

Growth and Productive Sophistication of Minas Artisanal Cheese from Canastra: An Analysis Based on Innovative Processes in Natural Resources

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Keywords

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Abstract

This article aims to delineate the role of innovation in the successful outcomes of Minas Artisanal Cheese (QMA) from Canastra. The methodological foundation is built upon literature review, documentary analysis, field research, and interviews. Our findings reveal the interplay between traditional and scientific knowledge as a pivotal element in the productive sophistication of Canastra's QMA, facilitating work enhancement and striving to meet consumer market demands while maintaining local know-how and practices, which the society-nature relationship has historically shaped. The discussion is situated within the realm of empirical studies on natural resource-based innovation in Latin America and reflections on Territorial Innovation Systems (TIS), which consider a multiscale perspective of the innovation process prevalent in studies in the field of Knowledge and Innovation Geography. Despite advancements, we underscore that the establishment of Canastra's QMA still faces challenges stemming from typical structural frailties of peripheral TIS. We aspire that these results not only contribute to comprehending the productive region of Canastra's QMA but also serve as a supportive framework for innovation policies that acknowledge the necessity of contextual considerations in regional realities.

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INTRODUCTION

The discussion surrounding the innovative process in natural resources in peripheral countries has sparked significant interest in the literature (Caye *et al.* 2020; Giuliani; Bell, 2005; Iizuka; Gebreyesus, 2016; Katz *et al.* 2011; Martínez; Rivera, 2018). Building on a proposal to study analogies between cases whose productive logic is based on natural resources (Andersen *et al.*, 2015), the objective of this article is to recognize the role of innovation in the recent growth (both quantitatively and qualitatively) of Minas Artisanal Cheese (QMA) production in the Canastra region of the state of Minas Gerais.

The way cheese is produced in Canastra has experienced, especially in the last twenty years, a reaffirmation of customs and traditions, including as a means of complying with registration requirements. This required strengthening the local production methods and support from public and private institutions, generally in education, research, and extension. Through multiscale practices and the integration of various forms of knowledge, the social agents involved in this dynamic have brought about transformations that have contributed to establishing an innovative system. The structuring of this system has been crucial for consolidating the growth and productive sophistication of Canastra's Minas Artisanal Cheese because it has promoted the revitalization of production processes, the pursuit of meeting consumer market standards, and the preservation of local know-how and practices.

This production chain's qualitative and quantitative growth can be evidenced based on several significant historical moments. The first law about QMA dates back to 2002, and QMA became a Brazilian Intangible Heritage in 2008. Canastra's QMA was granted a Geographic Indication (GI) label in 2012 and won several awards in national and international competitions in 2015, 2017, 2019, and 2021. In this context, in 2018, the "Selo Arte" (Artisan Seal) was sanctioned (Federal Law 13.680), the first Brazilian law specifically regulating the artisanal production of raw milk cheeses.

The pillars of our research were established through questions developed during the analysis of case studies that exhibited some similarity to the innovative system involving Canastra's QMA. The research was directed toward understanding the alignments with the literature addressing innovation in peripheral contexts and identifying the specificities that

indicate the participation of an innovative dynamic in the successful outcomes of this production chain. It is worth noting that innovation poses one of the challenges for the members of this productive dynamic, and this article also discusses the difficulties in this production territory.

The approach to territorial innovation systems (TIS) pointed out by Fernandes (2016) is used here to emphasize the need for the innovation process to be considered from a multiscale perspective, wherein the local context is subject to its positioning in a national and international labor division. We believe that the literature concerning these themes contributes to a better understanding of the elements that have contributed to structuring innovations in Canastra's QMA production chain.

To establish this theoretical and empirical discussion, the methodological foundation consists of a literature review, documentary analysis, field research, and interviews. Without exhaustively covering the debate on the subject, the text is structured based on literature that directly relates to its central theme; then, the main methodological aspects are presented, followed by the results and responses to the questions raised, and finally, the concluding remarks.

Natural Resources and Innovative Processes in Peripheral Regions

The innovation process in activities heavily reliant on natural resources differs from the patterns observed in other sectors, such as services and manufacturing. As previously highlighted by Rosenberg (1976), ecological conditions directly influence the production process in agriculture, introducing unique characteristics into technological trajectories. Productive success in the agricultural context depends on the natural environment's attributes, including topography, precipitation, sunlight, temperature variations, and soil chemical composition.

Andersen *et al.* (2015) delve deeper into this topic by exploring the "idiosyncrasy of natural resource knowledge concept." According to their perspective, each natural environment possesses a distinctive combination of endowments and technological capabilities. Therefore, the diversity of natural spaces often necessitates specific innovations that require developing and applying knowledge in the local context. For innovative success, the new technologies developed in these areas must align

with the cultural and ecological characteristics of the geographic space.

Productive systems based on natural resources rely on innovation to achieve productivity and profitability advances and overcome specific limitations imposed by the natural environment on the production process. To achieve this, “the production of natural resources necessitates innovative inputs from a range of knowledge-intensive services and manufacturing activities, along with support for

the development of science and technology (S&T)” (Andersen *et al.*, 2018, p.7).

The strategy of innovative practices in natural resource-based production, especially in peripheral countries, has garnered attention in recent studies. Table 1 presents a collection of studies, authors, products, and locations; the primary challenges encountered in the production process under consideration; and the actions identified as critical for the success of the production chains under analysis.

Table 1 - Empirical Studies on Natural Resource-Based Innovation

Authors/Year	Product(s)/ Country(ies)	Key Actions for Successful Outcomes
Giuliani and Bell (2005)	Wine / Chile	Institutional investment in applied research in viticulture and enology; exchange between producers and research institutes and universities; accumulation of knowledge acquired through communication with consultants and suppliers of materials and machinery; well-established connection with international sources of expertise; intermediation of specific institutions to support exports.
Caye <i>et al.</i> (2020)	Olive oil / Brazil (Rio Grande do Sul)	Various technological knowledge flows were developed (international exchanges; Empresa de Assistência Técnica e Extensão Rural - EMATER (public company supporting family farmers with technical guidance, training, and technology to improve farm productivity and rural development); Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA (public research institution focused on the development of technologies and innovation in the agricultural sector in Brazil); investments in foreign technology; pursuit of professional qualification (both domestically and abroad); quality legitimization for the product based on awards in international competitions; firms possess a significant absorption of technological knowledge.
Iizuka and Gebreyesus (2016)	Flowers / Ethiopia and Salmon/Chile	In both cases, there was an appropriate combination of production factors, technological choices, and market niches; knowledge creation and diffusion were developed progressively based on “learning by doing and interacting” and entrepreneurial experimentation. Capacity logistics, human resource development, and adaptation to international standards were achieved.
Katz <i>et al.</i> (2011)	Salmon / Chile	Strong government support; international sources (USA, Canada, and Japan) for technological support, technical assistance, and financing; creation of an association; development of local technology for domestic manufacturing of utensils (nets, cages) and feed; knowledge exchange between Chilean and foreign companies; successful application of new technologies adapted to local ecological conditions, which led to significant involvement of multinational corporations.
Martínez and Rivera (2018)	Artisanal cheeses and rice / Mexico	Rice: support from the local government and research institutions; interaction between producers and researchers; incorporation of technological innovations; development of quality standard regulations; achievement of the Designation of Origin seal. Cheeses: linkage to research centers and other local and non-local institutions; organization in an associative manner; participation in a government program with support; innovative efforts related to new production processes; better utilization of natural resources and local knowledge.

Source: Adapted from Bastos (2022).

Most of the challenges identified in the works listed in Table 1 are related to the need for greater access to knowledge, technology, and infrastructure. Therefore, the practices that directly contributed to a successful productive reorganization of these production systems focused on the exchange of knowledge based on science and local know-how; the introduction of new technologies (by internal or external agents); and the support (technical assistance and/or financing) from local and non-local (public and private) institutions.

Hence, nature and primarily socioeconomic conditions act as limiting factors in innovative processes. As Fernandes (2016, p. 132) points out:

The territory and its attributes are factors that encourage or limit the possibilities of producing and disseminating new products and processes, so these will not occur except in appropriate conditions, which are not always available in a given territory.

The notion of a Territorial Innovation System (TIS) places the understanding of local innovative processes in a “space of complex relations among various agents, located within a specific spatial framework but interconnected with other frameworks at different scales, coming together for the production, appropriation, and dissemination of innovations” (Fernandes, 2016, p. 132). Such a system comprises components of the productive sector, which can be local but are interconnected with external components, such as research, the market, and the production of inputs and technology (Fernandes, 2016).

The TIS supports the creation of scientific knowledge that transforms nature according to the rationality of a technical-scientific-informational milieu (Santos, 2013), which is understood through the circulation of knowledge flows of hegemonic agents as well as the structuring of small producers’ coexistence and resistance. These characteristics and determinants can be observed in the case of Canastra’s Minas Artisanal Cheese (QMA), as explored in the following sections.

METHODOLOGY

This study’s methodological foundation is structured in a qualitative approach. It is consolidated through a literature review and documentary analysis (with a focus on the

relevant TIS), as well as field research and interviews (including the development of a field diary) that allowed for immersion in the region, engagement with producers, and understanding of the production process in detail.

The interviews were conducted in 2021 (from January to September) with 22 producers and 22 researchers involved with QMA from Canastra. Due to the challenge of precisely determining the sample universe, the saturation criterion used was the snowball sampling method, which consists of asking for new interviewees’ recommendations at the end of each interview (Goodman, 1961).

Subsequently, invitations were extended, new interviews were conducted, and the conclusion was reached when enough robust data were collected to address the research questions, focusing on repeating recommendations from interviewees. In addition to this sample, interviews were conducted with members of two grassroots organizations that stand out in supporting and representing producers, the Associação de Produtores de Queijo Canastra - APROCAN (organization that promotes the valorization, preservation, and regulation of artisanal cheese production in the Serra da Canastra region) and the NGO SerTãoBras. Due to the social distancing measures imposed by the COVID-19 pandemic, the interviews were conducted remotely and with the approval of the Ethics Committee (CAAE: 18724819.3.0000.8142).

Therefore, the primary methodological source adopted was the interview, and the triangulation of data acquired from various sources of information proved effective in achieving the intended objectives.

Specifics of QMA Production

Cheese production has been a part of Brazil’s history since the colonial period of gold exploration, particularly in Minas Gerais State. Over time, the production process spread to various parts of the state, adapting the methods to the natural and technical resources available in the colony (Meneses, 2006).

Concerning cheese production in Brazil, it can be said that the national market includes many small and micro dairies that often characterize their production as *artisanal*. However, to receive this designation, they must be “typically characterized by small-scale production, using milk produced on their own farms and following traditional cheese-making techniques specific to each region” (Kamimura *et al.*, 2019, p. 1636). These authors also argue that Brazilian artisanal cheeses have significant

historical and socioeconomic importance, especially because their distribution throughout the country helps maintain the connection between the product and the popular culture, which is essential for preserving this heritage.

Minas Artisanal Cheese (QMA), as demonstrated by Shiki and Wilkinson (2016, p. 257), “represents the economic and social foundation for nearly 30,000 rural families in Minas Gerais.” Most of the time, the nuances involved in producing artisanal cheeses indicate that developing the skills and technologies necessary for successful innovation must respect the characteristics of each locality. Martins *et al.* (2015) state that raw milk artisanal cheeses are involved in complex systems that result in unique sensory properties influenced by the production’s environmental conditions and maturation sites, local soil and climatic conditions, the indigenous microbiota involved in all processes, and variations in unpasteurized milk. Therefore, production methods can offer multiple possibilities for cheese based on each natural environment’s unique endowments and technological capabilities.

The “idiosyncrasy of knowledge about natural resources” (Andersen *et al.*, 2015) directs the understanding of the intrinsic characteristics of cheese production. It is important to note that there are various types of cheeses, a number that is difficult to measure due to the dynamism of cheese-making methods (culturally determined) and the natural characteristics of the production environment (milk and cheese), which can cause the same recipe to yield completely different results depending on the ecological, socioeconomic, and socio-cultural attributes of the location.

Due to the need to prove the safety of raw milk cheeses, agents involved in microbiological analyses, either independently or affiliated with inspection agencies, can also be essential for the success and continuity of the production process. Typically, producers receive specialized training when preparing for inspection procedures, which may involve other relevant agents in the system.

In the specific case of artisanal cheese in Minas Gerais, it is common for these actions to be promoted through institutions such as associations, unions, regulatory agencies at municipal, state, or federal level, educational, research, and extension institutions, the EMATER/MG, the Empresa de Pesquisa Agropecuária de Minas Gerais- EPAMIG (public institution focused on research, development, and innovation in agriculture and livestock in the state of Minas Gerais), and the Serviço Brasileiro de Apoio às Micro e Pequenas

Empresas - SEBRAE (private institution that provides guidance, support, and training for micro and small businesses in Brazil). In these cases, the diversity of techniques and agents is even more evident, interacting with each other in multiple ways.

Idiosyncrasies of Canastra’s QMA Innovative Process

To comprehend the idiosyncrasies within the Science, Technology, and Innovation (STI) system of which Canastra’s Minas Artesanal Cheese (QMA) is a part, we examined the specific processes that have led to the growth, both quantitatively and qualitatively, of this production chain. These analyses point to a discourse focused on understanding innovative practices arising from the interaction between traditional, local and scientific knowledge that relies on contact with nature. In this context, we also discuss the dynamics that highlight the main obstacles and the ways to overcome barriers established in this innovative system.

The knowledge interaction in the consolidation of Canastra’s QMA Innovative System

Despite having a history dating back at least two centuries, the artisanal production of raw milk cheese in Brazil only gained greater recognition and innovative strategies in the past two decades. A historical moment considered pivotal in the increased appreciation of the product was the silver medal awarded to Canastra’s QMA at the Mondial du Fromage et des Produits Laitiers, the world’s premier cheese competition, in France in 2015. This achievement’s positive impact on the region contributed to a better understanding of this product’s immense market potential. It triggered significant discussions about the challenges in obtaining sales authorization with the relevant regulatory authorities.

The peculiarity of the knowledge in cheese production underlines its dependence on natural resources and the production process’s central agents, especially in territorial demarcation and the establishment of knowledge flows. It is worth noting that Canastra’s QMA is produced with raw milk and is characterized by unique sensory attributes.

Therefore, the cheese production method in Canastra has reaffirmed customs and traditions, including adapting to registration requirements, strengthening local production practices, and receiving support from public and private institutions, typically in education,

research, and extension. Operating across multiple scales, the interaction between the social agents involved in this process, each with their distinct knowledge and presence, simultaneously enables the dynamization of production to meet the quality standards of the consumer market and the preservation of local traditions and practices. We believe these transformations have contributed to establishing an innovative system involving the production chain of this type of cheese.

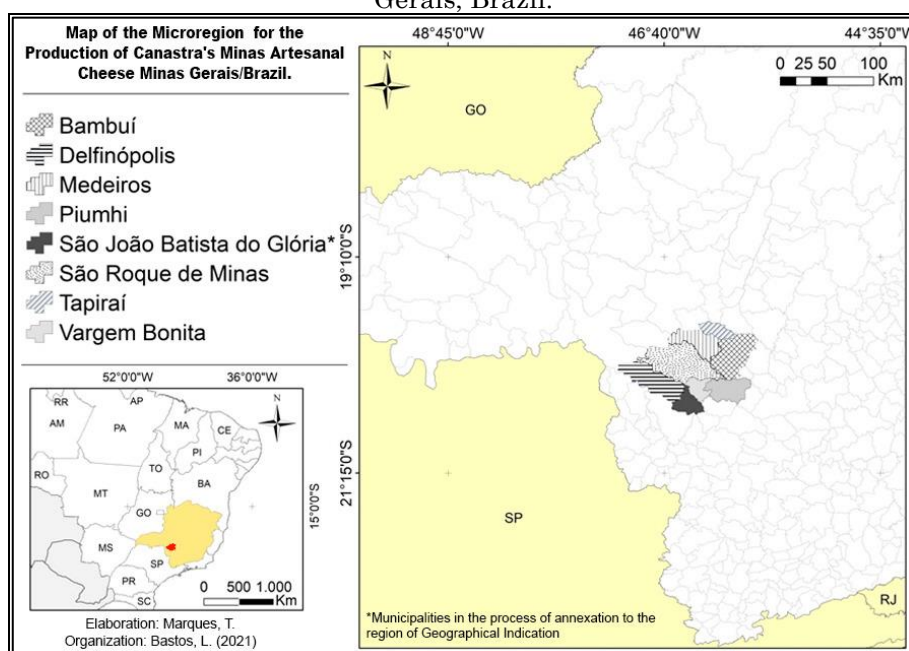
The changes during the mentioned historical period are part of a global dimension of production restructuring and social reorganization that have established innovation and knowledge as the most effective means for socioeconomic advancement. In this manner, science and technology can also be produced and territorially appropriated by individuals and institutions that are not among the world's dominant hegemonic agents. Projects developed in peripheral contexts also have the potential to create innovations and generate knowledge through the interaction of diverse forms of expertise from agents established at different scales.

The innovative system involving Canastra's QMA is established in a peripheral region of

Brazilian national territory, with a logic of small-scale production and social articulations across various scales: local, regional, national, and international. Albuquerque (1996), analyzing national efforts related to Science, Technology, and Innovation (STI) development based on categories from the international literature on innovation systems (Lundvall, 1992), argues that Brazil is in an ongoing structuring process and lacks many of the elements necessary to be classified within a central socioeconomic position.

The innovative system in the Canastra Microrregion has distinctive characteristics that contribute to its strengthening. Furthermore, it is evident that among the critical social agents contributing to the consolidation of this production chain are those directly involved in the production process of this QMA and researchers working in the STI field. This microregion, delimited by EMATER/MG, encompasses seven municipalities: Tapiraí, Medeiros, Bambuí, São Roque de Minas, Vargem Bonita, Delfinópolis, and Piumhi, all connected to the Serra da Canastra in Minas Gerais, Brazil.

Figure 1 - Map of the Microregion for the Production of Canastra's Minas Artesanal Cheese – Minas Gerais, Brazil.



Source: Bastos (2022)

The GI was awarded to cheese produced with raw milk (from specific cattle) in an artisanal manner within an area delimited by characteristics of the pasture that are linked to local climate, altitude, terrain, soil, and water - defining its *terroir* (see Figure 2). *Terroir* is

commonly defined as the unique character of a food product resulting from specific edaphoclimatic conditions. In other words, it is a complex interaction between soil, plants, and climate combined with traditional production methods and raw materials (APROCAN, 2011).

Figure 2 - The terroir of the Serra da Canastra characterizes the cheese produced there.



Source: Silva (2018).

* On the image board: Gastronomic Routes of Canastra Minas Artesanal Cheese

The peculiarities of the knowledge about natural resources can be associated with a broader understanding of the meaning of terroir. Casabianca *et al.* (2005) emphasize that terroir can be understood as a territory constructed by a group of individuals who have developed specific collective knowledge, and this learning is linked to how this community interacts with each other and the natural environment. In other words, terroir is formed by a set of socio-cultural and biological specificities that give rise to the construction of collective knowledge historically established and typical of a particular place.

Based on Benko and Pecqueur (2001), we can state that the productive condition established in the Canastra Highland was built from resources anchored in a territory that becomes used as specific assets. In the local strategy of its agents, the dynamics established around these resources “result in the effect of rules, customs, a culture developed in the space of geographical and cultural proximity” (p. 46). Thus, “the specific resource of a territory, taken globally, then appears as the result of a long process of collective learning that ends in the establishment of tacit rules” (p. 47).

Challenges and solutions in the innovative system involving Canastra’s QMA.

As terroir can be a determinant for the socioeconomic dynamics established in the territory, it was observed that the interaction between individuals in the Canastra’s QMA production chain and their physical and social environment generates successes and obstacles.

For families that depend economically on cheese, obtaining authorization for sales is one of the most significant challenges. The fact that raw milk cheese was ignored in Brazilian regulations dealing with animal origin production, in a way, established its inability to meet inspection standards, created the interpretation that it was a product with food insecurity, and prevented producers from issuing invoices. At the same time, a significant economic devaluation of the product was consolidated, associated with the increasing dependence of producers on go-betweens. Historically, the commercial production of this type of cheese has always depended on non-local sales to flourish.

Producers’ efforts towards regulation generated various conflicts, especially between producers and inspectors. These power relations are consolidated in the territory in a very complex way. They are based on disagreements caused, most of the time, by a lack of understanding of each other’s knowledge and suitable legislation for that production process.

Often, these difficulties reinforced the bond between the region’s producers and go-betweens (known as “queijeiros”), mainly because they were the ones who assumed the risk of having the product seized by supervisory bodies. As a result, the *queijeiros* determined how much they would pay for the product, and, in this context, many producers abandoned the commercial practice.

Several movements have directly contributed to reducing these conflicts, including a) efforts around the need for adequate legislation for the production of raw milk cheese motivated the regulation of the Selo Arte law, the first national

law that qualifies this type of product; b) the consolidation of municipal inspection seals (SIM) in Canastra municipalities created the possibility for inspections to be conducted by people who are already familiar with the local artisanal production process and, in general, established protocols considered more suitable for that type of production; c) producers started to receive more training and had more contact with social agents (researchers, teachers, extensionists) who understand the parameters imposed by pasteurized dairy legislation. Therefore, they had the opportunity to collectively reflect on the “good manufacturing practices” capable of ensuring the required microbiological quality without changing the artisanal product’s nature. These three movements increased the number of registered producers (with bodies supervising animal-origin food production) and concurrently improved the cheese’s quality.

However, commercial intermediation by *queijeiros* is still dominant, mainly because most Canastra producers do not have the socioeconomic conditions to invest in structural changes to obtain sales authorization. Nevertheless, the activity is considered profitable with the increasing valorization of the product. It is common for producers to gradually experiment with selling part of their production directly to customers without giving up on *queijeiros*. This way, they gain empowerment and autonomy until they no longer need the support of these intermediaries.

The lack of transportation infrastructure and access to communication means also generates dependence on go-betweens. This often occurs because the budget constraints of many producers make commercial autonomy unfeasible, such as the difficulty of buying a vehicle suitable for transportation on unpaved roads. Furthermore, many producing families argue that they do not have time to dedicate to sales, do not have access to the communication means that would facilitate this commercialization or do not have the skills to use digital technologies that are accessible to them.

Most of these families’ productive autonomy depends on the support of various institutions, as it requires a series of structural, economic, and social adaptations that will only be established through financial and educational support. In this perspective,

(...) the promotion of horizontal integration of social groups less benefited by scientific and technological development can contribute to making

them subjects of the political use of science and technology decision-making, particularly in the case of peripheral or subordinate socioeconomic formations (Fernandes, 2016, p. 115).

Technology has been an ally in overcoming challenges in Canastra, and a good example is the adoption of casein seals. Numerous cases of misuse of the “Canastra” brand and label counterfeiting occurred. The search for traceability strategies led to a partnership with a French company that produces labels with an IG-registered trademark that numerically identifies the producer and the product. Furthermore, there is a significant nationwide effort to help consumers understand which municipalities are part of the Canastra geographical microregion and to encourage reporting irregularities.

The peculiarities of Canastra’s QMA can reveal both challenges and opportunities. In terms of challenges, distinctions (physical, chemical, microbiological) in the outcome of the production process stand out, often due to seasonal fluctuations in temperature and humidity. The lack of knowledge regarding the reasons behind these “irregularities” in the cheese (in terms of taste, aroma, color, or texture) creates considerable uncertainty. The questions raised by this condition have turned into an opportunity to generate knowledge and innovation since it became clear that a better understanding and documentation of these distinctions were necessary. Producers also noted that it was possible to “create” new types of cheese. The wide diversity of QMAs that can be produced adds value to the product (both symbolically and financially) while instilling a fear that innovative processes might alter Canastra’s cultural heritage.

It is common for some of these variations of Canastra’s QMA to gain prominence in international cheese competitions. There are very controversial opinions about changes in the manufacturing process and the possible loss of authenticity of this product/heritage. The main focus is on the different aging strategies, which can also result in highly unique outcomes concerning new types of cheese. However, the non-local demand for products with distinct aging methods is so significant (and the supply so insufficient) that it becomes increasingly economically attractive to consolidate the production of new varieties. Producers seeking to meet this demand through profit and additional financing have invested in the necessary adaptations to register with

regulatory authorities, obtain invoices, and increase the product's value.

Table 2 synthesizes the central challenges and successful actions within the studied

context. This table also highlights the operation scale, clarifying the scope of each group of measures developed to overcome the challenges mentioned.

Table 2 - Challenges and Solutions Developed in the Innovative System Involving Canastra's Minas Artisanal Cheese (QMA)

Main Challenges	Critical Actions to Achieve Solutions	Scale
1. Lack of appropriate legislation	French mission visit to Canastra; creation of state laws; establishment of collective organizations to seek qualification, legal, and fiscal adjustments; collaboration with R&D institutions to highlight product specifics and safety.	Regional, national.
2. Dependency on go-betweens (cheesemakers)	Explore new marketing options (direct-to-consumer, agricultural and gastronomic fairs, retailers, chefs).	Local, regional.
3. Economic sustainability (small-scale production and undervalued)	Collectively, producers sought external recognition (designation, label, gastronomic competitions, media exposure) and new markets to gain higher value.	Local, regional, national, and international
4. Lack of sales authorization	Training in good manufacturing practices; structural adaptations in the manufacturing process (loans/financing); pursuit of municipal-level registration (creation of the SIM).	Local, regional, and national.
5. Lack of transportation infrastructure	Selective road improvements in some municipalities; new means of transportation (postal services, carriers); financing for four-wheel drive vehicles.	Local.
6. Lack of access to communication	Access to communication through phone and the internet; increased involvement of younger family members in marketing and sales strategies; higher education, facilitating digital technologies, and engagement in social networks.	Local, regional, national, and international
7. Counterfeiting of Canastra's QMA/ Misuse of the brand	Achievement of Geographic Indication (GI) with geographical area delimitation; importation of casein labels for tracking.	National and international
8. Seasonal production (seasons of the year)	Greater understanding (physical, chemical, and microbiological) of differences between types of cheese (dry season and rainy season); increased appreciation of their specific characteristics.	Local.
9. Innovating without losing identity (connection with tradition)	Detailed registration (Heritage, GI) and teaching new generations the cheese manufacturing method considered traditional while experimenting with new recipes and creating new products.	Local and national.

Source: Adapted from Bastos (2022).

Within Canastra's QMA production chain, the challenges and actions listed in Table 2 are in constant flux, operating across multiple transformation scales. While some difficulties are being overcome, positive results are being consolidated. Various social agents (individuals

and institutions) are collectively engaged in minimizing the negative impacts of the barriers that still hinder the robustness of this production system. However, the need for constant changes, mainly due to adaptations in regulations and inspection protocols to meet

external demands, is perceived by many producers as something negative. As a result, they are not willing to change their production or marketing methods. This kind of attitude is more common among producers for whom cheese production is not their primary source of income. Among the 21 producers interviewed, four shared this view.

CONCLUSION

Considering the debate on innovation based on natural resources that focuses on peripheral contexts, this study highlights Canastra's QMA and points out some similarities between its production dynamics and those presented in Table 1. Among these similarities are the need for a scientific foundation that supports the knowledge of local socio-environmental characteristics to define better production and regulation strategies; the classification in a sector composed of products that typically differentiate themselves through less standardization; the use of technologies that are minimally adapted to local socio-environmental specifics; and the establishment of knowledge exchange, promoting interactive learning aimed at the consolidation of the production chain. Regarding challenges, regulation, infrastructure, technology, and knowledge stand out. On the other hand, decisive actions for overcoming these problems include interactions between the understanding of local and non-local agents and institutions involved in the production chain, efforts to broaden the knowledge of local socio-environmental characteristics to define better production strategies, and the creation of new techniques and technologies adapted to local socioeconomic and environmental specifics. Maintaining production with lower standardization is also necessary to consolidate sales in high-value market niches.

The unique character of Canastra's terroir has been unveiled and cataloged primarily after 2000 through activities based on connections between producers and researchers. In this vein, science and technology can be used to improve the gains that unique environmental conditions offer to Canastra's QMA. As in empirical studies on innovation based on natural resources (Table 1), this production chain also depends directly on actions aimed at knowledge exchange. Through these knowledge flows and the construction of new knowledge (structured by cooperation between endogenous and exogenous agents), more assertive technologies and

innovative practices can be developed to meet local socioeconomic demands, even in the face of peripheral fragilities.

The collective activities developed to overcome difficulties in this production chain foster new occupations, qualifications, and even professions. Examples of these transformations include: a) the pursuit of autonomy in marketing stimulates digital marketing initiatives and generates new occupations; b) the expectation of obtaining sales authorization leads many producers to take courses and adapt their production methods; c) the appreciation of the numerous possibilities for maturing raw milk cheese has consolidated the profession of *maturer*, a professional who develops specific ripening methods and techniques to produce cheeses with new flavors, aromas, and textures. Such factors demonstrate the need for innovation as one of the production strategies and the institution of new labor practices in this production chain. The dynamism established by these actions impacts the production structure in various ways. It promotes interaction between knowledge at multiple scales, encourages innovative activities, contributes to problem-solving, and strengthens the local economy.

The results obtained contribute to a greater understanding and cataloging of the microbiological biodiversity in Canastra Highlands, a better understanding of the dynamics that promote differentiation among cheese types for possible adaptations in the production process and the creation of new products, a greater appreciation of the product's specificities and the natural resources that differentiate it, the consolidation of new knowledge that contributes to empowering producers, and finally the achievement of external exposure and greater notoriety.

Just as with wine and salmon in Chile, flowers in Ethiopia, artisanal cheeses and rice in Mexico, and olive oil in Rio Grande do Sul (to name a few), Canastra's QMA demonstrates that natural resources can gain competitiveness and enter high-value market niches with the help of innovation. Despite the typical structural weaknesses of peripheral regions, the producers in the Canastra region, in collaboration with science and technology institutions, have succeeded in promoting a complex knowledge exchange that underlies the various awards received by Canastra's QMA. We hope that the results of this work will not only contribute to understanding the specific production region but also serve as a supportive resource for innovation policies that consider the

need for a realistic approach to regional realities.

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AUTHORS CONTRIBUTION

Letícia da Silva Bastos, Flávia Luciane Consoni and Fernando Campos Mesquita conceived the study, collected, analyzed the data and wrote the text.



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