Personnel (CAPES) covering the period from 2012 to 2022. The findings indicate that organic cow milk production yields fewer adverse environmental impacts compared to conventional production.

PALAVRAS-CHAVE
Vaca. Lácteos.
Sustentável.

Resumo: *A pecuária é apontada como uma das atividades que gera prejuízo ao meio ambiente, sendo assim, dentre as alternativas buscadas está a produção de forma orgânica, ecológica ou biológica. O objetivo é identificar os impactos para o meio ambiente decorrentes da produção de leite de vaca orgânico em comparação à produção convencional. Metodologicamente é um estudo exploratório, classificado como descritivo e realizado por meio de uma revisão sistemática da literatura aplicando métodos definidos e sistematizados de busca. A pesquisa foi realizada no Portal de Periódicos da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Capes) e compreendeu o período de 2012 a 2022. Os resultados encontrados apontam para o fato de que a produção* *de leite orgânico de vaca traz menos impactos negativos para o meio ambiente quando comparado com o sistema de produção convencional.*

PALABRAS CLAVE
Vaca. Productos lácteos Sostenible.

Resumen: *En este contexto, la dimensión ambiental está presente, pues la ganadería ha sido identificada como una actividad que genera grandes daños al medio ambiente. Este nuevo sistema de producción se denomina producción de leche de vaca orgánica, ecológica u orgánica. Este estudio tuvo como objetivo identificar si la producción de leche de vaca orgánica tiene menos impacto en la sostenibilidad ambiental que la producción convencional. Metodológicamente, es un estudio exploratorio, puede clasificarse como descriptivo y realizado a través de una revisión sistemática de la literatura, aplicando métodos de búsqueda definidos y sistematizados. Los resultados encontrados apuntan a que la producción de leche de vaca orgánica trae menos impactos negativos al medio ambiente en comparación con el sistema de producción convencional.*

Introduction

Legal requirements regarding agribusiness have undergone considerable increment in recent decades, seeing adjustments in the areas of production, health, and the environment. Consequently, one of the challenges that rural producers need to overcome is finding ways to increase the profitability of enterprises while remaining environmentally sustainable. This requires a management process that allows for the continuity of production activities with a less aggressive approach towards the environment (Cyrne, 2016).

Building upon the works of Duran, Gogan, Artene, and Duran (2015), Mensah and Casadevall (2019), and Nogueira (2019), it becomes possible to identify that the concern for environmental management is not a recent development and has been growing in importance, considering its possibilities, limitations, and even contradictions. In turn, this necessitates organizations to seek alternatives to remain competitive, paying attention to the "environmental variable" as a managerial tool that can sustain the pursuit for competitiveness as it contributes to improving societal wellbeing. A new perspective on environmental issues leads to viewing the environment as an opportunity rather than a problem.

In the last century, economic and technical progress led to negligence and deterioration of natural resources. The global economy, however, is structured on non-renewable resources with strong environmental impacts, exceeding the capacity of different ecosystems (Duran et al., 2015). The consequence of this is the emergence of a movement that seeks to mobilize society to pay attention to environmental problems.

In rural areas, environmental management plays a critical role in integrating agricultural practices with the conservation of natural resources, aiming for long-term sustainability. In this perspective, rural environmental management can be defined as the segment of rural administration dedicated to establishing, directing, and implementing environmental policy guidelines, armed with a sense of commitment and responsibility towards environmental preservation. These policies are essential to ensure that agricultural practices not only comply with current environmental legislation, but also promote continuous improvement of processes regarding the protection and conservation of natural resources (Nascimento, Nascimento, Hanke, Avila, & Silva, 2020).

The dairy cow production chain is characterized by the use of genetic improvements aimed at achieving higher productivity and greater profit. However, this model has been scrutinized regarding the impacts it can cause on the environment because, as Orlandini and Tortelly Neto (2020) state, livestock farming has been identified as an activity that generates significant environmental damage due to high concentration of waste corresponding to urine, feces, food residues, bedding leftovers, and hygiene and sanitation residues.

Dairy production is a complex process, involving the use of water, animals, plants, humans, land, among other factors, and "the balanced use of these resources is a condition that contributes, although not exclusively, to achieving business competitiveness" (Cyrne, Rempel, Haetinger, & Eckhardt, 2015; p. 181), but also the preservation of natural resources. Due to the intensification of production, the dairy industry worldwide is constantly confronted with issues such as water quality, energy consumption, greenhouse gas emissions, loss of biodiversity, antibiotic resistance, and animal health (Gomes et al., 2020; Guerci et al., 2013).

According to De Boer (2003), organic agriculture contributes to meeting public demand of reducing environmental pollution from agricultural production, as livestock farming is among the global industrial sectors with the highest environmental impact (Angerer, Sabia, von Borstel & Gauly; 2021; Scozzafa, Gerini, Boncinelli, Marone & Casini, 2020). Consumers consider organic foods to be healthier, of higher quality, and less harmful to the environment compared to conventional foods because they use fewer pesticides and artificial fertilizers (Bonnet & Bouamra-Mechemache, 2015). Organic agriculture is increasingly promoted to reduce the environmental impact of artificial fertilizers, pesticides, herbicides, and antibiotics in conventional dairy production systems (Gomes et al., 2020).

In this context, a new proposal emerges with the aim of obtaining a higher quality product which aligns with the interests of consumers. This new production system is called organic cow milk production, also known as ecological or biological production, and has been experiencing high rates of growth in both the numbers of producers and volume of product (Méndez & Pinilla, 2008).

Organic production is one that, through the use of soil conservation techniques and improvement of soil quality, favors the ecosystem. It enables the production of high nutritional quality foods without the use of chemical inputs, respecting the environment, and promoting environmental sustainability (COAG, 2006). Organic production also does away with genetically modified organisms, in addition to being concerned with animal welfare and consumer health (Rouco, 2004). Thus, "organic livestock farming is a production model that has simplicity and harmony with nature at its core, without neglecting productivity and profitability" (Aroeira et al., 2001, p. 437). According to agroecological techniques, dairy production accounts for the balance between socioeconomic and environmental aspects and has enabled the production of higher quality milk, offering an alternative for family farming properties to face large-scale, industrial production logic in agribusiness.

On the other hand, the sale of organic food and beverages exceeded 120 billion euros in 2020, according to the *Research Institute of Organic Agriculture* (FIBL) (2021). The countries with the largest organic markets were the United States (49.5 billion euros), Germany (15.0 billion euros), and France (12.7 billion euros). In this context, according to Liang, Sun, Wattiaux, Hedtcke, and Silva (2017), the demand for organic milk has recently surpassed available supply, which presents an opportunity for producers.

Therefore, this article aims to identify the environmental impacts or organic cow milk production compared to conventional practices.

Theoretical research elements

Environmental sustainability

According to Klarin (2018), mankind has negatively impacted the environment, jeopardizing the survival of Earth and future generations. Over time, however, humanity has become aware of these hazardous conditions, and behavioral changes have been prompted towards a more rational and efficient management of resources, leading to less environmental pressure and impact.

The discourse around sustainability became more prominent following the publication of "Silent Spring", authored by Carson and Polillo (1962), which exposed environmental contamination by toxic waste. In 1968, the Club of Rome was established, leading to the publication of 1972's "Limits to Growth" report, which highlighted the unfeasibility of the industrial model of growth. In the same year, the World Conference on the Environment was held in Sweden, where the Stockholm Treaty was signed, and the United Nations Environment Programme (UNEP) was created. In 1980, the Montreal Protocol aimed to discuss solutions to mitigate the depletion of the ozone layer.

Subsequently, other discussions involving economic and social issues were conducted in pursuit of more sustainable conditions. Significant moments include the 1992 United Nations Conference on Environment and Development (also known as the Earth Summit) in Rio de Janeiro, Brazil; the 1997 Conference of the Parties in Kyoto, Japan; the Rio+10 Summit in Johannesburg, South Africa, in 2002; and the United Nations Conference on Sustainable Development, Rio+20, held again in Rio de Janeiro in 2012, among many other important discussions held worldwide (Sugahara & Rodrigues, 2019; Hopwood, Mellor & O'brien, 2005; Santos, Braga, Santos & Braga, 2012).

Duran et al. (2015) and Klarin (2018) present synoptic tables with the various definitions of sustainable development proposed over the years, highlighting the complexity around the term and echoing the idea that it is a multidimensional and controversial concept, subjective to different approaches (Santos et al., 2012; Oliveira, 2002; Hopwood et al., 2005; Mensah & Casadevall, 2019; Rosen, 2017).

To Sartori, Latrônico, and Campos (2014), sustainability can be described as a process and mechanism to achieve sustainable development, while Olawumi and Chan (2018) define sustainability as a process of intentional change and improvement. Although both terms (sustainability and sustainable development) are frequently used interchangeably, distinctions are made between them at other times.

When one seeks to observe the similarities between the works of these authors, it becomes noticeable that both Duran et al. (2015) and Klarin (2018) emphasize the multidimensional nature of sustainable development; such characteristic is also implicit in the definitions used by Sartori, Latrônico, and Campos (2014) and Olawuni and Chan (2018). This indicates a general recognition that both sustainability and sustainable development encompass social, economic, and environmental aspects. The authors acknowledge the complex and controversial nature of these concepts. Literature further suggests that there is no single understanding or approach, reflecting a plurality of views and interpretations. It is clear that, in certain contexts, the terms are used interchangeable. In this study, both concepts are considered synonymous.

While Duran et al. (2015) and Klarin (2018) focus on offering an overview of the various definitions of sustainable development over time, Sartori, Latrônico, and Campos (2014) and Olawumi and Chan (2018) discuss sustainability in a more focused manner, describing it as a process or mechanism to achieve sustainable development. This difference in conceptual focus suggests a divergence in the prioritization of terms and approach to them.

Sartori, Latrônico, and Campos (2014) and Olawumi and Chan (2018) view sustainability as a continuous process of change and improvement, contrasting with the more static approach to sustainable development by Duran et al. (2015) and Klarin (2018), who tend to present sustainable development as a goal or state to be achieved.

The environmental issue has grown in importance in all branches of economic activity; in dairy production, it is no different (Pirlo & Lolli, 2019), as the activity needs to strive for a status and performance that allow for its (sustainable) continuity. For the agricultural sector, "sustainable" is used to define practices that comprise integrated systems of animal and plant production under specific local conditions that can continue in the long term (Arcuri & Berndt, 2015). According to Galloway, Conradie, Prozesky, and Esler (2018), addressing sustainability implies considering the trade-off between production and environmental impact, as there is often a conflict between economic growth and environmental preservation, especially in the last 30 years given the need for increased production.

Tomich, Pereira, and Paiva (2016, p. 384) consider that "among the challenges that the livestock sector faces are those related to the pressing need to address environmental issues so that productive systems become environmentally adequate, as well as technically efficient, economically viable, and socially accepted." The environmental adequacy and the integration of this productive system are necessary for it to endure in time and space as an activity capable of promoting a higher quality of life (Kayser, 2015).

Dairy cattle farming mobilizes millions of people throughout the country, most of which are family properties. It is necessary to ensure the ecological foundations under which it can sustain itself to remain economically profitable and capable of producing or distributing wealth and promoting social justice (Kayser, 2015).

Organic cow milk

According to Oliveira et al. (2014), one of the challenges in agricultural sciences is to maintain agricultural production at levels that can sustain a growing population without contributing to increased environmental degradation and aggression. Dairy cattle farming is one of the most complex production systems involving a dynamic relationship between man-soil-water-animal-environment (Santos, 2008).

Worldwide, dairy farming has significant socioeconomic importance, with an estimated production of 718,038,443 tons/year in 2020 (FAO, 2022). Brazil is the third largest milk producer in the world, behind only the United States and India, according to data from the United Nations Food and Agriculture Organization (FAO, 2019). According to Muñoz, Soares, Brisola, Junqueira, and Pantoja (2022), considering the increasing demands for product quality, food safety, societal well-being, and environmental sustainability, it is necessary to consider the possibility of implementing production systems different from traditional/conventional models.

Organic agriculture, according to the IFOAM (2008), is based on four fundamental principles: health, ecology, fairness, and care. These principles express the contribution that organic agriculture can offer to the world, as well as a vision to improve all agricultural practices in a global context. The principles are interconnected and serve as inspiration for the organic movement in its diversity, guiding the development of positions, programs, and standards. The system, meanwhile, combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and good quality of life for all involved (IFOAM, 2008).

The organic production system, aligned with the principles of agroecology, excludes the use of synthetic substances such as pesticides, chemical medicines, genetically modified organisms, and artificial fertilizers, standing out for its concern for the preservation of natural resources. This approach emphasizes the importance of agricultural practices that respect natural cycles, contributing to environmental sustainability. In view of this, there is a need to address challenges to the expansion and strengthening of these practices, aiming not only at environmental health, but also their economic viability and food security as a goal on global scale.

Some challenges need to be overcome when it comes to organic cow milk production, including: ensuring quality and sanitation, which requires extra care in management; producing milk free from biological and chemical hazards without the use of artificial inputs; overcoming the decline in animal productivity, despite their increased longevity; producing food in the quantity and quality required, preferably on the farm itself; and facing logistical challenges in distribution, mainly due to the small scale of production.

In recent years, consumer demand for organic food has increased significantly worldwide (Scozzafava et al., 2020). Given this, the global market for organic dairy is expanding, emphasizing that organic dairy products are vital in addressing consumer concerns regarding sustainability (Soares, Sales, Sousa, Malaquias & Rodrigues, 2015).

It is this context that organic cow milk production is inserted. According to the FIBL, approximately 8.1 billion liters of organic cow milk were produced in 2017, which accounted for around 1% of the total milk volume produced that year. The largest producers were the United States (26.1%), China (10.9%), Germany (10.3%), France (7.7%), Denmark (7.0%), and the United Kingdom (5.1%).

According to Machado, Castro, Magalhães Júnior, and Pires (2021, p. 19), "in Brazil, organic cow milk production is an incipient activity still in expansion stage", but the country has "potential to expand organic milk production, as pasture-based production systems are predominant in the country" (Machado et al., 2021, p. 20), which is one of the requirements for organic certification.

To be considered "organic", the cow milk production process must follow specific regulations of each country, including actions that promote animal welfare by respecting natural behavior, herd health without the use of antibiotics, favoring the use of herbal and homeopathic remedies; feed produced with GMO-free inputs and preferably produced on the farm; good management practices; among others (Machado et al., 2021). After presenting the theoretical considerations that underpin this study, the discussion moves onto our findings.

Methodological research elements

Methodologically, this is an exploratory study conducted with the purpose of familiarizing researchers with the topic, and it can be classified as descriptive in terms of its objectives. In terms of technical procedures for data collection aimed at identifying studies on organic milk production and its environmental impacts, a systematic literature review was conducted. This type of review allows for finding studies on a specific topic by applying well-defined and systematized search methods. Following Galvão and Ricarte (2020), the sequence of steps was defined as follows: a) delimitation of the issue to be addressed in the review; b) selection of bibliographic databases for consultation and material collection; c) selection of texts and systematization of information found, including a set of inclusion and exclusion criteria; d) analysis, synthesis, and dissemination of the results.

Given the theme of organic milk production and its implications for the environmental sustainability of said practice, in the first stage, our investigative question was "Does organic cow milk production have less impact on environmental sustainability than conventional production methods?" In the second stage, the *Portal Periódicos* of the Coordination for the Improvement of Higher Education Personnel (CAPES), which provides access to databases through an agreement with the University, was chosen as the data source. The initial search term used was "*Comparing environmental impacts of conventional and organic milk*", resulting in the selection of 26 scientific articles. In the third stage, it was decided to include only peer-

.

reviewed articles published between 2012 and 2022, resulting in 24 articles; three were excluded due to being written in Slovak, Norwegian, and Czech, totaling 21 articles eligible for analysis. Additionally, though Google Scholar, publications addressing Brazilian cases studies of organic milk production were sought. The results are presented in Table 1, which includes the title, objective, authors of the article, year of publication, and initial analysis: whether they addressed organic milk production or not.

To achieve the proposed objective, efforts were made to locate studies addressing dairy cow milk production and environmental sustainability. Table 1 presents the list of references used for this analysis.

Table 1
Selected manuscripts

Idt	Article	Objective	Authors	Year	Organic Milk Production Yes/No
A	The carbon footprint of milk during the conversion from conventional to organic production on a dairy farm in central Germany	To estimate GHG emissions associated with milk production in a large dairy farm in Germany during the conversion from conventional to organic milk production.	Gross, Bromm, Polifka, Schierhorn	2022	Yes
B	Environmental impacts of transition from conventional milk production to organic production	To evaluate the environmental impacts of the transition to organic milk production practices.	Soares, Sales, Sousa, Malaquias, Rodrigues	2021	Yes
C	Environmental and biodiversity effects of different beef production systems	To examine the environmental impact of different organic and conventional beef production systems in South Tyrol (Italy) and to compare their environmental impact and effect on biodiversity under Alpine production conditions.	Angerer, Sabia, von Borstel, Gauly	2021	No
D	Dairy Farms and Life Cycle Assessment (LCA): The Allocation Criterion Useful to Estimate Undesirable Products	To estimate the environmental impact of three dairy farms operating with different farming systems, namely conventional (CON), organic (ORG), and high quality (HQ).	Romano, Roma, Tidona, Giraffa, Bragaglio	2021	Yes
E	Redução de impactos ambientais gerados pela bovinocultura de leite: revisão bibliográfica	To point out some of the consequences generated by milk production systems, as well as possible alternatives to minimize these impacts.	Orlandini e Tortelly Neto	2020	No
F	Estado da arte da produção de leite orgânico: revisão sistemática da literatura	To characterize the current state of scientific studies focused on organic milk production, seeking to identify the most studied areas, techniques, and possible research gaps.	Sales, Soares, Pantoja, Junqueira	2020	No
G	Organic farming as a strategy to reduce carbon footprint in Dehesa agroecosystems: a case study comparing different livestock products	To analyze the impact of organic livestock farming on pastures by analyzing and reviewing the carbon footprint of seven extensive organic farming systems on various pastures in southwestern Spain.	Horrillo, Gaspar, Escribano	2020	No
H	The importance of including soil carbon changes, ecotoxicity and biodiversity impacts in environmental life cycle assessments of organic and conventional milk in western Europe	To investigate the magnitude of including several impact categories in a comprehensive environmental impact assessment of organic and conventional dairy systems that differ in basic production conditions.	Knudsen, Dorca-Preda, Djomo, Peña, Padel, Smith, Zollitsch, Hörtenhuber, Hermansen	2019	Yes
I	Environmental impact of milk production from samples of organic and conventional farms in Lombardy (Italy)	To assess the impact of organic milk production on global warming potential (GWP), acidification potential (ACP), and eutrophication potential (EUP) in comparison with the impact of conventional milk production systems.	Pirlo e Lolli	2019	Yes
J	Impactos ambientais, sociais e econômicos da conversão para a produção de leite orgânico em propriedades familiares na Bacia Hidrográfica do Rio Paraná III	To assess the sustainability of the conversion to organic milk production in the Paraná III River Basin, by analyzing the social, environmental, and economic impacts observed by local producers.	Campos, Soares, Junqueira, Rodrigues, Malaquias	2018	Yes
K	Making Conventional Agriculture Environmentally Friendly: Moving beyond the Glorification of Organic Agriculture and the Demonization of Conventional Agriculture	To review the latest research around this critical debate, questioning the claims of absolute environmental superiority of organic farming.	Tal	2018	No
L	Effect of feeding strategies and cropping systems on greenhouse gas emission from	To estimate the effect of different feeding strategies and associated crop production	Liang, Wattiaux, Hedtcke, Silva	2017	No

.

	Wisconsin certified organic dairy farms	on greenhouse gas (GHG) emissions from certified organic dairy farms in Wisconsin, USA.			
M	Low-input dairy farming in Europe: Exploring a context-specific notion	To empirically examine, across the EU, the farm structure, production intensity, and productivity of low-input (LI) farming in relation to its conventional high-input (HI) counterpart and to organic dairy production (ORG).	Bijttebier, Hamerlinck, Moakes, Scollan, van Meensel, Lauwers	2017	No
N	Animal Board Invited Review: Comparing conventional and organic livestock production systems on different aspects of sustainability	To provide a systematic overview of the differences between conventional and organic livestock production systems over a wide range of sustainability aspects and animal species available in peer-reviewed literature.	Van Wagenberg, Hass, Hogeveen, Krimpen, Meuwissen, Van Middelaar, Rodenburg	2017	Yes
O	Nitrogen flows on organic and conventional dairy farms: a comparison of three indicators	To analyze nitrogen (N) flows on organic and conventional dairy farms in Sweden and compare three indicators for N pollution associated with milk production: (1) the farm-gate N surplus, (2) the chain N surplus, and (3) the N footprint.	Einarsson, Cedeberg, Kallus	2017	No
P	Environmental assessment of small-scale dairy farms with multifunctionality in mountain areas	To estimate the environmental impact of organic and conventional small-scale dairy farms in mountain areas.	Salvador, Corazzin, Piasentier, Bovolenta	2016	Yes
Q	Sustainability of milk production in the Netherlands, and A comparison between raw organic, pasteurised organic and conventional milk	To evaluate the sustainability of different types of dairy products using a pre-defined transparent approach, considering the entire production chain.	van Asselt, Capuano, van der Fels-Klerx	2015	Yes
R	Impactos ambientais da transição entre a produção de leite bovino convencional para orgânico na Região Integrada de Desenvolvimento do Distrito Federal e entorno – RIDE/DF	To evaluate the environmental impacts of adopting an organic cattle milk production system in seven family production units in the Integrated Region of the Federal District and Surrounding Area (Brazil).	Soares, Sousa, Malaquias, Rodrigues, Borba Junior	2015	Yes
S	Avaliação da gestão ambiental em pequenas propriedades produtoras de leite no Vale do Taquari a partir do uso da matriz importância x desempenho	To contribute to the management of small dairy farms by focusing on environmental aspects.	Cyrne, Rempel, Haetinger, Eckhardt	2015	No
T	Organic label, bargaining power, and profit-sharing in the French fluid milk Market	To determine how the value-added created by an organic label is shared in a vertical chain among manufacturers and retailers.	Bonnet, Bouamra-Mechemache	2015	No
U	Environmental impacts of organic and conventional agricultural products – are the differences captured by cycle assessment?	To show how LCA can be improved to better differentiate products from different agricultural systems.	Meier, Stoessel, Jungbluth, Juraske, Schader, Stolze	2015	No
V	Impactos ecológicos e socioambientais da transição agroecológica para produção orgânica de leite em Sidrolândia-MS	To assess the ecological and socio-environmental impacts of the agroecological transition to organic milk production in Sidrolândia, Mato Grosso do Sul, Brazil, using the AMBITEC method.	Oliveira, Muniz, Soares, Carbonari, Carbonari, Gabriel, Padovan, Rezende, Gandra	2014	Yes
W	Comparing direct land use impacts on biodiversity of conventional and organic milk—based on a Swedish case study	To quantify and compare the direct impacts of land use on biodiversity of organic and conventional food products such as milk.	Mueller, Baan e Koellner	2014	Yes
X	Energy use and greenhouse gas emissions in organic and conventional farming systems in the Netherlands	To present the results of a model study on energy use and GHG emissions in Dutch organic and conventional farming systems.	Bos, Haan, Sukkel, Schis	2014	Yes
Y	Farm- and product-level biodiversity assessment of conventional and organic dairy production in Austria	To address the methodological shortfall by presenting a novel, farm-level approach to assess the species diversity potential of agricultural land of different agricultural production systems, and to extend the assessment to product level.	Schader, Drapela, Markut, Meier, Lindenthal, Hörtenhuber e Pfiffner	2014	Yes
Z	Parameters affecting the environmental impact of a range of dairy farming systems in Denmark, Germany and Italy	To evaluate the environmental impact of different farming systems across Europe and identify the parameters that most strongly affect environmental performance for six impact categories of strategic importance to dairy farmers.	Guerci, Knudsen, Bava, Zucali, Schönbach, Kristensen	2013	Yes
AA	Organic Production Enhances Milk Nutritional Quality by Shifting Fatty Acid Composition: A United States–Wide, 18-Month Study	To identify whether organic production improves the nutritional quality of milk by altering the composition of fatty acids.	Benbrook, Butler, Latif, Leifert, Davis	2013	No
AB	Proposta metodológica de avaliação da sustentabilidade ambiental de propriedades produtoras de leite	To present a methodological approach for assessing the environmental sustainability of dairy farms.	Rempel, Eckhardt, Jasper, Schultz, Hilgert, Barden	2012	No

.

AC	Greenhouse gas emissions from life cycle assessment of Norwegian food production systems	To evaluate GHG emissions and land use associated with the production of milk, meat, grain, and potato in conventional and organic production systems, comparing crop and meat production,	Refsgaard, Bergsdal, Berglann, Petersen	2012	No

Source: The authors (2022).
Legend: Idt – Article ID

Subsequently, a detailed reading of the articles was conducted, employing content analysis as a methodology for qualitative data analysis. The result of this analysis is depicted in Table 2, which provides a visualization of the indicators evaluated in each of the texts, indicating whether the impact of organic production is favorable or not for environmental sustainability when compared to conventional methods.

A total of 16 studies were analyzed, which presented the combination of organic milk and environmental sustainability, while the other three addressed at least one of the terms.

Results and Discussion

The textual analysis focused primarily on identifying the possible indicators addressed by the authors in their studies. Alphabetical coding was used to allow readers to identify which article later inferences will be referring to. As depicted in Table 2, the scope of analysis is broad: a single article (H) covers seven indicators, while the use of indicators could not be clearly identified in others (such as articles J, O, and R). For articles J and R, indicators were presented in combination with other dimensions comprising an index, making comparison unfeasible.

Table 2
Assessed indicators and the impact of organic production on environmental sustainability compared to conventional production

Article	Indicator							
	Biodiversity	Use of pesticides	Land use	Use of non-renewable energy	Eutrophication	Acidification	Greenhouse gas emissions	Impact on landscape
A							▼	
B	▼		▲	▼			▼	
D			▲	▼	▲	▼	■	
H	▼	▼	▲	▼	■	■	■	
I					▼	▼	▼	
J								
N	▼	▼	▲	▼	■	■		
O								
P					▼	▼	▼	
Q	▼	▼		▼	▼	▲	▼	
R								
V								
W	▼		▲					
X				▼			▼	
Y	▼							
Z	▼		▲	▼	▼	▼	▼	

Source: The authors
Legend: ▼: Lower impact; ▲: Higher impact; ■: Stable

In relation to the individual indicators addressed in the texts, there is a narrower scope, with the prevalence of analyses on greenhouse gas emissions, acidification, eutrophication, biodiversity, land use, and pesticide use. On the other hand, it is noteworthy that none of the texts included landscape impacts in their analysis, and the motivation for not considering this indicator could not be identified.

If one understands biodiversity as the diversity of life, the variety, and the multiplicity of living beings on the planet, it is important to comprehend that living beings coexist in an interdependent relationship within food chains, and the elimination of any link causes an imbalance that brings environmental, social, and economic damages. A meta-analysis comparing the biodiversity of organic and conventional farms found that the prior generally have 30% more species richness and 50% more organism abundance than conventional farms (Bengtsson et al., 2005 *apud* Tuomisto, Hodge, Riordan, & Macdonald, 2012). Similarly, Van Wagenberg et al. (2017), as well as Gross, Bromm, Polifka, and Schierhorn (2022), state that biodiversity assessment studies have found that the impact per unit of milk is lower in organic systems compared to conventional production systems, despite the larger land areas required.

Mueller, Baan, and Koellner (2014), much line Pirlo and Lolli (2019), suggest that although organic cow milk requires about twice as much land use compared to conventional production, it has lower direct impacts on biodiversity. Pirlo and Lolli (2019) further reinforce that the environmental impact of organic cow milk production is more favorable than conventional systems regarding land use. According to the authors, this is explained by the absence of pesticides and synthetic fertilizers (Knudsen et al., 2019; Van Wagenberg et al., 2017), lower stocking rates per hectare, and a better balance between cutting, grazing, and level of external inputs applications in organic production systems.

Although organic cow milk requires about twice the amount of agricultural land to produce 1 kg of milk, the impact of land occupation by animals in organic milk production was only half that of conventional milk. Additionally, the different composition of raw materials, with larger portions of roughage and pasture in organic farms, and larger portions of concentrated feed in conventional ones, significantly influence this outcome (Mueller, Baan & Koellner, 2013).

As for soil quality, improvement is achieved by excluding the use of fertilizers and pesticides (Knudsen et al., 2019), which are replaced by organic fertilizations produced, preferably, on the farm itself. Another favorable aspect of organic production is a lower stocking rate, with fewer cattle per hectare, resulting in less soil compaction.

With the maintenance of permanent preservation areas and legal reserves, and with minimal soil disturbance under pasture, there are gains in terms of lower energy consumption, lower gas emissions, and biodiversity conservation (Oliveira et al., 2014; Soares, Sousa, Malaquias, Rodrigues, & Borba Junior, 2021; Pirlo & Lolli, 2019).

Soares et al. (2021) found lower emissions of air and water pollutants, soil contaminants, and food residues when agroecological principles were applied. The best pro-organic performance was found regarding waste disposal indicators; however, in chemical input management, a quasi-equal condition was observed. Regarding animal health and welfare, as well as intrinsic milk quality, the authors did not find significant differences between the two production systems. When comparing conventional farms and those undergoing transition to organic production after a two-year follow-up, the authors observed an evolution, stating that "the adoption of organic production practices tends to be beneficial for the environment" (Soares et al., 2021, p. 58).

In terms of energy consumption, fossil-based energy consumption per unit of milk is lower in organic production (-29%) compared to conventional systems (Romano, Roma, Tidona, Giraffa & Bragaglio, 2021; Knudsen et al., 2019; Guerci et al., 2013). This was explained by the absence of synthetic fertilizers and a relatively low use of concentrates. Both the production and transportation of concentrates are significant contributors to energy consumption (Van Wagenberg, et al., 2017).

Bos, Haan, Sukkel, and Schis (2017) assert that energy consumption per unit of milk in organic dairy farms is approximately 25% lower than in conventional ones, while GHG emissions are 5 to 10% lower. Although the percentage may vary, the findings reported by Gross, Bromm, Polifka, and Schierhorn (2022), Salvador et al. (2016), and Guerci et al. (2013) all point in the same direction. However, Knudsen et al., (2019) found identical results between the two production systems, while the study conducted by Pirlo and Lolli (2019) reported that the farms in their sample did not differ in their consumption of fossil fuels and energy.

The lower energy consumption by organic farms can be explained by the reduced use of imported concentrates and the absence of mineral fertilizers. In line with this, Tuomisto, Hodge, Riordan, and Macdonald (2012) state that, in their studies, the average energy consumption was found to be 21% lower in organic agriculture systems per unit of product compared to conventional production.

When it comes to eutrophication and global warming potential (greenhouse gas emissions), findings diverge regarding whether organic cow milk has any significant advantage in terms of environmental sustainability impacts compared to conventional milk. (Mueller, Baan, & Koellner, 2014; Pirlo & Lolli, 2019). Pirlo and Lolli (2019), Van Wagenberg et al., (2017), Salvador, Corazzin, Piasentier, and Bovolenta (2016), and Guerci et al. (2013) argue that organic systems generally show lower eutrophication potential per unit of milk due to the absence of synthetic fertilizers and lower levels of nitrogen and phosphorus fertilization.

In terms of acidification, the studies analyzed by Van Wagenberg et al., (2017) identified that the acidification potential was higher (9%) in organic systems than conventional ones. This finding was corroborated by the results presented by Pirlo and Lolli (2019), Salvador et al. (2016), and Guerci et al. (2013). However, Van Wagenberg et al. (2017) argue that the effects are similar, with a slight advantage for the organic production system.

Soares et al. (2021), Campos, Soares, Junqueira, Rodrigues, and Malaquias (2018), and Oliveira et al. (2014) studied environmental impacts using the ecological and socio-environmental impact assessment system for agricultural technological innovations (Ambitec-Agro), developed by Embrapa Meio Ambiente. By comparing the indices of Ecological and Socio-Environmental Impacts of milk production across conventional and organic methods, they found that each exhibits significant values distinctively, as indices present both positive and negative values. "It was observed that out of the 25 analyzed indicators, 19 obtained values that contributed to the improvement of the transition from conventional to organic" and "[…] the results indicate that the transition from conventional to organic management proves to be efficient based on the socio-environmental and ecological impact indices" (Oliveira et al., 2014, p. 5).

The same authors found that the use of veterinary inputs, water quality, and environmental recovery show a reduction in the transition indices from conventional to the organic system, as conventional production makes intensive use of chemical products (Oliveira et al., 2014).

Some of the results that point to the environmental advantages of organic cow milk production raise questions, as put by Guptill (2009), about a possible "conventionalization" of organic cow milk production due to regulatory and market conditions, as small-scale enterprises may be conditioned to adopt practices consistent with the industrial model under competitive pressures. The author further problematizes not whether new producers are committed or not, but whether the system as a whole will allow the social and ecological practices that the organic movement promoted during its inception. Mueller, Baan, and Koellner (2014) state that some consider organic production as a solution for "environmentally friendly" food production, while for others, it is an inefficient and resource-intensive production system, so it would not make sense to forego conventional production methods.

Many generalizations about the superior environmental results of organic agriculture do not withstand rigorous evaluation, as there is a tendency on both sides of the organic/conventional divide to caricature the other and choose extreme examples of environmentally problematic practices (Tal, 2018).

Concluding Remarks

The environmental impact associated with dairy farming is generally related to the use of natural resources, energy, use of external inputs, and the generation of waste with pollutant potential. Both confined and pasture-based systems production can generate impacts and can be considered environmentally suitable depending on the intensity of the technologies adopted (Tomich, Pereira & Paiva, 2016).

This study aimed to identify the environmental impacts of organic cow milk production compared to conventional production. Through the conducted research, it is possible to affirm that organic cow milk production has fewer negative impacts on environmental sustainability compared to conventional production systems. Among the studies analyzed in this work, the advantages predominated over possible disadvantages; however, it is important to note that there are relevant similarities in both production systems.

As a limitation of the research, it should be noted that differences in economic and social performance were not considered, and these dimensions could be subject of future studies. Another limitation concerns the choice of the scientific database for data collection, as well as the criteria for including and excluding articles from this review. Additionally, it should be considered that a limited number of studies were analyzed, although they converged in most of their findings and conclusions.

Acknowledgments: We would like to express our gratitude to CNPq for the financial support provided for this research through the Edital Universal, as well as to the University of Vale do Taquari (Univates).

References

Angerer, V., Sabia, E., Von Borstel, U. K. & Gauly, M. (2021). Environmental and biodiversity effects of different beef production systems. *Journal of Environmental Management,* 289. DOI: https://doi.org/10.1016/j.jenvman.2021.112523

Arcuri, P. B. & Berndt, A. (2015). Uma visão internacional da sustentabilidade na pecuária leiteira. In: MARTINS et. al. *Sustentabilidade ambiental, social e econômica da cadeia produtiva do leite: desafios e Perspectivas* (pp. 169-187). Brasília, DF.

Aroeira, L. J. M., Carneiro, J., Paciullo, D. S. C., Fernandes, E. N., Xavier, D. F., Furlong, J. & Alvim, M. J. (2001). Tecnologias para a produção orgânica de leite. In: Madalena, F. E; Matos, L. L; Holanda Jr, E. V. (Org). *Produção de Leite e Sociedade* (pp. 435-449). Belo Horizonte.

Benbrook, C. M., Butler, G., Latif, M. A., Leifert, C. & Davis, D. R. (2013). *Organic Production Enhances Milk Nutritional Quality by Shifting Fatty Acid Composition*: A United States–Wide, 18-Month Study. PLoS ONE. DOI: https://doi.org/10.1371/journal.pone.0082429

Bijttebier, J., Hamerlinck, J., Moakes, S., Scollan, N., Van Meensel, J. & Lauwers, L. (2017). Low-input dairy farming in Europe: Exploring a context-specific notion. *Agricultural Systems*, 156, 43-51. DOI: http://dx.doi.org/10.1016/j.agsy.2017.05.016

Bonnet, C., & Bouamra-Mechemache, Z. (2015). Organic label, bargaining power, and profit-sharing in the french fluid milk Market. *Amer. J. Agr. Econ*., 1-2. DOI: https://doi.org/10.1093/ajae/aav047

Bos, J. F. F. P., Haan, J. De, Sukkel, W. & Schils, R. L. M. (2014). Energy use and greenhouse gas emissions in organic and conventional farming systems in the Netherlands. *NJAS-Wageningen Journal of Life Sciences*, 68, 61-70. DOI: http://dx.doi.org/10.1016/j.njas.2013.12.003

Campos, M. B. N., Soares, J. P. G., Junqueira, A. M. R., Rodrigues, G. S. & Malaquias, J. V. (2018, julho). Impactos ambientais, sociais e econômicos da conversão para a produção de leite orgânico em propriedades familiares na Bacia Hidrográfica do Rio Paraná III. *Cadernos de Agroecologia - Anais do VI CLAA, X CBA e V SEMDF*, 13(1).

Cardoso, A. S. & Santos Jr, R. A. O. (209). Indicadores de sustentabilidade e o ideário institucional: um exercício a partir dos ODM e ODS. *Ciência e Cultura*, 71(1), 50-55. DOI: http://dx.doi.org/10.21800/2317-66602019000100014

Carson, R. & Polillo, R. (1962). *Primavera silenciosa* (2a. ed.). São Paulo: Melhoramentos.

Coordinadora de Organizaciones de Agricultores y Ganaderos [COAG]. (2006). *De la producción agraria convencional a la ecológica*. Madrid.

Cyrne, C. C. S., Rempel, C., Haetinger, C., & Eckhardt, R. R. (2015). Avaliação da gestão ambiental em pequenas propriedades produtoras de leite no Vale do Taquari a partir do uso da matriz importância x desempenho. *Redes – Revista do Desenvolvimento Regional*, 20(2), 176-194. DOI: https://doi.org/10.17058/redes.v20i2.3724

Cyrne, C. C. S. (2016). *Indicadores de gestão em propriedades produtoras de leite – Um modelo a partir do comparativo entre as propriedades do Vale do Taquari – RS e da Galícia – Espanha*. Novas Edições Acadêmicas: Saarbrücken, Deutschland.

Cyrne, C. C. S., Sindelar, F. C. W., Buttenbender, B. N., Gausmann, E., Barden, J. E., & Flach, D. H. (2021). A política nacional de resíduos sólidos e a logística reversa como aliadas da sustentabilidade. In: Rempel, Claudete; Turatti, L. & Dalmoro; M. (Org.). *Desafios da Sustentabilidade.* Lajeado: Ed. Univates.

De Boer, I. J. M. (2003). Environmental impact assessment of conventional nad organic milk production. *Livestock Production Science*, 80, 63-77. DOI: https://doi,org/10.1016

Duran, D. C., Gogan, L. M., Artene, A., & Duran V. (2015). The components of sustainable development-a possible approach. *Procedia Economics and Finance*, 26, 806-811. DOI: https://doi.org/10.1016/S2212-5671(15)00849-7

Einarsson, R., Cederberg, C., & Kallus, J. (2017). Nitrogen flows on organic and conventional dairy farms: a comparison of three indicators. *Nutr Cycl Agroecosyst*. DOI: https://doi.org/10.1007/s10705-017-9861-y

Organização das Nações Unidas para a Alimentação e Agricultura [FAO]. *FAO STAT.* (2022). Available in: https://www.fao.org/faostat/es/#data/QCL

Organização das Nações Unidas para a Alimentação e Agricultura [FAO]. (2019). *FAO STAT - Livestock Primary.* Roma, Italy.

Galloway, C., Conradie, B., Prozesky, H. & Esler, K. (2018). Opportunities to improve sustainability on commercial pasture-based dairy farms by assessing environmental impact. *Agricultural Systems*, 166, 1-9. DOI: https://doi.org/10.1016/j.agsy.2018.07.008

Galvão, M. C. B., & Ricarte, I. L. M. (2020). Revisão sistemática da literatura: conceituação, produção e publicação. *LOGEION: Filosofia da Informação*, 6(1), 57-73.

Gomes, S. I. F., Van Bodegom, P. M., Van Agtmaal, M., Soudzilovskaia, N. A., Basteman, M., Duijm, E., & Van Eekeren, N. (2020). Microbiota in dung and milk differ between organic and conventional dairy farms. *Frontiers in Microbiology*, 11, 17-46. DOI: https://doi.org/10.3389/fmicb.2020.01746

Gross, A., Bromm, T., Polifka, S. & Schierhorn, F. (2022). The carbon footprint of milk during the conversion from conventional to organic production on a dairy farm in central Germany. *Agronomy for Sustainable Development*. DOI: https://doi.org/10.1007/s13593-022-00775-7

Guerci, M., Knudsen, M. T., Bava, L., Zucali, M., Schönbach, P., & Kristensen, T. (2023). Parameters affecting the environmental impacto of a range of dairy farming systems in Denmark, Germany and Italy. *Journal of Cleaner Production,* 54, 133-141. DOI: http://dx.doi.org/10.1016/j.jclepro.2013.04.035

Guptill, A. (2009). Exploring the conventionalization of organic dairy: Trends and counter-trends in upstate New York. *Agriculture and Human Values*, 26(1), 29-42. DOI: https://doi.org/10.1007/s10460-008-9179-0

Horrillo, A., Gaspar, P., & Escribano, M. (2020). Organic farming as a strategy to reduce carbon footprint in dehesa agroecosystems: a case study comparing different livestock products. *Animals*, 10, 162. DOI: https://doi.org/10.3390/ani10010162

Hopwood, B., Mellor, M. & O'brien, G. (2005). Sustainable development: mapping different approaches. *Sustainable Development*, 13(1), 38-52. DOI: https://doi.org/10.1002/sd.244

International Federation of Organic Agriculture Movements [IFOAM]. (2008). *General Assembly*. Available in: https://www.ifoam.bio/why-organic/organic-landmarks/definition-organic

Kayser, A. L. (2015). A sustentabilidade da bovinocultura de leite: a perspectiva do sistema de proteção ambiental. In: Martins, P. C. *Sustentabilidade ambiental, social e econômica da cadeia produtiva do leite*: desafios e perspectivas (pp. 339-342). Brasília.

Klarin, T. (2018). The concept of sustainable development: From its beginning to the contemporary issues. *Zagreb International Review of Economics & Business*, 21(1), 67-94. DOI: https://doi.org/10.2478/zireb-2018-0005

Knudsen, M. T., Dorca-Preda, T., Djomo, S. N., Peña, N., Padel, S., Smith, L. G., & Hermansen, J. E. (2019). The importance of including soil carbon changes, ecotoxicity and biodiversity impacts in environmental life cycle assessments of organic and conventional milk in western europe. *Journal Cleaner Production*, 215, 433-443. DOI: https://doi.org/10.1016/j.jclepro.2018.12.273

Liang, D., Sun, F., Wattiaux, M. A., Hedtcke, J. L., & Silva, E. M. (2017). Effect of feeding strategies and cropping systems on greenhouse gas emission from Wisconsin certified organic dairy farms. *Journal of Dairy Science*, 100(7), 5957-5973. DOI: https://doi.org/10.3168/jds.2016-11909

Machado, F. S., Castro, C. R. T., Diniz, F. H., Magalhães Junior, W. C. P. de & Pires, M. de F. A. (2021). *Leite orgânico: cenário da pecuária leiteira orgânica no Brasil*. Juiz de Fora: Embrapa Gado de Leite.

Meier, M. S., Stoessel, F., Jungbluth, N., Juraske, R., Schader, C. & Stolze, M. (2015). Environmental impacts of organic and conventional agricultural products – are the differences captured by cycle assessment? *Journal of Environmental Management*, 149, 193-208. DOI: http://dx.doi.org/10.1016/j.jenvman.2014.10.006

Mensah, J. & Casadevall, S. R. (2019). Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review. *Cogent Social Sciences*, 5(1). DOI: https://doi.org/10.1080/23311886.2019.1653531

Mueller, C., De Baan, L. & Koellner, T. (2014). Comparing direct land use impacts on biodiversity of conventional and organic milk—based on a Swedish case study. *The International Journal of Life Cycle Assessment*, 19(1), 52-68. DOI: https://doi.org/10.1007/s11367-013-0638-5

Muñoz, M. S. G., Soares, J. P. G., Brisola, M. V., Junqueira, A. M, R. & Pantoja, M. J. (2022). Impactos ambientais e socioeconômicos da produção integrada de base ecológica em unidades de produção familiar do Distrito Federal e entorno. *Revista de Economia e Sociologia Rural*, 60(1). DOI: https://doi.org/10.1590/1806-9479.2021.222418

Nascimento, S. G. S., Nascimento, J. C., Hanke, D., Ávila, M. R., & Silva, F. N. (2020). Gestão ambiental e agricultura familiar: um olhar sobre o município de Dom Pedrito - RS. *R. Gest. Sust. Ambient.*, 9(3), 480-499.

Nogueira, C. (2019). Contradictions in the concept of sustainable development: An analysis in social, economic, and political contexts. *Environmental Development*, 30, 129-135. DOI: https://doi.org/10.1016/j.envdev.2019.04.004

Olawumi, T. O., & Chan, D. W. M. (2018). A scientometric review of global research on sustainability and sustainable development. *Journal of Cleaner Production*, 183, 231-250. DOI: https://doi.org/10.1016/j.jclepro.2018.02.162

Oliveira, E. R., Muniz, E. B., Soares, J. P. G., Carbonari, V. M. De S., Carbonari, O. S., Gabriel, A. M. De A., Padovan, P. S., Rezende, G. B. De & Gandra, J. R. (2014). Impactos ecológicos e socioambientais da transição agroecológica para produção orgânica de leite em Sidrolândia-MS. *Cadernos de Agroecologia*, 9(4), 1-9.

Oliveira, G. B. (2002). Uma discussão sobre o conceito de desenvolvimento. *Revista da FAE. Curitiba*, 5(2), 37-48.

Orlandini, I. & Tortelly Neto, R. (2020). Redução de impactos ambientais gerados pela bovinocultura de leite: revisão bibliográfica. *Arquivos Brasileiros de Medicina Veterinária*, 3(1), 144-156.

Méndez, J. A. P. & Pinilla, A. A. (2008). Análisis Económico de la Producción de Leche Ecológica. *Revista ICE*, 843.

Pirlo, G. & Lolli, S. (2019). Environmental impact of milk production from samples of organic and conventional farms in Lombardy (Italy). *Journal of Cleaner Production*, 211, 962-971. DOI: https://doi.org/10.1016/j.jclepro.2018.11.070

Research Institute of Organic Agriculture [FIBL]. (2022). *Info Centre.* Recuperado de https://www.fibl.org/en/

Refsgaard, K., Bergsdal, H., Berglann, H., Pettersen, J. (2012). Greenhouse gas emissions from life cycle assessment of Norwegian food production systems. *Acta Agriculturae Scandinavica, Section A — Animal Science*, 62(4), 336-346. DOI: https://doi.org/10.1080/09064702.2013.788204

Rempel, C., Eckhardt, R. R., Jasper, A., Schultz, G., Hilgert, Í. H. & Barden, J. E. (2012). Proposta Metodológica de Avaliação da Sustentabilidade Ambiental de Propriedades Produtoras de Leite. *Revista Tecno-Lógica*, 16(1). DOI: https://doi.org/10.17058/tecnolog.v16i1.2613

Romano, E., Roma, R., Tidona, F., Giraffa, G. & Bragaglio, A. (2021). Dairy Farms and Life Cycle Assessment (LCA): The Allocation Criterion Useful to Estimate Undesirable Products. *Sustainability*, 13, 43-54. DOI: https://doi.org/10.3390/su13084354

Rosen, M. A. (2017). Sustainable development: A vital quest. *European Journal of Sustainable Development Research*, 1(1). DOI: https://doi.org/10.20897/ejosdr.201702

Rouco, R. G. (2004). *Ganadería Ecológica*. Guía de Actividad Empresarial. Santiago de Compostela.

Sales, P. C. M., Soares, J. P. G., Pantoja, M. J. & Junqueira, A. M. R. (2020). Estado da arte da produção de leite orgânico: revisão sistemática da literatura. In *Anais do 58º Congresso SOBER*.

Salvador, S., Corazzin, M., Piasentier, E. & Bovolenta, S. (2016). Environmental assessment of small-scale dairy farms with multifunctionality in mountain areas. *Journal of Cleaner Production*, 124, 94-102. DOI: https://doi.org/10.1016/j.jclepro.2016.03.001

Santos, E. L., Braga, V., Santos, R. S. & Braga, A. M. Da S. (2012). Desenvolvimento: um conceito multidimensional. *DRd - Desenvolvimento Regional em Debate*, 2(1).

Sartori, S., Latrônico, F., & Campos, L. M. S. (2014). Sustentabilidade e desenvolvimento sustentável: uma taxonomia no campo da literatura. *Ambiente &*

.
Sociedade, 17(1), 1-22.

Schader, C., Drapela, T., Markut, T., Meier, M. S., Lindenthal, T., Hörtenhuber, S., & Pfiffner, L. (2014). Farm- and product-level biodiversity assessment of conventional and organic dairy production in Austria. *International Journal of Biodiversity Science, Ecosystem & Management*, 10(1), 29-39. DOI: https://doi.org/10.1080/21513732.2013.878752

Scozzafava, G., Gerini, F., Boncinelli, C. C., Marone, E. & Casini, L. (2020). Organic milk preference: is it a matter of information? *Appetite,* 144. DOI: https://doi.org/10.1016/j.appet.2019.104477

Soares, J. P. G; Sales, P. C. M., Sousa, T. C. R., Malaquias, J. V. & Rodrigues, G. S. (2015). *Impactos ambientais da transição entre a produção de leite bovino convencional para orgânico na Região Integrada de Desenvolvimento do Distrito Federal e Entorno (RIDE/DF).* Embrapa Cerrados, Planaltina. DOI: https://doi.org/10.30612/realizacao.v8i16.15218

Soares, J. P. G; Sales, P. C. M., Sousa, T. C. R., Malaquias, J. V. & Rodrigues, G. S. (2021). Impactos ambientais da transição entre produção de leite convencional para orgânico. *Realização - Revista Online de Extensão e Cultura*, 8(16).

Souza, R. M. H. (2011). *A Influência do Ambiente Institucional e Organizacional no Desenvolvimento Rural de Propriedades Produtoras de Leite na Região Extremo-Oeste Catarinense.* 125 p. Dissertação (Mestrado em Desenvolvimento Regional e Agronegócios) - Programa de Mestrado em Desenvolvimento Regional e Agronegócios, Universidade Estadual do Oeste do Paraná, Toledo.

Sugahara, C. R., & Rodrigues, E. L. (2019). Desenvolvimento Sustentável: um discurso em disputa. *Desenvolvimento em Questão*, 17(49), 30-43. DOI: https://doi.org/10.21527/2237-6453.2019.49.30-43

Tal, A. (2018). Making conventional agriculture environmentally friendly: moving beyond the glorification of organic agriculture and the demonization of conventional agriculture. *Sustainability*, 10. DOI: https://doi.org/10.3390/su10041078

Tomich, T. R., Pereira, L. G. R., & Paiva, C. A. V. (2016). Avanços tecnológicos para a redução do impacto da pecuária no meio ambiente. In: Vilela, D. et al. *Pecuária de leite no Brasil: cenários e avanços tecnológicos* (pp. 384-400). Brasília, DF: Embrapa.

Tuomisto, H. L., Hodge, I. D., Riordan, P & Macdonald, F, W. (2012). Does organic farming reduce environmental impacts?–A meta-analysis of European research. *Journal of Environmental Management*, 112, 309-320. DOI: http://dx.doi.org/10.1016/j.jenvman.2012.08.018

Van Wagenberg, C. P. A., Hass, Y., Hogeveen, H., Van Krimpen, M. M., Meuwissen, M. P. M., Van Middelaar, C. E., & Rodenburg, T. B. (2017). Animal Board Invited Review: Comparing conventional and organic livestock production systems on different aspects of sustainability. *Animal*, 11(10), 1839-1851. DOI: https://doi.org/10.1017/S175173111700115X

Van Asselt, E. D., Capuano, E. & Van Der Fels-Klerx, H. J. (2015). Sustainability of milk production in the Netherlands - A comparison between raw organic, pasteurised organic and conventional milk. *International Dairy Journal,* 47, 19-26. DOI: http://dx.doi.org/10.1016/j.idairyj.2015.02.007

Willer, H., Trávníček, J., Meier, C. & Schlatter, B. (2021). *The World of Organic Agriculture 2021 - Statistics and Emerging Trends*. Research Institute of Organic Agriculture FiBL and IFOAM - Organics International, Frick and Bonn., CH-Frick and D-Bonn. Avaliable in: https://orgprints.org/id/eprint/40014