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revista online de extensão e cultura
REALIZAÇÃO

DOI 10.32612/realização.v8i15.15218
ISSN: 2358-3401

Submetido em 30 de Setembro de 2021
Aceito em 10 de Novembro de 2021
Publicado em 17 de Dezembro de 2021

ENVIRONMENTAL IMPACTS OF THE TRANSITION BETWEEN CONVENTIONAL AND ORGANIC BOVINE MILK PRODUCTION IN THE INTEGRATED DEVELOPMENT REGION OF THE FEDERAL DISTRICT AND SURROUNDING AREAS (RIDE/DF)

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)

IMPACTOS AMBIENTALES DE LA TRANSICIÓN ENTRE LA PRODUCCIÓN DE LECHE BOVINA CONVENCIONAL Y ORGÁNICA EN LA REGIÓN DE DESARROLLO INTEGRADO DEL DISTRITO FEDERAL Y ÁREA CIRCUNDANTE (RIDE/DF)

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Abstract: The objective of this study was to evaluate the environmental impacts of adopting the organic milk production system for cattle in seven family production units in the Integrated Development Region of the Federal District and Surrounding Areas (RIDE), using the Ambitec Agro-Animal Production system, developed by Embrapa Meio Ambiente. Data were obtained through questionnaires administered to representatives of the family units in 2012 and 2013. After inserting the coefficients of change for each variable per production unit, the impact coefficient was calculated using the Ambitec spreadsheet. The average environmental impact index was -2.13 and 3.37 for the conventional production system and the organic production

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system, respectively. "Soil quality" (19.1), "Waste disposal" (16.4), "Property value" (15.1) and "Income generation" (13.9) were the components that contributed most to the higher index of the organic system. The percentage increase in technology was 18.35%.

Keywords: Organic milk, Agroecological conversion, Family farming.

Resumo: O objetivo deste trabalho foi avaliar os impactos ambientais da adoção do sistema de produção de leite orgânico de gado bovino, em sete unidades de produção familiar na Região Integrada de Desenvolvimento do Distrito Federal e Entorno (RIDE), utilizando o sistema Ambitec Agro-Produção Animal, desenvolvido pela Embrapa Meio Ambiente. Os dados foram obtidos através da aplicação de questionários aos representantes das unidades familiares, nos anos de 2012 e 2013. Após a inserção dos coeficientes de alteração de cada variável por unidade de produção, o coeficiente de impacto foi calculado por meio da planilha Ambitec. O índice médio de impacto ambiental foi de -2,13 e de 3,37 para o sistema de produção convencional e do sistema de produção orgânico, respectivamente. "Qualidade do solo" (19,1), "Disposição de resíduos" (16,4), "Valor da propriedade" (15,1) e "Geração de renda" (13,9) foram os componentes que mais contribuíram para o maior índice do sistema orgânico. O percentual de incremento da tecnologia foi de 18,35%.

Palavras-chave: Leite orgânico, Conversão Agroecológica, Agricultura familiar.

Resumen: El objetivo de este trabajo fue evaluar los impactos ambientales de la adopción del sistema de producción de leche orgánica para bovinos, en siete unidades de producción familiar de la Región de Desarrollo Integrado del Distrito Federal y Área Contigua (RIDE), utilizando el sistema de Producción Agroanimal Ambitec, desarrollado por Embrapa Meio Ambiente. Los datos se obtuvieron mediante la aplicación de cuestionarios a representantes de unidades familiares en los años 2012 y 2013. Luego de insertar los coeficientes de cambio de cada variable por unidad de producción, se calculó el coeficiente de impacto utilizando la hoja de cálculo Ambitec. El índice de impacto ambiental promedio fue de -2,13 y 3,37 para el sistema de producción convencional y el sistema de producción orgánico, respectivamente. "Calidad del suelo" (19,1), "Eliminación de residuos" (16,4), "Valor de la propiedad" (15,1) y "Generación de ingresos" (13,9) fueron los componentes que más contribuyeron al índice más alto del sistema orgánico. El incremento porcentual en tecnología fue del 18,35%.

Palabras clave: Leche orgánica, Conversión agroecológica, Agricultura familiar.

INTRODUÇÃO

The low technical indices of the conventional dairy sector show that increases in productivity are necessary to meet consumption needs in Brazil. Brazil's potential to produce milk is based, for example, on 11,506,788 million milked cows (Census 2017), and millions of hectares available in the Cerrado alone (Alvim, 2003). The indices presented suggest that intensification of milk production is necessary (SOARES et al., 2011).

Organic milk production can be an option to increase milk production without degrading natural reserves. According to FAO (1998), IFOAM (2008), BRAZIL, 2003, organic agriculture is defined as the holistic production of a management system that promotes and stimulates the health of the agro-system, including biodiversity, biological cycles and soil biological activity.

As in any animal production system, in organic milk production it is recommended that animal nutrition and feed be balanced. Supplements must be free of antibiotics, hormones and dewormers, and additives that promote growth, appetite stimulants and urea are prohibited, as well as supplements or foods derived or obtained from genetically modified organisms or even vaccines manufactured with transgenic technology (FIGUEIREDO, SOARES, 2012; BRASIL, 2011).

Soares et al. (2011) recommend the management and fertilization of pastures, as well as the consortium of grasses and legumes, for nitrogen management in the system, requiring, for this purpose, the diversification of plant species. Thus, they propose the implementation of agroforestry systems, such as silvopastoral systems, in which nitrogen-fixing trees and shrubs (legumes) can be associated with agricultural crops and pastures.

Regarding the health management of livestock under organic management, SOARES et al. (2011) adds that veterinary treatment is considered a complement and never a substitute for good management practices. However, if necessary, the use of herbal medicines and homeopathy is recommended. All vaccines established by law are mandatory, and vaccinations and examinations for the most common diseases in each region are recommended. As a preventive measure against ecto and endoparasites, pasture rotation and the use of homeopathic and herbal compounds are recommended, together with feed or mineral salt.

Although data on organic milk production in Brazil is still scarce, according to Neiva (2000), organic production of milk and its derivatives has been emerging timidly in Brazil. The South Region produces around 10,000 liters of milk per day, the Southeast, 1,800 liters, and the Northeast, 500 liters.

According to more recent estimates, organic milk production in the Federal District (DF) represents approximately 182.5 thousand liters/year (SOARES et al., 2011). These values are higher than the Brazilian reality for this activity, since in 2005 organic milk production was 0.01% (AROEIRA et al., 2005) and grew to 0.02% (6.8 million liters in 2010) of the total milk production produced in Brazil (28 billion liters in 2010) according to preliminary data from surveys carried out by the organic animal production systems project in 2011, with producers and cooperatives in different states.

This reality contrasts with the current demand for organic milk in society, showing that it is essential to increase production. The consumer wants a quality product, at a fair price, healthy from the point of view of food safety, free from biological hazards and with care regarding animal welfare (NICHOLAS ET AL., 2014), (BAINBRIDGE ET AL., 2017), (REY, 2015).

The marketing of organic milk is usually done on a small scale, especially in the case of dairy products (bakeries, mini-markets, street markets, stores and home delivery baskets), given the requirements of health legislation for them to be placed in a large retail channel. State and municipal legislation has been facilitating the actions of small farmers and small-scale agro-industries (FONSECA, 2000). There are still limitations, especially in the dissemination and transfer of technologies, where extension training is necessary to make the different available technologies reach producers who may be having problems and do not have available solutions due to lack of knowledge (FONSECA, 2000).

Even with marketing difficulties, it is possible to make a profit from the activity, as this is no longer an incipient activity. Taking into account that Brazil is the fifth country with the largest area of organic production in the world, 1.77 million hectares as of 2007 (IFOAM 2011). According to Willer and Lernoud (2019) in the survey carried out by the Research Institute of Organic Agriculture (FIBL), in partnership with IFOAM, organic agriculture is at its greatest stage of development since FIBL research began 20 years ago, with 70 million hectares and showing market growth worldwide, which culminated in reaching the mark of 97 billion dollars (around 90 billion euros), these being the highest levels ever recorded.

Among organic products of animal origin, organic milk stands out for being present in all European countries, presenting high growth rates, doubling its production since 2008, in order to meet the great demand for organic dairy products in these countries. The production of organic milk in the European Union recorded for the year 2017 was 4.4 million tons, which constitutes about 3% of the total production (WILLER; LERNOUD, 2019).

It is estimated that annual trade is R$500 million, with 30% for the domestic market and 70% for export. According to MIDIC (2007), US$5.5 million in organic products were exported, with the main items sold to foreign markets being sugar, coffee, cocoa, and fresh and dried fruits, including butter. The main buyers of these products are the USA (41.2%) and the Netherlands (29.5%), followed by Canada, Japan, and the United Kingdom. The sector grows 20 to 30% per year. Based on these data, we can see that organic milk production does not only serve a niche market; it has production, profitability, and sustainability, and is a market waiting for production (SOARES et al., 2011).

Thus, the present work aims to perform a comparative analysis between the indicators obtained with the use of technologies before and after adoption, together with milk producers who adopted organic milk production in the Integrated Development Region of the Federal District and Surrounding Area.

MATERALS AND METHODS

Given the need to evaluate and measure the environmental impacts of these practices, the methodology used was Ambitec - Animal Production - described by IRIAS et al. (2004) and ÁVILA et al. (2008), which was developed by Embrapa Meio Ambiente, reproducing data from the assessment of socioeconomic and environmental impacts, identifying the factors that increase or decrease the level of impact.

Environmental impact assessment (EIA) was designed to reduce negative impacts, defined as “any change in the physical, chemical or biological characteristics of the environment, caused by any form of matter or energy derived from human activities, and which may directly or indirectly affect the health, safety or well-being of the population, economic and social activities; the biota; aesthetic and sanitary conditions; and the quality of natural resources” (RODRIGUES et al., 2003a).

The applications of EIAs include studies of changes observed in production activities as a result of the adoption of new management practices and technologies, particularly when directed at rural activities (RODRIGUES et al., 2003b). The assessment of the impacts of agricultural technological innovations has been carried out, within the institutional context of research and development at Embrapa, by applying a multicriteria approach method (Ambitec-Agro; RODRIGUES et al., 2010), the results of which are consolidated in the company's social balance sheet (Balanço social da pesquisa agropecuária brasileira, 2006, 2009).

The Ambitec-Agro indicator system allows for the clear and concise measurement of the main factors related to the development of agricultural production units and constitutes a tool applicable to environmental certification processes, contributing to sustainable rural development (MONTEIRO; RODRIGUES, 2006; AVILA et al., 2008).

TECHNOLOGIES FOR ORGANIC PRODUCTION

In a comparative approach, studies were developed with seven milk producers from the Integrated Development Region of the Federal District and Surrounding Area, where a set of technologies provided for in normative instruction IN 46 (Brazil, 2011) was evaluated, which describes practices and processes permitted in organic production systems for dairy cattle.

ORGANIZATION AND CHARACTERIZATION OF PRODUCERS

The organization of producers began in 2011, in conjunction with Emater-DF, based on their demand for interest in becoming organic milk producers. The technologies described for the transition to organic milk production were implemented during the 2011/2012 rainy season, while the initial socioeconomic and technical conditions in which these producers found themselves in the conventional system were measured. At the end of 2013/2014, the conditions of all producers were again evaluated, using the Ambitec-Agro Animal Production method at both times, focusing on the socioenvironmental and ecological impacts of the agroecological transition from conventional to organic milk production as described by SOARES and RODRIGUES, (2013). The characterization of the producers is described below:

"Producer 1" has his property located in Parque das Umbaúbas, Tabatinga Rural Center, lot 134, Tabatinga-DF, has an area of 66 hectares, and began his dairy activity in 1991. He lives alone on the property and has 2 employees. He left plant production, maintaining only the dairy activity, which became the main activity of the property.

The main problems faced in the activity are the lack of labor, financing, equipment and technical assistance. The producer has a milk production of 6.3 liters/cow/day. Due to his area of only 2 ha, there is a need for other sources of food to maintain a total herd of 90 animals. One positive point is the registration with the Inspection Board of Products of Plant and Animal Origin (DIPOVA), which regularizes his production of his small agribusiness of production and commercialization of cheese.

"Producer 2" has his property located at Capim Jasmim farm, BR 251 Km 21, PAD-DF. He began his agricultural activity in 2004 and has a total area of 78 ha, of which 16 ha are pasture and 3 ha are bulky for feeding the herd during dry periods. His herd has 60 animals, which produce 150 liters of milk per day, with a monthly revenue of R$ 3,231.47. The lack of labor, the price of milk on the market and the control of parasites in the herd are his main problems. He has an agroforestry system, certified in 2013, which is his main source of income, with the main sale of bananas and citrus fruits.

"Producer 3" is a land reform settler on Chácara 40.B, Três Conquistas rural area, DF-130 km 20, Tabatinga-DF. The area has 9.7 ha, of which 3 ha are pastures, 1.5 ha are for the production of bulky products and 2 ha are for plant production. He produces fruits, vegetables and greens. He raises poultry and pigs, in addition to producing milk. His plant part has organic certification. The farm's activities are carried out exclusively by the family (wife and three children), having started their dairy activity in 2009. His biggest difficulties in milk production are the cost of feed, electricity and the low price of milk.

"Producer 4" is a land reform settler on the Thawini site, Colony 1, Padre Bernardo-GO. He owns 12 hectares, has no family and has the help of an assistant. He produces milk and vegetables that are sold at the Ecological Agriculture Association-DF-AGE Fair at CEASA-DF. He began his agricultural activity in 2007 and has five matrices that produce 40 liters of milk/day. He presents adequate zootechnical levels as monitored by Emater – DF, reflecting a financial return of 3041.67 reais/month. He produces cheese in a small agroindustry on the property. His entire area is certified, which allows the direct sale of all his products of animal and vegetable origin.

"Producer 5" is a land reform settler with a total area of 17.5 ha, 4 ha of pasture, 1.5 ha of production of bulky feed used to feed the herd during dry periods and 3 ha for plant production. He has been in the activity since 1995, lives with his wife and three children who work on the property. His biggest problems are with the certification of the animal production system, obtaining inputs, the structure of his property which, despite the constant improvements after the transition, still needs adjustments to the facilities, as well as the logistics for selling his products. He sells the products in the region itself. Even with the need for improvement in herd management, the producer has a monthly net profit from milk of 1.3 minimum wages, approximately R$ 1,144.00 considering the salary at the time.

"Producer 6" has a total area of 17 hectares, 1 ha of pasture, 3 hectares for the production of bulky products such as sugarcane and capiaçu to feed the herd during dry periods. He is a land reform settler and lives with his wife, 2 children and his mother. His biggest problems are water for irrigation and supply, soil erosion and the price paid for milk. In the case of this producer, he delivers the milk to the São Sebastião agricultural cooperative (COPAS) and participates in the Balde Cheio program, supported by the cooperative. He produces organic vegetables and fruits and began dairy farming in 2012.

"Producer 7" is a land reform settler, has 17 ha of total area, 1 ha of pasture and 2 ha of production of bulky products, such as sugar cane used to feed the herd during dry periods. The activities are shared with his wife and 2 daughters. He produces organic vegetables and milk. The producer was part of the Balde Chele program, but left due to the high costs of the program, which was one of the reasons that led him to transition to organic production. Income generation and soil quality, which were limitations before the transition, now show positive aspects. Milk production represents 1,639.46 reais in his monthly budget.

EVALUATION OF THE PERCENTAGE IMPACT OF TECHNOLOGY-PIT

Aiming to extend the impact assessment approach, to provide comparative analysis between conditions before and after technological adoption, data surveys were carried out to verify how producers developed their activities before and after, in order to highlight the differences in terms of technical coefficients.

To calculate the percentage of technology impact in this proposed method, values are assigned on an interval scale from -15 to +15. These scores represent the technology impact index, allowing the estimation, from two moments, of the percentage of technology impact (PIT) introduced for each individual or for a given production system. This measure can assume positive or negative values, indicating the direction, if the impact index measured between the two moments (before and after the introduction of the technology) was increasing or decreasing, respectively (SOARES AND RODRIGUES, 2013). This same measure can also indicate the intensity or magnitude related to these impact indexes in the change of moments.

The formula for calculation is described below as follows:

$$\text{PIT}_\text{i} = \left(\frac{\mu_{2i} - \mu_{1i}}{AM}\right) x\ 100$$

Being:

PIT_i: Percentage of Technology Impact of individual i, i=1..n;

μ_{2i}: Impact index after the introduction of technology, referring to individual i;

μ_{1i}: Impact index before the introduction of technology, referring to individual i;

AM: Maximum possible amplitude of the Ambitec scale (= 30).

To obtain the percentage of general impact of the technology of the production group with *n* individuals participating in the sample, the following formula was used:

$$\text{PIT} = \left(\frac{\sum_{i=1}^{n} \mu_{2i} - \sum_{i=1}^{n} \mu_{1i}}{n\ .AM}\right) x\ 100$$

Being:

PIT: Overall Technology Impact Percentage;

n: Total number of producers;

$\sum_{i=1}^{n} \mu_{2i}$: Sum of the impact indices referring to the moment after the introduction of the technology of the n individuals;

$\sum_{i=1}^{n} \mu_{1i}$: Sum of the impact indices relating to the moment prior to the introduction of the technology of n individuals;

AM: Maximum possible amplitude of the Ambitec scale (= 30).

STATISTICAL ANALYSIS

For statistical analysis, producers were grouped using the cluster analysis technique, using the results of the environmental impact indicators expressed by the Ambitec-Agro indexes themselves. The similarity measure adopted was the “Quadratic Euclidean Distance” and the agglomerative method used was the Ward hierarchical linkage method.

To assess the possible existence of significant differences between the 2012 and 2013 periods, for each variable that makes up the ecological and socio-environmental indicators, the non-parametric Wilcoxon test was performed for paired samples, at a significance level of 5%. Since the sample elements did not have behavior compatible with the normal distribution, the non-parametric test was adopted. To analyze the data obtained, the statistical treatment program SPSS (Statistical Package for the Social Sciences), for Windows, version 19.0 and free software R version 2.14 were used.

RESULTS AND DISCUSSION

When comparing the Impact Index calculated for the production system for the years 2012 and 2013, it was verified through the non-parametric Wilcoxon test that it presented a significant difference ($p<0.05$).

To better understand and analyze the set of technologies evaluated, it was necessary to study each indicator in particular, which were discussed in the evaluation groups of ecological and socio-environmental impact indicators.

Comparing conventional dairy farming and the transition to organic farming, the index that presented the greatest variation within the group of ecological impacts was soil quality, with a variation of $\mu = 19.11$ (Table 3), resulting from the comparison of soil management of pastures used for conventional milk production ($\mu = -8.39$) in relation to milk production under organic management ($\mu = 10.71$), being the greatest contribution to the formation of the general index of ecological impacts for organic production (Tables 1 and 3). The increase in the soil quality index is related to the non-use of chemically synthesized fertilizers, prohibited in organic production systems (SOARES et al., 2011; SOARES et al., 2012).

The use of agricultural inputs and resources was the second index that presented the greatest variation, being equal to $\mu = -4.43$ in conventional milk production, increasing to $\mu = -5.32$ in organic management (Tables 2 and 3), with an increase in the use of inputs in organic management of 10.39, which can be explained by the non-use of chemicals, and greater reuse of materials from within the property, thus increasing the quantity and diversity of inputs used. In the other indexes of this group there was no statistical difference (Tables 4).

For both soil quality and use of agricultural inputs, this increase was evidenced by the organic management process, since, when in a conventional system, practically no inputs were used due to costs and availability.

The agroecological transition of milk production systems in the region also provided improvements in the socioeconomic and environmental conditions of producers, evidenced by the increase in the indexes of most indicators used in this group, especially factors related to the well-being and improvement of the quality of life of the families involved, demonstrating the possibility of functioning as a promising alternative to guarantee social benefits (Tables 1 and 2), thus corroborating the statement by . MULLER (2007) who describes family farming as multifunctional.

Table 1. Coefficients of alteration, criteria and indices of ecological and socio-environmental impacts of conventional management in milk production units in the Federal District and surrounding integrated region estimated by the Ambitec-Agro System, in 2012.

Impact Coefficients (2012)								
Producer	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Average overall impact index				**-2.13**				
Ecological Impact Indicators								**Average**
Use of Agricultural Inputs and Resources	-10.00	-1.50	-3.00	-8.00	-6.50	-4.75	-1.75	-5.07
Use of Veterinary Supplies and Raw Materials	-5.00	-2.50	-7.00	-4.00	-7.00	-3.50	-2.00	-4.43
Energy Consumption	-12.00	-4.00	-9.00	0.00	3.50	-4.50	-4.00	-4.29
Atmospheric Emissions	-6.20	0.80	-1.00	-7.00	0.10	-2.70	0.30	-2.24
Soil Quality	-5.00	-5.00	-12.50	-10.00	-15,00	1.25	-12.50	-8.39
Water Quality	0.00	-3.00	-0.75	-2.00	1.75	-1.75	-0.75	-0.93
Biodiversity Conservation	-1.50	-1.00	-0.90	0.00	-3.00	10.50	6.00	1.44
Environmental Recovery	2.40	2.40	2.40	1.60	3.00	0.60	0.60	1.86
Socio-Environmental Impact Indicators								
Product Quality	6.25	-7.50	1.25	1.25	-2.50	-1.25	-7.50	-1.43
Share Capital	0.85	-1.10	-0.10	0.30	-0.40	0.10	0.35	0.00
Animal Welfare and Animal Health	4.50	-5.00	-2.50	1.75	-10.00	-6.75	-8.50	-3.79
Training	5.00	-5.75	2.75	8.25	-1.25	-1.25	-1.50	0.89
Qualification and job offer	1.86	0.27	1.03	0.02	-0.22	0.42	3.51	0.98
Quality of Employment	2.50	1.00	1.00	0.00	-1.00	0.00	0.00	0.50
Income Generation	7.50	-10.00	3.75	-15,00	-15,00	-2.50	1.25	-4.29
Diversity of Income Sources	11:00	-3.25	0.75	-3.00	-4.75	3.75	3.50	1.14

Property Value	-0.50	-8.25	-3.00	-6.75	-8.75	-5.00	-12.75	-6.43
Environmental and Personal Health	-2.20	-3.00	-1.20	-0.60	-2.40	-9.00	0.00	-2.63
Occupational Health and Safety	-13.00	-1.00	-8.50	-3.50	-6.50	-8.50	-3.75	-6.39
Food Safety	-3.00	-2.40	-1.20	-2.20	-5.10	1.20	-6.00	-2.67
Dedication and Profile of the Responsible Person	-2.25	-13.00	1.00	5.25	-8.50	0.75	-4.75	-3.07
Marketing condition	2.25	-6.00	2.00	-3.00	-0.75	1.50	4.50	0.07
Waste disposal	-6.00	-15,00	-6.00	-8.00	6.00	-3.00	-11.00	-6.14
Management of chemical inputs	8.75	0.50	5.25	5.00	0.00	0.00	0.00	2.79
Institutional Relationship	6.00	-2.00	0.75	2.00	2.75	-0.75	-6.75	0.29
Activity Impact Index	**-0.52**	**-4.01**	**-1.44**	**-1.93**	**-3.43**	**-1.06**	**-2.55**	-2.13

Initially, most indicators were positively altered. In the group of socio-environmental indicators, the indexes that presented statistical differences ($p<0.05$) were “Animal health and welfare”; “Qualification and job offer”; “Income generation”; “Property value”; “Environmental and personal health”; “Occupational health and safety”; “Food safety”; “Dedication and profile of the person in charge”; “Waste disposal” and “Management of chemical inputs” (Table 3). It can be inferred that, in an integrated manner, all these indexes contributed to the improvement of the production system through the organic transition.

The individual contribution of each of the indicators of positive socio-environmental impact may be associated with greater income generation on the property, as evidenced and reported by the producers themselves, which is directly related to the increase in the added value of the organic product, even though it is still in the transition process.

The appropriation and experimentation of agroecological principles allowed farmers to add value to their products, as well as receive appreciation from society for the services they provide, especially through the producer-consumer interaction that occurs, especially with those with direct sales.

In this sense, due to the diversity of aspects, those related to socioeconomic aspects will be addressed first within the environmental indicators. The income generation index, the third most important of the group, showed great variation between conventional livestock farming and organic livestock farming, with this variation of $\mu = 13.93$ between conventional production ($\mu = -4.29$) and organic production ($\mu = 9.64$). In the case of the property value index, the variation between the two forms of production was $\mu = 15.07$ between conventional livestock farming (μ = -6.43) and transition to organic livestock farming (μ = 8.64), being the second index with the greatest variation within the group of socio-environmental impacts.

Analyzing the income generation of establishments, it can be observed that the increase in income is associated with greater stability, better security and its distribution throughout the year, being influenced by the diversification of the sources generating this income, obtained from technological innovation.

In addition to milk, other plant-based products produced as required by law also undergo the transition process. In this sense, the improvement in food security for families through the introduction of adopted ecological practices, which reduced the risk of food contamination, and through the regularity of their supply, factors considered by BELIK (2003) as essential to achieving full food security.

Table 2. Coefficients of alteration, criteria and indexes of ecological and socio-environmental impacts of the transition management to organic in milk production units in the Federal District and surrounding integrated region estimated by the Ambitec-Agro System, in 2013.

Impact Coefficients (2013)								
Producer	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Average overall impact index				**3.37**				
Ecological Impact Indicators								**Average**
Use of Agricultural Inputs and Resources	13:00	-0.25	9.50	7.25	7.50	5.50	-5.25	5.32
Use of Veterinary Supplies and Raw Materials	-1.00	-2.00	6.00	-6.00	6.00	3.50	-7.50	-0.14
Energy Consumption	12.00	2.00	-2.00	-4.40	-6.00	2.00	-12.00	-1.20
Atmospheric Emissions	5.40	-0.80	-2.20	-3.00	-0.90	1.10	-0.10	-0.07
Soil Quality	7.50	7.50	15.00	15.00	7.50	7.50	15.00	10.71
Water Quality	0.75	5.25	0.75	-1.75	-2.00	2.75	0.75	0.93
Biodiversity Conservation	2.10	2.20	1.30	0.00	5.10	-7.50	8.30	1.64
Environmental Recovery	2.80	0.00	0.40	2.40	6.00	-0.20	3.00	2.06
Socio-Environmental Impact Indicators								
Product Quality	5.00	-5.00	0.00	1.25	7.50	3.75	5.00	2.50
Share Capital	-0.35	1.50	0.00	1.25	1.75	2.20	3.00	1.34
Animal Welfare and Animal Health	10.50	11:00	3.25	3.75	10.00	5.25	8.50	7.46
Training	-2.50	6.75	0.00	8.25	3.75	5.00	8.25	4.21
Qualification and job offer	-1.76	0.27	-0.90	0.00	0.34	0.12	-1.44	-0.48
Quality of Employment	0.75	1.00	-3.25	3.50	1.00	0.00	0.00	0.43

Income Generation	5.00	15.00	-3.75	15.00	15.00	6.25	15.00	9.64
Diversity of Income Sources	-4.00	0.75	-3.25	7.50	4.25	2.50	10.75	2.64
Property Value	5.25	5.75	8.75	10.25	12.25	4.75	13.50	8.64
Environmental and Personal Health	1.00	-0.40	0.40	-2.40	-0.40	9.00	0.20	1.06
Occupational Health and Safety	13.50	-1.50	5.00	-0.50	-1.50	6.50	1.25	3.25
Food Safety	3.00	3.00	1.50	2.20	5.10	0.90	6.00	3.10
Dedication and Profile of the Responsible Person	7.50	10.00	2.00	0.00	7.00	2.25	9.75	5.50
Marketing condition	3.75	6.00	-0.75	9.00	2.50	1.00	0.00	3.07
Waste disposal	12.00	15.00	9.00	7.00	3.00	11:00	15.00	10.29
Management of chemical inputs	-12.75	4.00	-5.25	-3.50	0.00	0.00	0.00	-2.50
Institutional Relationship	-3.25	3.75	1.75	3.00	8.25	3.00	8.25	3.54
Activity Impact Index	**3.82**	**4.07**	**1.82**	**2.92**	**4.23**	**2.90**	**3.83**	3.37

These improvements are also related to the increase in herds, made possible by the greater availability of food, and the diversification of activities, achieved through the integration of agricultural activities.

Regarding social aspects, the indicator “Dedication and profile of the person in charge” was positively influenced by technological innovation, from the moment in which several training sessions aimed at the activity took place, seeking a better understanding of the agroecological issues of organic management and the technical and social issues inherent to these principles and the requirement for the farmer to remain on the establishment, due to the practices and the increase in agricultural activities.

According to GAZOLLA (2004), the greater dedication can also be explained by the greater demand for family consumption in the search for food security. In this indicator, in conventional production, the value obtained was $\mu = -3.07$, rising to $\mu = 5.77$ in organic beef production. Comparing conventional production and organic production, the variation was $\mu = 8.57$.

In the analysis of the indicators together for “Environmental and personal health”, “Occupational health and safety” and “Food safety”, all showed a more discreet variation between conventional management and organic management, with this variation for the first indicator being $\mu = 3.69$ between conventional production ($\mu = -2.63$) and organic production ($\mu = 1.06$). In the case of the Occupational health and safety index, the variation between the two forms of production was μ = 9.64 between conventional production (μ = -6.43) and the activity in transition to organic (μ = 3.25). The food safety index showed a variation between the two forms of management of μ = 5.77.

It is observed that the lower emission of air and water pollutants, soil contaminants and residues in food is closely related to the practices of agroecological principles and directly influenced these indicators. Regarding the indicators of waste disposal, the highest differentiation index obtained (μ = 16.43) and Management of chemical inputs, the lowest differentiation index observed (μ = -5.29) which were positively and negatively evaluated, also showed an influence on the indicators of environmental and personal health and Occupational health and safety (Table 3).

Table 3. Differentiation values of the Ecological and Socio-environmental impact indices between conventional and organic management in milk production units in the Federal District and the surrounding integrated region estimated by the Ambitec-Agro System, between 2012 and 2013.

Impact Coefficients (Differentiation)								
Producer	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Average overall impact index				**5.50***				
Ecological Impact Indicators								Average
Use of Agricultural Inputs and Resources *	**23.00**	**1.25**	**12.50**	**15.25**	**14.00**	**10.25**	**-3.50**	**10.39**
Use of Veterinary Supplies and Raw Materials	4.00	0.50	13:00	-2.00	13:00	7.00	-5.50	4.29
Energy Consumption	24.00	6.00	7.00	-4.40	-9.50	6.50	-8.00	3.09
Atmospheric Emissions	11.60	-1.60	-1.20	4.00	-1.00	3.80	-0.40	2.17
Soil Quality *	**12.50**	**12.50**	**27.50**	**25.00**	**22.50**	**6.25**	**27.50**	**19.11**
Water Quality	0.75	8.25	1.50	0.25	-3.75	4.50	1.50	1.86
Biodiversity Conservation	3.60	3.20	2.20	0.00	8.10	-18,00	2.30	0.20
Environmental Recovery	0.40	-2.40	-2.00	0.80	3.00	-0.80	2.40	0.20
Socio-Environmental Impact Indicators								

Product Quality	-1.25	2.50	-1.25	0.00	10.00	5.00	12.50	3.93
Share Capital	-1.20	2.60	0.10	0.95	2.15	2.10	2.65	1.34
Animal Health and Welfare *	**6.00**	**16:00**	**5.75**	**2.00**	**20.00**	**12.00**	**17.00**	**11.25**
Training	-7.50	12.50	-2.75	0.00	5.00	6.25	9.75	3.32
Qualification and job offer *	**-3.62**	**0.00**	**-1.93**	**-0.02**	**0.56**	**-0.30**	**-4.95**	**-1.47**
Quality of Employment	-1.75	0.00	-4.25	3.50	2.00	0.00	0.00	-0.07
Income Generation *	**-2.50**	**25.00**	**-7.50**	**30.00**	**30.00**	**8.75**	**13.75**	**13.93**
Diversity of Income Sources	-15,00	4.00	-4.00	10.50	9.00	-1.25	7.25	1.50
Property Value *	**5.75**	**14.00**	**11.75**	**17.00**	**21.00**	**9.75**	**26.25**	**15.07**
Environmental and Personal Health *	**3.20**	**2.60**	**1.60**	**-1.80**	**2.00**	**18:00**	**0.20**	**3.69**
Occupational Health and Safety *	**26.50**	**-0.50**	**13.50**	**3.00**	**5.00**	**15.00**	**5.00**	**9.64**
Food Safety *	**6.00**	**5.40**	**2.70**	**4.40**	**10.20**	**-0.30**	**12.00**	**5.77**
Dedication and Profile of the Responsible Person *	**9.75**	**23.00**	**1.00**	**-5.25**	**15.50**	**1.50**	**14.50**	**8.57**
Marketing condition	1.50	12.00	-2.75	12.00	3.25	-0.50	-4.50	3.00
Waste disposal *	**18:00**	**30.00**	**15.00**	**15.00**	**-3.00**	**14.00**	**26.00**	**16.43**
Management of chemical inputs *	**-21.50**	**3.50**	**-10.50**	**-8.50**	**0.00**	**0.00**	**0.00**	**-5.29**
Institutional Relationship	**-9.25**	**5.75**	**1.00**	**1.00**	**5.50**	**3.75**	**15.00**	3.25
Activity Impact Index	4.34	8.08	3.26	4.85	7.66	3.96	6.38	5.50

(*) Indicators with statistically significant difference at the 5% probability level in the Wilcoxon test.

The technologies used for organic milk production management had a low influence on the “Qualification and labor supply” indicator due to the need for labor, observed in livestock activities, which was met by family labor relations. This had a negative impact, as it was the second lowest significant index (μ = -1.47) observed, which, together with the Management of chemical inputs, contributed to the reduction in the average overall impact index of the organic milk production management technology.

Finally, the animal welfare indicator was also considered, which encompasses the forms of raising animals under pasture and under confinement, the latter being not practiced by any of the producers, since only semi-confinement is permitted in the legislation on organic animal production (BRASIL, 2011). The animal welfare index did not show great variation between conventional and organic livestock farming, with this variation of 2.73 between conventional (μ = -0.24) and organic production (μ = 2.48), being the fourth index with the greatest variation of the socio-environmental indicators (Tables 3 and 4); however, its evaluation is of utmost importance as addressed by (HURNIK, 1992); (MIRANDA, 2011).

The “Product quality” indicator did not show significant differences ($p>0.05$), which was not expected, since one of the main advantages of organic production is the added value to the product, especially in relation to quality, as it is considered a food free of chemical residues. The small variation was consequently due to Federal Inspection and Legislation (IN 46), which is strict, especially regarding chemical contaminants (FIGUEIREDO, SOARES, 2012).

In the general assessment, based on conventional cow's milk production, that is, in the period prior to organic conversion (2012), the average general impact index of the activity was in the order of μ = -2.13. With the migration to the system in transition to organic milk (2013), the average general impact index rose to μ = 3.37, with the differentiation between the two forms of production being μ = 5.50 (Tables 2, 3 and 4). This result confirms that the adoption of methods for organic production tends to be beneficial to the environment (FIGUEIREDO and SOARES, 2012), since it promoted an increase of 18.35% in the average impact index over the two years (Table 4).

For a better explanation of the results obtained from the groups of producers, a comparison was made between the seven milk producers in transition to organic production, with groups ('clusters') being formed among the producers who obtained greater increases in the indicators of ecological and socio-environmental impacts in the evaluation of the organic management technology (Table 4 and Figure 3).

The first cluster analyzed grouped the producers who obtained the best indexes of the ecological impact indicators, being producers 1, 2, 6 and 7, (Figure 3) who presented the differentiation values of the impact index of the organic management technology of milk production between μ = 4.34 and μ = 6.38, demonstrating the greater concern of these producers with the ecological aspects of production (Table 4). These producers, on average, presented an increase of 18.9% in the average environmental impact index.

Table 4. Coefficients of change in the criteria of the Ambitec-Agro indicator system and the percentage of increase in technology (PIT) as a function of the effect of technology.

PIT - PRODUTORES				
Farmer	**Conventional**	**Transition**	**Difference**	**PIT**
1	-0,52	3,82	4,34	14,47%
2	-4,01	4,07	8,08	26,93%
3	-1,44	1,82	3,26	10,87%
4	-1,93	2,92	4,85	16,17%
5	-3,43	4,23	7,66	25,53%
6	-1,06	2,90	3,96	13,20%
7	-2,55	3,83	6,38	21,27%
Mean	**-2,13**	**3,37**	**5,50**	18,35%

In the second cluster analyzed in the group of indicators, the socio-environmental technologies are grouped with producers 2, 4, 5 and 7, as can be seen in Figure 3, whose differentiation values of the impact index of the organic management technology for milk production are between μ = 4.85 and μ = 6.38, presenting an average percentage increase in the technology of μ 22.5%. In these clusters, the producers stood out for their environmental concern, since they presented the highest values of the differentiation indexes before and after, during the data surveys, they were already using good environmental practices, only requiring adjustments with the change to organic production, as required by law (BRASIL, 2011).

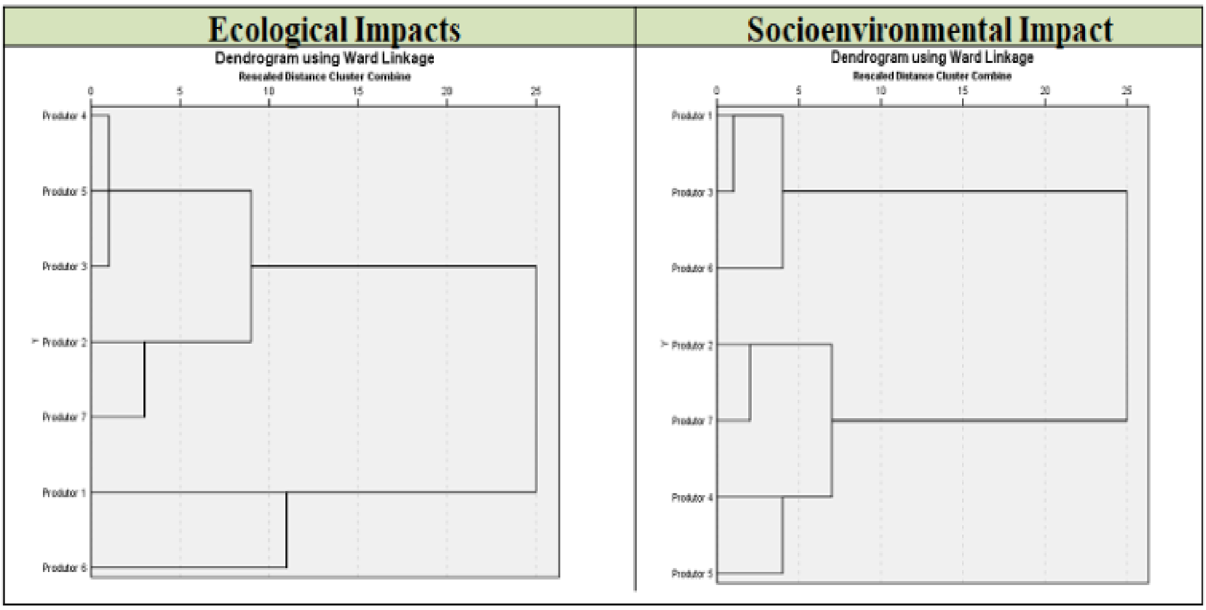

Figure 3. Cluster analysis to classify the ecological, socio-environmental and integrated impact indices observed among the seven milk producers in the process of transition to organic production selected in the present study.

There was an increase of 18.35% in ecological and socio-environmental indicators. It was noted that the improvement in these indicators was provided by the technologies used in the transition from conventional production to the organic milk production system, demonstrating the activity's capacity to generate better results, both financially and environmentally.

The proposed analysis made it possible to identify which indicators evolved best over two years with the implementation of the technologies used for organic production as provided for in normative instruction IN 46 (BRASIL, 2011). These include pasture management in rotational systems with a consortium of grasses and legumes in silvopastoral systems and the use of alternative inputs for soil fertility management that were used by producers.

The group of producers that presented the best socio-environmental and ecological impact indexes was the one that included producers: 1, 2, 6 and 7, as they were those that obtained the highest values of the general impact indexes of the activity. This can be explained by the fact that they were already more advanced in the agroecological transition process since the beginning of the studies. In addition, these producers had already participated in other programs, such as the “bucket full” program, which ended up providing greater technical capacity for production than the other participants in the study .

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