
A2
A2

The A2 milk as an upgrading strategy in the cattle global value chain in Brazil

O leite A2 como estratégia de upgrading *na cadeia global de valor bovina no Brasil*

ALESSANDRA POLASTRINI
Doutoranda em Desenvolvimento Regional do Programa de Pós-Graduação em Desenvolvimento Regional da Universidade Federal de Tocantins.
Palmas – TO – Brasil
orcid.org/0000-0002-8237-8810
alessandra.polastrini@mail.uft.edu.br

WALDECY RODRIGUES
Professor do Programa de Pós-Graduação em Desenvolvimento Regional da Universidade Federal do Tocantins. Atualmente, é Coordenador Adjunto de Programas Profissionais da Área de Planejamento Urbano e Regional no Brasil - CAPES (2018 -).
Palmas – TO – Brasil
orcid.org/0000-0002-5584-6586
waldecy@uft.edu.br

MANOEL XAVIER PEDROZA FILHO
Professor associado do Programa de Pós-Graduação em Desenvolvimento Regional da Universidade Federal de Tocantins.
Palmas – TO – Brasil
orcid.org/0000-0003-4144-0654
manoel.pedroza@embrapa.br

Abstract

The objective of this study was to evaluate the potential of the A2 milk as an upgrading strategy for milk producers in Brazil. The primary data were obtained through semi-structured interviews with eight strategic actors of the A2 milk chain in September and October 2021. Five producers, two researchers and one member of the movements called the #bebamaisleite. The study was led by the theoretical framework of global value chain, focusing on the upgrading dimension. A2 milk is an upgrading opportunity for producers, following a global trend of food premiumization. However, caution is needed for producers to enter this chain because the market is incipient, the costs are significant, and the financial return is uncertain. Otherwise, there will be a reproduction of the inequalities and bottlenecks which are present in the conventional dairy chain. It was found that the A2 milk chain is not intended to replace the conventional one, but it aims to capture vegetable beverages consumers.

Keywords: Added value. Cattle. Casein. Dairy products. A2A2 cows.

Resumo

Objetivou-se avaliar o potencial do leite A2 como estratégia de upgrading aos produtores de leite no Brasil. Os dados primários foram obtidos através de entrevistas semiestruturadas à oito atores estratégicos da cadeia do leite A2 em setembro e outubro de 2021. Foram entrevistados cinco produtores, dois pesquisadores e um do movimento denominado #bebamaisleite. O estudo foi norteado pelo arcabouço teórico de Cadeia Global de Valor, focando na dimensão upgrading. O leite A2 é uma oportunidade de upgrading aos produtores, seguindo uma tendência global de premiumização de alimentos. Entretanto, é preciso cautela para produtores entrarem nessa cadeia pois o mercado é incipiente, os custos significativos e o retorno financeiro incerto. Caso contrário, haverá uma reprodução das desigualdades e gargalos presentes na cadeia leiteira convencional. Constatou-se que a cadeia do leite A2 não tem a finalidade de substituir a convencional, mas capturar consumidores de bebidas vegetais.

Palavras-chave: Agregação de valor. Bovinos. Caseína. Laticínios. Vacas A2A2.

http://dx.doi.org/10.51861/ded.dmvdo.2.107
Recebido em: 16 de dezembro de 2021. Aprovado em: 30 de junho de 2022.

INTRODUCTION

The bovine species occupies a prominent place in several countries of the world, being important for the economy, environment, health, culture and even in the spirituality of human beings (JOSHI *et al*., 2021). Dairy activity is a source of continuous food, work and income, contributing significantly to regional development (ACETO *et al*., 2017). Milk is still one of the main commodities, improving the life of millions of people all around the world (FAO, THE GLOBAL DAIRY PLATFORM & IFCN, 2018).

Milk is one of the main foods for humans and it contains a rich nutritional composition (THIRUVENGADAM *et al*., 2021), which includes constituents such as proteins of high biological value, carbohydrates, lipids, vitamins and minerals (FAO, 2021). Because of this rich nutritional composition, milk is considered to be as a "perfect food of nature" (SHASHANK *et al*., 2018, p. 221). It has also been reported that milk performs various physiological functions in the body (GORKHALI *et al*., 2021).

Benefits have been attributed to the consumption of milk and its derivatives: reducing the risk of cardiovascular problems (TALAEI *et al*., 2017), type 2 diabetes (DÍAZ-LÓPEZ *et al*., 2016), dental caries, cancer, obesity, also helping in the improvement of learning and memory, are some of the advantages reported in the literature (LECERF, 2020) and also sleep improvement and circadian rhythm regulation (SANGSOPHA *et al*., 2020).

In the case of colostrum, studies have demonstrated the benefit of its consumption by people with inflammatory bowel disease, in nutrition, intestinal modulation and reduction of cytokine storm and immunological regulation (SIENKIEWICZ, SZYMANKA & FICHNA, 2021).

In addition to the benefits mentioned, milk is an affordable source of bioactive peptides, which are released from the main and the most abundant milk protein, casein, after industrial processing or gastrointestinal digestion (BROOKE-TAYLOR *et al*., 2017). Bioactive peptides are attracting the attention of researchers due to their benefits to human health, generating a scientific effervescence on the subject (THIRUVENGADAM *et al*., 2021). However, those originating from milk were still little studied and their effects were still uncertain, one of which was particularly worrisome, β-casomorphine-7 (BCM7) (SHASHANK *et al*., 2018). What is found is that there are significant differences in milk produced by the different breeds of bovine females, affecting in different ways the health of humans (THIRUVENGADAM *et al*., 2021). Thus, conventional A1/A2 milk can cause health damage in a portion of consumers (DE GAUDRY *et al*., 2019).

In this sense, there are studies reporting that bovine milk could be harmful to health, negatively affecting human nutrition and its added value, due to the relevance of dairy activity to the economy and food security (THIRUVENGADAM *et al*., 2021). However, these splurges need to be clarified, correctly, to consumers, and it has not happened worldwide and especially in Brazil.

Milk presents a significant difference in its nutritional and bioactive composition, depending on the species and even among breeds of the same species (FAO, 2021). And in this aspect lies a niche market of premium milk[1] or functional[2] which can benefit milk producers, adding greater value to milk production and consumers, and meet their expectations and needs with regard to superior organoleptic characteristics meaning that it contributes to the health of human beings (BARBOSA *et al.*, 2019).

In Brazil, the milk market is still incipient. The regulation for the inclusion of milk origin as of A2A2 cows in milk and dairy labels occurred in 2019 only. The inclusion on the label that the dairy products A2 have functional characteristics was regulated only in October 2021 through Resolution 3.980 of the National Health Surveillance Agency (ANVISA) (ABRALEITE, 2021). From then on it was allowed to claim on the label as "A2 milk does not promote the formation of BCM7, which causes digestive discomfort", that was previously prohibited. The first specific certification for A2 milk took place in 2019 (ABRALEITE, 2021).

Production is still symbolic and inaccessible to most of the Brazilian population, reaching only 1% of the national dairy chain, according to estimates by Abraleite. However, there is a growing interest in A2 milk well as other milk modalities regarded as high standard or premium. Increasingly, consumers are concerned about the origin and quality of the products they consume. On the other hand, the number of A2 milk producers is insufficient to meet the national demand, since they are a small number, leaving the majority of the population without the choice between conventional A1/A2 milk or premium containing only A2 protein.

Given the above, the question that guides this study is as follows: is the production of A2 milk a potential of upgrading to the bovine chain in Brazil? In order to answer this question this study aimed to evaluate the potential of A2 milk as a strategy of upgrading to milk producers in Brazil.

WHAT IS A2 MILK?

First, it is necessary to clarify what is considered milk, since there is a lot of divergence and confusion in society in general terms. Normative Instruction (NI 51) N° 51, of September 18, 2002, defines milk as "a product derived from the complete and uninterrupted milking, in hygienic conditions, of sound, well-fed and rested cows". When the milk is of another species "it must be called according to the species of

1 Adjective attributed to milk that presents characteristics considered superior, special or differentiated, conferring it a high standard, either by the breed or origin of the milked animal, by the production system and the type of management or even by the form of processing, storage and distribution. Examples of milk premium organic milk, milk containing only Protein A2, Milk Night (milk with high melatonin), plus some others exist on the market.

2 According to the International Food Information Council Foundation (IFICF), functional foods "are foods or food components that can provide benefits beyond basic nutrition" (IFICF, 1998).

which it proceeds" (BRASIL, 2002, p.1). Therefore, vegetable beverages popularly called "vegetable milk" are not in fact milk, as clarified by NI 51, but vegetable drink.

Although all mammalian females produce milk, only a few species are commercially exploited, mainly due to domestication and/or ease of management and the amount produced. In this sense, cow's milk, buffalo, goat, sheep, camel and, to a lesser extent, yankee and mare´s milk is traditional (FAO, 2021). The nutritional composition of milk differs both between species and between breeds of the same species (FAO, 2021).

Bovine milk is, from a nutritional point of view, balanced in nutrients because it presents all essential nutrients and in the appropriate proportion (FAO, 2021). With regard to protein profile, bovine milk has 3.5 to 4% protein (DANILOSKI *et al*., 2021). This variation occurs by several factors, including: diet of the animal in lactation, breed, climate, management, lactation period, among others.

Approximately one third of the protein fraction consists of β-caseins (aggregates complexes or micelles) (DE GAUDRY *et al*., 2019). This group of proteins consists of 209 amino acids (GORKHALI *et al*., 2021). The remainder of the protein fraction is composed of other caseins (α-s1, α-s2 and κ) and serum proteins (α-lactalbumin and β-lactoglobulin) (BROOKE-TAYLOR *et al*., 2017; DANILOSKI *et al*., 2021). Twenty-two variants (A1, A2, A3, A4, B, C, D, E, F, H1, H2, I, G) were found in the β-casein (β-CN) (FARRELL *et al*., 2004; FERRETTI, LEONE & SGARAMELLA, 1990; NGUYEN *et al*., 2018; PATEL *et al*., 2020). The position and composition of the chain profile of 209 amino acids classifies the variants of β-casein (GORKHALI *et al*., 2021). Ferretti, Leone & Sgaramella (1990) postulate that the variants commonly found in the bovine species are the A1 and A2 alleles. Variant B is unusual and A3 and C are considered rare variants. Farrell *et al.* (2004) also clarify that the family of β-caseins corresponds to 45% of the casein of the bovine milk and it is quite complex

This is where the tonic of this study is included. According to Barbosa *et al.* (2019), the bovine species is the only one that has undergone a transverse mutation, resulting in the production of a modified protein which is structurally located and more difficult for digestion. The A2 β-casein was "found mainly in cows, even before humans domesticated them. But a mutation may have occurred a few thousands of years ago, which gave rise to a fraction of cows of European breeds producing a variant of casein called A1 β-casein", with a A2 predominance (SHASHANK *et al*., 2018, p. 222).

And harmonic health achievements have been attributed to this protein, which is called A1 β-casein (SHASHANK *et al*., 2018). This variant was not found in any other species (BARBOSA *et al*., 2019). However, within the bovine species, some breeds predominate the A1 allele and others of the A2 allele. Native breeds and, in particular, Indian breeds (*Bos indicus*) such as Gir and Guzerá, the A2 allele predominates at a genotypic frequency of 0.98% and 0.97%, respectively (BARBOSA *et al* ., 2019).

In general, Asian and African bovine breeds are almost exclusively A2 milk producers (DE GAUDRY *et al*., 2019). In this sense, Gorkhali *et al*. argue that it is necessary to raise an awareness of the importance of preserving native A2A2 breeds, because crossings with specialized and highly productive exotic breeds, such as Holstein and Friesian, can lead to unfavorable outcomes both to human health and to the extinction of native breeds. Gorkhali *et al*. assert that "A2 homozygous is predominantly found in most Indian cattle (Gir, Haliana and Kangayam, 2021, p. 17 apud SODHI et al., 2012).

What differs from the two variants (A1 and A2) is only one amino acid at position 67 of β-casein, which is composed of 209 amino acids in total. It was found in the milk variant A1, in position 67 of the peptic chain, a residue of histidine (His^{67}), and in A2 milk there is a proline residue (Pro^{67}). Although the difference seems subtle, the result of the cleavage of proteins from conventional A1/A2 milk and A2 tend to be quite different (BARBOSA *et al*., 2019).

Milk digestion and processing trivially releases bioactive compounds such as BCM. However, the cleavage of conventional A1/A2 milk is easier, by the residue His^{67}, releasing a BCM of longer length, BCM7. In this process are involved the enzyme pepsin, pancreatic elastase and leucine amino peptidase, producing "opioid peptides, which have seven amino acids in length, with sequence Tyr-Pro-Phe-Pro-Gly-Pro-Ile" (THIRUVENGADAM *et al*., 2021, p. 2). This heptapeptide (BCM7) is resistant to "proteolysis by the pronase enzyme" and even after hydrolysis, it would release "subsequent minor peptides of hexa, penta and tetra- amino acids, of which the pentapeptide would have the highest opioid activity" i.e., "its activity is similar to morphine" (THIRUVENGADAM *et al*., 2021, p. 2) . This process is four times higher in conventional A1/A2 milk compared to A2 milk (THIRUVENGADAM *et al*., 2021). On the other hand, The Pro^{67} of A2 milk prevents this process by not producing BCM7 and BCM5 or producing them in negligible quantities (ASLEDOTTIR *et al*., 2018; DANILOSKI *et al*., 2021). Asledottir *et al*. (2018) found BCM7 in both variants, but at very low concentrations in A2 milk (0.01 mg g^{-1} β-CN digested) compared to conventional (1.85mg g^{-1} β-CN digested).

This subtle difference in the proteoforms of β-CN (A1 and A2) is sufficient to cause conformational changes, functional changes and in the release of peptic bioactives, leading to changes in milk processing and digestion and, consequently, in its effects on human health (DANILOSKI *et al* ., 2021). These points are at the heart of studies in recent years aiming to understand the consequences of conventional A1/A2 milk for dairy products and health, and, on the other hand, the possible benefits of A2 milk for both parties.

Several studies have been published and the subject has gained increasing relevance in the scientific community (BARBOSA *et al*., 2019; BROOKE-TAYLOR *et al*., 2017; DANILOSKI *et al*., 2021; NGUYEN *et al*., 2018; PATEL *et al*., 2020; THIRUVENGADAM *et al*., 2021). Previous and recent studies have pointed to the fact that the consumption of conventional A1/A2 milk has negative effects on the health of

some individuals. This has been the cause of the trend of reducing the consumption of milk and dairy products (BENTIVOGLIO *et al.*, 2020). Allergic, cardiovascular, endocrine and neurological diseases (THIRUVENGADAM *et* al., 2021) and pulmonary inflammation (YADAV *et al.*, 2020) have been related to milk intake with variant A1 β-CN. There is also a relationship between inflammatory bowel diseases (ulcerative colitis and Crohn's disease) and BCM7 (SIENKIEWICZ, SZYMANKA & FICHNA, 2021). On the other hand, milk with the variant A2 β-CN is safe and it decreases the incidence of health problems (BROOKE-TAYLOR *et al.*, 2017; HE *et al.*, 2017). And the exclusion of A1 β-CN in the diet would avoid digestive problems (BARNETT *et al.*, 2014).

Despite the still incipient and controversial results in the scientific literature (GORKHALI *et al.*, 2021), recent research points to greater benefit to human health of milk consumption exclusively A2. The A2 milk causes fewer undesirable gastrointestinal effects, such as bloating, diarrhea, constipation, flatulence and abdominal pain (RAMAKRISHNAN *et al.*,2020). Even in lactose-intolerant people, the intake of A2 milk without the lactase enzyme, i.e. with lactose, presents less discomfort than lactose-free conventional A1/A2 milk (MILAN *et al.*, 2020; RAMAKRISHNAN *et al.*, 2020; HE *et al.*, 2017). Researchers have stressed the importance of developing more research on the effect of A1/A2 milk on human health and the benefits of A2 milk, especially for children and for the development of infant nutritional formulas (DUARTE-VÁZQUEZ *et al.*, 2017).

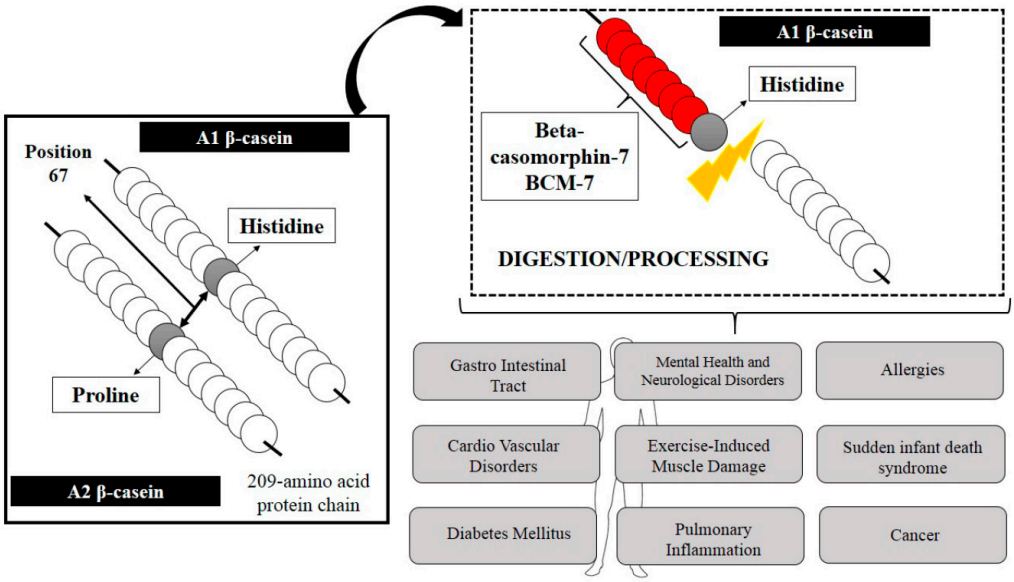
Studies correlate conventional A1/A2 milk consumption with the pathogenesis of autism in children (SOKOLOV *et al.*, 2014; SHENG *et al.*, 2019). High levels of BCM7 were found in the urine of autistic children and the severity of symptoms was correlated with these high concentrations. The reduction in exposure to BCM7 was also related to the better cognitive performance of chinese children (SHENG *et al.*, 2019).

Thiruvengadam *et al.* (2019), when discussing the effects of BCM7 on human health, presents that the consumption of milk containing A1 β-casein would be related to a negative lipid profile, favoring the occurrence of heart diseases. Thus, BCM7 would have a direct relationship with the progress of atherosclerosis (THIRUVENGADAM *et al.*, 2021). According to the authors, there is a relationship between containing A1 β-casein consumption and the development of allergy, type I diabetes, sudden death syndrome of babies, neuritis, asthma and other respiratory problems, psychosis, mastitis in postpartum women, rode generative and inflammatory diseases.

Nevertheless, it should be considered that studies assessing BCM-7 formation often use raw milk, and pasteurisation and UHT treatments for commercialization have been revealed that the formation of BCM-7 is inhibited in both A1 and A2 milk in a similar fashion (LAMBERS *et al.*, 2021).

Figure 1 illustrates the difference in structure of β-CN1 and β-CN2, the release of BCM7 through digestion or processing and its effects reported in the literature.

Figure 1 – Possible effects of BCM7 of A1/A2 milk on human health.



Source: Prepared by the authors

Another possibly positive aspect of milk production solely with variant A2 is that the A2 allele is related to desirable zootechnical characteristics, such as higher milk production and higher milk solids profile.

However, the existing results in the scientific literature are not always consistent, sometimes even contradictory (CAROLI, CHESSA & ERHARDT, 2019; CENDRON *et al.*, 2021; DUIFHUIS-RIVERA *et al.*, 2015; OJALA, FAMULA & MEDRANO, 1997). Some studies suggest that genetic polymorphism influences milk production, while others found no statistical difference. Therefore, studies in this direction could guide the genetic improvement of dairy herds.

In addition, studies have shown that there is a difference between conventional A1/A2 milk and A2 both in processing and in the organoleptic characteristics of the final products (MENDES, MORAIS & RODRIGUES, 2019). Nguyen *et al.* (2018) found that yogurt made from A2 milk presented a microstructure that would favor digestion, but required greater care during the handling and transportation.

In relation to cheeses, the presence of BCMs is relative, since there is a great diversity of cheeses that are processed and matured differently, influencing the final composition of the product (THIRUVENGADAM *et al.*, 2021). On the other hand, Bisutti *et al.* (2022) found that the A2A2 genotype presents worse performance in cheese making, in addition to causing negative changes in coagulation,

when compared to the A1A1 genotype, demonstrating that the change of the herd from the A1A1 genotype to the A2A2 can influence the quality of dairy products.

The A2 milk is currently produced and marketed in several countries, including the United States, Australia and New Zealand (NGUYEN *et al.*, 2018), and its demand is growing worldwide (THIRUVENGADAM *et al.*, 2021). The Canadian company Precedence Research reports that A2's global milk market moved $8.21 billion by 2020 and the outlook points out that it will reach $25.04 billion by the end of 2030 (PRECEDENCE RESEARCH, 2020).

In Brazil, estimates indicate that this market moves R$ 100 million annually (MILKPOINT, 2021). This demand has been seen as an opportunity to add value to the production and marketing of premium dairy products. It also adds the comparative advantage of Brazil having a high number of Zebu animals, naturally A2 milk producers. Therefore, A2 milk can be an interesting alternative of upgrading to milk producers, since the management of animals, the processing of milk products is similar to those of conventional A1/A2 milk, but the final value can be up to four times higher, improving the profitability of the activity.

Although there is no consensus in the scientific community on the effects of conventional milk consumption and, at least for the time being, researchers do not recommend the replacement of conventional milk by A2 (DANILOSKI *et al.*, 2021), current literature shows that this is a niche market for people who have food sensitivities, health problems or who already consume functional products (BENTIVOGLIO *et al.*, 2020). The consumer of A2 milk is willing to pay a higher price for a product that can be ingested without fear or that is of superior quality, has a guarantee of animal welfare, is sustainable and produced in ethical production systems. These aspects may be better used by the dairy sector, but more research is also needed to investigate the effects of conventional A1/A2 milk and A2 on human health more thoroughly (DUARTE-VÁZQUEZ *et al.*, 2017).

GLOBAL VALUE CHAIN THEORY AND ITS ANALYSIS DIMENSIONS

Globalization has brought about marked changes in society. The rise of new technologies, extremely sophisticated forms of communication and rapid flows, increasingly cheap and efficient means of transport, have led to a globalization of culture, life habits, knowledge, products and services and, of course, food. The same phenomenon occurs in relation to the product and service chains. Thus, there is a worldwide fragmentation of the productive stages, specialization in specific segments of the chain and a significant increase in economic interdependencies between countries, with a significant increase in the participation especially of developing countries in global chains without requiring the acquisition of all existing competencies in a value chain, as occurred with developed countries (GEREFFI & FERNANDEZ-STARK, 2016).

This new dynamic of globalized chains was dubbed by Gary Gereffi the "Global Value Chain" (GVC) (GEREFFI & FERNANDEZ-STARK, 2011). The definition that Gereffi and Fernandez-Stark propose is that GVC is "the full range of activities that companies and workers perform to bring a product from conception to final use and beyond" (2011, p. 4). GVC emerged in 2000 with the aim of developing a standard structure that would allow understanding this new model of globally dispersed value chain, more complex and interdependent, which, despite increasing the competitiveness and range of opportunities of companies and countries, also implies bottlenecks and important challenges (GLOBALVALUECHAINS.ORG, 2011).

According to Gereffi and Fernandez-Stark (2011), in a given GVC, the activities that constitute it (design, production, marketing and distribution, for example) can be performed in various locations around the world. Thus, the concept of GVC also includes activities that add greater value to the product or service, which do not necessarily imply in its transformation, as happens in supply chains (GLOBALVALUECHAINS.ORG, 2011). On the other hand, GVC distinguishes itself from the conventional value chain by being distributed worldwide, that is, it is a complex and geographically fragmented network.

The development of research using the GVC approach is increasing (GLOBALVALUECHAINS.ORG, 2011). The GVC framework provides tools for mapping and it brings detailed analysis of the chain for understanding. As a result, the researchers understand the dynamics of the chain and how it is coordinated, identifying who has the greatest bargaining power, the role of the main institutions, the location of each activity and which paths lead to upgrading (GEREFFI & FERNANDEZ-STARK, 2016). Such information allows the identification of potential interventions, strategy of governance and evolution to more advantageous stages and even modification of the chain for companies and governments, in order to assist the formulation of strategic plans and public development policies (GEREFFI & FERNANDEZ-STARK, 2016).

To achieve its purpose, the GVC framework explores six dimensions of analysis, "divided into global (top down) and local (bottom up) elements" (GEREFFI & FERNANDEZ-STARK, 2016, p. 7). In the set of global dimensions, or Top-Down, are: "(1) input-output, which describes the process of transformation of raw materials into final products; (2) the geographical scope, which explains how the industry is globally dispersed and in which countries the different GVC activities are carried out; (3) governance, which explains how the value chain is controlled by companies" (GEREFFI & FERNANDEZ-STARK, 2016, p. 7). The other dimensions correspond to local elements, or bottom up, which are: (4) upgrading, which seeks to understand the movement within the productive stages, which are more advantageous and how it is possible to evolve to the steps that provide more benefits; (5) institutional context, which examines the institutions that affect the chain and; (6) "stakeholders, which describes how the different local actors of the value chain interaction to achieve upgrading" (GEREFFI & FERNANDEZ-STARK, 2016, p. 7).

The main top-down dimension is governance. The concept of the top-down vision is centered on the organization and coordination of the GVC and the leading companies, in which GVC is in control, because this information is essential for the understanding of GVC. In a contrasting position, not least, the so-called upgrading dimension is the main one in the bottom-up approach. In this case, the GVC study aims to identify strategies for a company or country to maintain or improve its position in a GVC, capturing more significant gains (GEREFFI & FERNANDEZ-STARK, 2016).

It is important to highlight that in this research, the focus will be on the upgrading dimension. This dimension is interesting when one wants to find ways to greater value aggregation, ways to capture greater gains and ways of change to more advantageous chain stages (GEREFFI & FERNANDEZ-STARK, 2016). In this sense, the needs and demands of consumers have the power to influence the productive sector, that is, downstream actors have the potential to shape the steps of the upstream chain (LOWE & GEREFFI, 2009). For Daly *et al.* (2018), the experience of other chains in the process of evolution to stages of higher added value serves as a trajectory model that can benefit other chains that are seeking upgrading. Thus, downstream sector characteristics direct or even determine the direction of the upstream chain, as is currently observed the pressure for sustainable production (FERNANDEZ-STARK, BAMBER & GEREFFI, 2016).

Research has been carried out in the most diverse sectors of the economy using the theoretical framework of GVC. It is appropriate to mention that some chains analyzed from GVC: milk (VON OPPENKOWSKI, HASSLER & ROESLER, 2019), carbon emission (LIU & ZHAO, 2021), mining (BAMBER,FERNANDEZ-STARK & GEREFFI,2016); cotton (FERNANDEZ-STARK, BAMBER & GEREFFI, 2016),coffee (DALY *et al*., 2018), medical equipment (GEREFFI, 2020), polycentric market (HORNER & NADVI, 2018), imperfect markets (CHOI, 2020), lithium batteries (MORENO-BRIEVA & 2019) and institutions (HONG, ZHOU & WANG, 2020), for example. In Brazil, the analysis of GVC was adopted to study chains as milk (POLASTRINI, PEDROZA FILHO & OLIVEIRA, 2020; POLASTRINI & PEDROZA FILHO, 2021) and coffee (BARBOSA, AGUILAR & MACIEL, 2021).

From the knowledge of GVC, the next topic details the procedures that will be adopted in the research.

METHODOLOGY

To evaluate the potential of A2 milk as an upgrading strategy for milk producers in Brazil, the research was based on a qualitative approach to. The primary data were obtained through semi-structured interviews with the strategic actors of the milk chain A2. Secondary data were collected from technical and scientific publications and official websites of governmental and non-governmental institutions.

Initially, a bibliographic review was carried out with the purpose of raising studies in which the theoretical field of CVG was used, as well as better understanding this framework, its applications, advantages, and limitations. In addition, we sought to understand the difference between conventional and A2 milk, its respective effects on the human organism and perceptions for the future.

Subsequently, documentary research was carried out to characterize and better understand the chain, the current Brazilian scenario of the dairy sector and, especially, premium or functional milk. Data on the dairy sector in Brazil and worldwide were collected, and data specifically on A2 milk, which are still scarce.

Pre-tests were applied to two producers so that the interview guides could be adequately adjusted to. The sampling adopted was of a sequential type guided by the Snowball technique. In this sample modality, an actor was interviewed, because he is inserted in the A2 dairy chain, and he could also indicate and share the contact of other actors, contributing doubly with the research. The interviewees totaled eight, five producers, two researchers (one for nutrition and one for bovine breeding) and one of the movement called #bebamaisleite. To preserve the anonymity without compromising the description of the statements, the interviewees will be named in this study as P1, P2, P3, P4 and P5, for producers, PQ1 and PQ2, for the researchers and BL, for the #bebamaisleite member.

The interviews took place in September and October 2021. The first contact to make the invitation and clarification about the ongoing study happened by phone and/or e-mail. From the positive response of the guest, the day and time were scheduled, taking into account their time availability. On the day of the interview, the link of the Free and Informed Consent Form (TCLE) was sent, via the WhatsApp App or e-mail, at least two hours in advance. This was created in a digital platform to adapt the research to the changes imposed even to academic research, due to the persistent pandemic conjuncture still throughout the year 2021. Technological resources also constituted one of the main instruments for the collection of primary data, since the pandemic scenario of Covid-19 lasted until the period of interviews and closing of the research. The interviews were conducted through a video call recorded with prior authorization from the interviewees.

Finally, the analysis was performed through the transcription of the recorded interviews in a spreadsheet. The thematic analysis of the collected information and data collected focused on the upgrading dimension of GVC, the main one at the Bottom-Up level. The results were examined and graphics were generated for better visualization of the results, which were submitted to thematic analysis and then discussed and inserted in the following section.

RESULTS AND DISCUSSION

In this section the main results found by this research are presented and discussed. First, for better contextualization, the *status quo* of the production and commer-

cialization of A2 milk in the world is presented, which helps in understanding about the national chain, since the chains, as previously explained, are globalized, even though, in principle, they are considered regions. The Brazilian scenario is described below, specifically.

THE A2 MILK IN THE WORLD

Worldwide there is still little consumer knowledge about A2 milk, and much is still needed for leading this milk to be widely known and distinguished from the conventional A1/A2 milk. As consumers become aware of the difference between conventional A1/A2 milk and A2, the demand grows. The justification is the fact that consumers are increasingly seeking healthy and sustainable products.

The first hypotheses that there would be some difference in the composition of bovine milk is not as recent as one might imagine. Shashank *et al.* (2018) clarifies that it all actually started in 1993 in New Zealand. According to the authors

> Professor Bob Elliott of the University of Auckland, during his epidemiological study on the incidence of type I diabetes among children in Samoa, was aware of the fact that children from Samoa in New Zealand were susceptible to type I diabetes, but the incidence of it in children living in Samoa was extremely low. So Prof. Elliott suspected that the answer might be related to milk consumption or around it, which was very low in Samoa. Along with Dr. Jeremy Hill of the New Zealand Dairy Research Institute, he began working on mice specially bred for susceptibility to diabetes. Where initial results revealed a difference in the incidence of diabetes between those fed β-casein A1 and those fed β-casein A2. None of the mice fed with β-casein A2A2 were considered diabetic, but on the other hand, 47% of rats fed with β-casein A1A1 were diabetic after 250 days (SHASHANK etal., 2018, p. 221).

Although it actually started in 2003, the market for A2 milk is still incipient. A2 milk production began with the founding of The a2 Milk Company in 2003, an Australian-registered body incorporated into New Zealand by researcher Dr. Corran Norman Stuart McLachlan and the multimillion-dollar farm owner Howard Paterson. This initiative played a key role in the emergence of A2 milk, but has been criticized by other researchers and fierce combat from conventional A1/A2 milk producing companies (THE TIMES, 2018). Still, McLachlan believed that β-casein was responsible for diseases such as type II diabetes and cardiovascular disease. According to the researcher, A2 milk was a public health issue (THE A2 MILK COMPANY, 2020). Through The a2 Milk Company's partnership with dairy giant and the world's largest dairy exporter, New Zealander Fonterra, the work in favor of the production and marketing of A2 milk has gained traction (THE TIMES, 2018).

Data on world production, commercialization, demand, and values are scarce. Currently there is no production of A2 milk in all countries and the process of genotyping of the herd, genetic selection and certification are costly and time consuming. Australian fresh liquid milk is the main one in all categories and grew

16.3%, totaling $86.9 million, according to the latest report for the year 2020 (THE A2 MILK COMPANY, 2020). Then the company has the segments of whole milk and skimmed milk powder.

In 2018 the a2 Milk Company announced a 40.5% increase in company revenue (LIFE SCIENCE WEEKLY, 2018). Currently the market is consolidated and is growing in the USA (9,000 stores sell A2 milk), Australia (10% of the fresh milk market is A2 milk), Great Britain (2,000 stores), China (especially infant formulas) and New Zealand (THE TIMES, 2018). This market grew to 200% in China and Asia as a whole only in the second half of 2018 (THE TIMES, 2018). In the U.S., brand growth and knowledge continues to increase and consumers are swapping conventional A1/A2 milk for A2, and thus Americans who do not consume milk and dairy products are returning to consume, a fact that can help dairy farmers (LIFE SCIENCE WEEKLY, 2018).

It is noted that in some countries the A2 milk market is evolving from a more concrete and resilient point of view. The UK case illustrates a case where the A2 milk market has not successfully developed. The A2 Milk Corporation arrived at supermarkets in 2012. However, the market did not develop as expected and seven years later, the Company announced that it was leaving the country to focus on other more solid markets such as the USA and China (HORNE, 2020). In Italy, Bentivoglio *et al.* (2020) diagnosed those consumers are willing to pay a higher price for premium milk, despite price being an important and even decisive factor in choosing a product.

Due to the pandemic scenario of Covid-19, the company recorded a drop in revenue of 36.2%. The company remains focused on the daigou/reseller channel and seeks offline retail growth in China (COMPANY, 2020).

Worldwide, The a2 Milk Company's A2 Milk™ remains a pioneer and leader in the milk market from A2A2 homozygous cows. In 2020, as a reflection of the global pandemic d andCovid-19, the company reached its largest share in market value, reaching 11.7%, especially due to the increase in Australian domestic demand (THE A2 MILK COMPANY, 2020). More recently, Nestlé, the world's largest dairy company, has entered the A2 dairy market, especially infant formula, a branch considered promising for A2 milk (THE TIMES, 2018).

THE A2 MILK IN BRAZIL

In the same direction as the world scenario, in Brazil A2 milk is increasingly known and valued among producers, researchers, industry and consumers. However, the movement for the selection of animals β-casein A2 homozygous and production and marketing of milk and derivatives exclusively A2 is much more recent, having an effective beginning in the last 4 years.

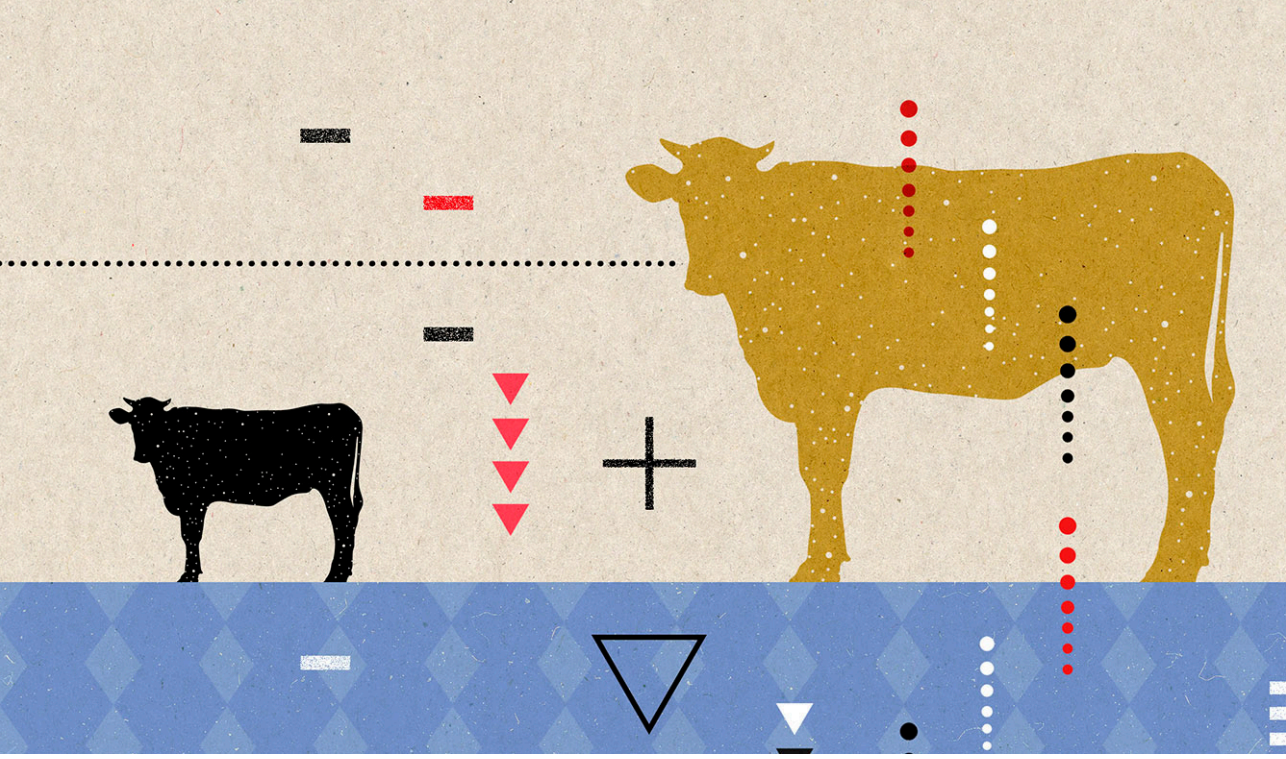
Initially, it is worth mentioning that two advantages of Brazil were frequently mentioned both by the scientific literature and by the interviewees in this study. Brazil has competitive advantages in the production of A2 milk. Primarily because there is a marked presence of Indian, African and Asian bovine breeds, that exhibit higher allelic frequency of A2 β-casein form. Especially when it comes to the Gir breed, "we have the best dairy Gir in the world," PQ2 explained. This was also observed in the statements of P2 and P5.

Secondly, because the federative regions are located in predominantly tropical regions, there is a favor of the management of Indian breeds, which are more rustic and adaptable to adverse conditions, to the detriment of European, which hinders the creation and production of these breeds and their crossbreeds such as Holstein, Jersey and Frisian in Brazil , especially in the north and northeast regions (GORKHALI *et al*., 2021). However, it is necessary that producers choose "dairy cows based on β-casein polymorphism" (GORKHALI *et al*., 2021, p. 18), performing sorting and selecting cows A2A2.

Sixteen A2 milk producers were identified in the country, exclusive or with in conjunction with conventional A1/A2 milk production. This number is still derisory compared to the total produced and conventional A1/A2 milk, which by the way is still insufficient to supply the national market, demanding the import of dairy products. However, it represents a major step taking into account that production has recently begun. This identification was possible through the indication of the interviewees themselves, previous knowledge of the researchers, journalistic articles published on websites, magazines and programs on the television network and even commercial profiles of properties on social networks, especially on Instagram.

It is also important to highlight the importance of social networks at this stage of the research, evidencing a marked change in the forms of social communication not only in Brazil, but worldwide. Of the 5 producers interviewed in this study, 4 (80%) have commercial profiles on Instagram with a link available for WhatsApp or at least the phone and address in the profile description or in the "contact" field. This significantly facilitated the location and contact of researchers with producers. In this particular, it collaboratively facilitates the contact of consumers to producers, being a bulwark against isolation caused especially by the Covid-19 pandemic, transforming both scientific research methodologies as well as means of production, marketing, marketing and after-sales services.

It was noticeable the great interest and motivation for A2 milk that all interviewees presented. The statements highlight this statement: "I believed a lot in the A2 project. When I understood A2 milk, I met A2 milk, I thought it would be a milk of the future in the dairy market, spatially in the fluids (P5)", "so to think that the woman's milk is a A2 milk, you already enchant it" (P3),"the world moves towards this, for increasingly selected and better-quality products" (P1).



THE A2 MILK PRODUCER PROFILE

The information previously shared above finds strong resonance with the findings of this study. It was found that the producers who were interviewed and, most likely, the other producers, present leading attitudes, are highly connected, have an innovative profile and adopt in the productive systems high technological level. In part, this profile of producers can be imputed by the best academic background of these, since 60% have complete higher education and 40% specialization.

It is important to mention that none of the producers who were interviewed depend exclusively on the production of A2 milk as a source of income. All producers perform other remunerated activities, whether external to rural activity or even in other agricultural activities. Therefore, there are two important points that can justify the protagonism of producers in the production of A2 milk in Brazil.

It was also noticed that the application of a "virtuous governance" by producers, since they have a powerful concern with the quality of what is produced on the property, with the health of the consumer, animal welfare and the environmental support of production. The interviewee P2 has A2 certification, animal welfare and Green Seal. In the case of P4, certification is underway and has expressed a desire to obtain organic certification in the future as well. In the case of P1, organic production status is also moving. Paradoxically, P3 and P5 do not have and are not on this path in the short term, because the volume of production is low, these are focused on expanding production first. Table 1 shows the main characteristics of the A2 milk producing establishments interviewed.

Table 1: Main characteristics of the A2 milk producing establishments interviewed.

Producer	Location of the property	Area (ha)	Volume produced (L/day)	Breeds	Handling	Certification	Expansion (L/day)
P1	Brasília/ Distrito Federal	30	100	Jersey	Artificial insemination	Organic (in progress)	700
P2	Carmo do Rio Claro/ Minas Gerais	2500	30000	Dutch	In Vitro Fertilization, Embryo Transfer, Compost Barn, Free Stall and Bed	Green Seal, A2A2 Cows and Animal Welfare	No
P3	Maringá/ Paraná	5,8	100	Dutch, Jersolanda, Girolanda	Artificial insemination	None	500
P4	Cidade Ocidenta/ Goiás	74	1800	Gir	Embryo Transfer and Artificial Insemination	A2A2 cows (in progress)	2000
P5	Palmeirant e/Tocantins	30	350	Gir, Girolanda, Sindi Jersey	Artificial insemination	S.I.M.*	3000
Total	-	**5279,6**	**32350**	-	-	-	**6200**

Source: Search results
*Selo de Inspeção Municipal (S.I.M.)/Municipal Inspection Seal.

It is possible to observe similarities in the technological and informational level of milk producers A2, which is higher than the average of conventional A1/A2 milk producers. Although the producers interviewed have these aspects in common, significant differences are noticeable in some points, which make them quite heterogeneous in terms of volume produced, breeds exploited, reproductive management, among others.

As discussed earlier, Indian, African and Asian breeds have a higher genotypic frequency of A2A2 and can reach almost 100%. But as can be seen from the results exposed, there are several breeds for the multiple production systems. In the case of P2, they had been working with milk production for decades and there are already three generations producing conventional A1/A2 milk from pure Dutch cows. According to P2 "we experimented in our herd and had almost 49% of A2A2 animals", for pure Dutch breed. And P2 continues, "work long with the Dutch genetics of the Netherlands [...] and A2 in the Netherlands already had a larger development process. So, it was a facility when we did the genotyping of our herd." Therefore, the potential to add value to a herd that already existed on the property was actually harnessed.

Unlikely conventional A1/A2 milk production systems, the A2 milk producers who were interviewed demonstrated unique motivation, a paradox that is not only philosophical. These are dairy producers who feel bad about conventional A1/A2 dairy products and have not been in the process of having any complications with A2 dairy products. They also did the empirical experience with children, grandchildren, nephews, friends, and children of collaborators who had a history of problems related to the consumption of conventional milk and dairy products and today, they report feeling absolutely nothing when consuming milk and derivatives exclusively A2 type.

Also, according to P2 "my daughters-in-law used to buy those expensive milk that the pediatrician recommended. Not now, they're taking our milk and they're getting along." He added that "we also have the case of several children in our city who could not consume cow's milk and today consume and are well."

It is evident in the interviewees' statements how much they believe in what they are producing, not only in a theoretical way, but in a concrete way. When asked what differs the production of A2 milk from conventional, P2 is emphatic in saying that "A2 milk has this advantage, it does not need any special process for its production. It doesn't change anything, food is the same, handling is the same, milking is the same." That is, having A2 genetics, there is no change in structure, nor in the feeding of animals or increase in production costs, it is exactly the same management. Similar answers were given by the other interviewees (P1, P2, P3, P4, P5, PQ1, PQ2, BL).

THE A2 MILK MARKET IN BRAZIL

In addition, special attention is required for marketing. Despite the motivation and the thought-provoking information of the results surrounding A2 dairy products, market-wisely, there are still significant difficulties.

As regards dairy products, only three were identified in Brazil processing and marketing A2 dairy products. The contact attempt was made, but we were unsuccessful. But the reality reported by the interviewees highlights that it is not easy to partner with the industry for it to process A2 milk. Firstly, because the establishment needs A2 certification and, to do so, to have structural and organizational conditions for the proper and safe separation of A2 milk from conventional. Requiring financial resources are still needed, which is not always available. Another point refers to demand, which is still low for investments of this size in dairy products without a secure horizon of financial return.

The P2 interview highlights this reality by saying that "I don't think we still have companies interested in working with A2 milk because volume is still very small. How will a company stop a conventional production line to process only 20 or 30,000 liters of A2 milk? It would have to be at least 100,000 liters/day." And continues "this milk today is not yet being marketed as A2 because we are looking for a

partner, an industry or a company that wants to do the second part of the project, which is to put this on the market". For P4, "we are not producers, accustomed to the field. We are good at the gate in, and we are looking for partners to do this part of processing, logistics, distribution, which is not easy". And P2 ends by saying:

> "We are aware that we took the step very early, but I think it was valid. We have to believe that things will have to happen one day and the sooner you can take the first step, the better, because when you arrive you will be ready first. So, we spend, invest, we are aware that it is a long-term investment."

The consumer generally knows little about the difference and even the existence of A2 milk. All interviewees (P1, P2, P3, P4, P5, PQ1, PQ2 and BL) were unanimous in stating that there is still great ignorance on all sides, but especially among consumers, who are largely responsible for leveraging the downstream chain, that is, demand.

Considering that only one producer, P1, claimed to be able to sell all milk and A2 products and at a price ranging from 3 to 5 times higher than those practiced with A1/A2 products and informally, it is emphasized that there is an important trajectory to be traveled for this market to expand. Producers P2, P3, P4 and P5 have not yet managed enough market to absorb all production and trade at the price of conventional.

In the case of P2, it differs concretely from P1. With a considerably large production (30,000 L/day), A2 certified and with adequate management, the production is passed on to the dairy that pays for milk quality, but not as A2. The forces of P2 have focused on seeking partnerships that can carry out the stages of processing, logistics and marketing. A similar case is that of P4, already in the process of certification, but without a consolidated partnership that performs the following steps, which require time, manpower, structure, knowledge and additional costs, fleeing the purview of the milk producer. P3 does the "word of mouth" job of bringing information to consumers and has been able to sell A2 products with a considerable added value.

All interviewees are unvocal about the need for greater dissemination of A2 milk, so that the large mass has knowledge, and the Government "looks" at this chain so incipient and so promising. In the hope of reducing this informational divide, each interviewee seeks to bring information and knowledge to people in daily attitudes. Whether addressing some consumer in the dairy gondola of a supermarket, commenting with friends, employees, arguing with the doctor who attends him, spreading on social networks. Thus, each interviewee has done his or her part in this process, as is explained in the statements. For P2

> "Milk is a fantastic food. I am very sad about the spread of fake news, that milk is bad for health, these professionals who recommend stop consuming milk and derivatives, veganism. This story that only the human baby milk after adult is a lie because any animal you give milk he will drink, does not drink because he does not have".

This point constitutes a multifaceted paradox, with multiple interpretative and crucial facets to increase or reduce the demand for dairy products. Within the milk chain it can be said that society is divided between those who consume milk and dairy products and those who do not. And, quite emphatically, those who do not consume claim that dairy products harm human health. For P4 "of high much knowledge, we need to inform people about it (A2 milk), participate in conversations, debates. [...] This type of work (research) is very important for us to take this step." And he says that "when it comes from the top down, through the university, it's going to happen," he adds.

A portion of the population does not consume milk and dairy products because they believe that such products cause symptoms, especially digestive. However, people who present such symptoms commonly attribute them to a possible lactose intolerance, which has not been confirmed by an appropriate diagnosis. In this sense, the literature has pointed out that other components of milk may be related to uncomfortable symptoms such as abdominal distension, pain, changes in fecal and evacuatory pattern, among others (CATANZARO, SCIUTO & MAROTTA, 2021).

At this point, the interview with a nutrition professional and dairy researcher was essential and brought exceptional contributions to this study. PQ1 clarifies that "there is no doubt that dairy products are healthy and important in nutritional terms". It is also clear that A2 milk came to add up, not to replace conventional A1/A2 milk, but "for those with sensitivity related to β-casein A1", completes PQ1. It's a premium product, that's for sure. "The cost will tend to be higher than conventional, but it is advantageous for consumers who no longer feel good about conventional, who already spend more for buying vegetable drinks and do not have the same nutritional value and have a higher cost than A1/A2 milk," added PQ1.

CERTIFICATION

In Brazil, the pioneering in the certification of A2A2 cows is the movement #bebamaisleite. The #bebamaisleite is an independent project that aims to encourage dairy consumption, often attacked even by health and nutrition professionals. Together with Genesis Group, they designed the specific A2 certification program. As the movement

> "this was the first certification accredited by the Ministry of Agriculture, Livestock and Supply (MAPA) to work in the area of the Service of Identification and Control of Cattle and Buffaloes (Sisbov) and tracking the productive process in rural properties" (BEBAMAISLEITE, 2021).

Also according to the movement, this "is a Product Certification Body, accredited by Inmetro, according to the requirements of ISSO/IEC 17065, to perform certification of products, processes and Storage Units" (BEBAMAISLEITE, 2021).

The certification program is independent and voluntary. But according to the interviewees P2, P4, PQ1 and BL, only with the specific certification the consumer can have the safety of the quality of the product, and the genotyping is insufficient to offer assurance that the product actually marketed consists exclusively of A2 Milk. On the other hand, producers who currently do not have certification (P1, P3 and P5) dispute this statement and consider genotyping to be the essential and decisive step for the production and marketing of products as A2 exclusively. In P5's speech, "I have the tests of all the animals, whoever wants to see I prove that they are A2".

With regard to certification, an interviewed producer has certification, one is in the process of being certified, with completion expected by the end of 2021. The other producers (3) performed the genotyping of the herd and commercialized the production without the A2 seal of #bebamaisleite.

The cost of A2 certification is a nodal point. BL states that "the cost varies from 1 to 2 cents per liter of milk produced, depending on the volume produced." However, producers who do not have the A2 certification have low production and the location of the property is far from the #bebamaisleite, which is located in the capital of the state of Minas Gerais, Belo Horizonte. Having a small production volume and an important distance, the costs related to certification are higher than those brought by producers who already have a higher production volume. This is a point in congener to capitalism and that tends to lead to abyssal inequality, repeating the same pattern of conventional A1/A2 milk, where there are alarming chasms between capitalized and decapitalized producers, between those who have a high technological level and the others who produce with a sparse technological framework.

According to respondents P1, P4, P5, PQ1 and PQ2, a governmental attitude is needed, which would potentially be reflected in greater knowledge about A2 milk, public policies that would help, motivate and subsidize especially small producers. In this direction, A2 milk could not only be a healthy food option for consumers but also an instrument to promote regional development by providing greater value aggregation and new spirit and motivation to small producers.

If there is no inclusive public policy, again the biface of Brazilian inequality will be reproduced, as with several other chains, even that of conventional A1/A2 milk, which remains divided between formal and informal production, between capitalized and decapitalized producers. That is, an opportunity to add value, a niche of market that could be used, however, it can become a new odyssey to producers.

With regard to the duration of the certification process, this is trivially fast, about three months, when the property already has an appropriate organization and structure. According to P2 "it was very easy to get into the certification process because we have four farms producing milk, it was just taking all the A2A2 animals to one of the farms. So "[...] the animals there are A2A2. Today we have 27,000 liters of A2 milk." For the interviewee (P2), what makes it difficult to certify is the lack

of organization of the properties. The animals need to be identified and then the capillary bulb is collected individually to perform genotyping. With the result, the earring is applied identifying the A2A2 animals.

On properties where only A2A2 animals will remain, the process is simpler. However, on those properties where they will remain, for the least initially, the herds A2A2, A1A2 and A1A1, need greater organizational control and a description of the care so that there is no infection of A2 milk, which can make the process to obtain certification more complex and laborious.

It is also worth clarifying that "the labeling of A2 products, even certified, cannot bring information that designates that it is superior to conventional dairy, it is healthier, it avoids diabetes, cardiovascular diseases, autism, among others", highlights the interviewee. He adds that "there are studies suggesting several points about the consumption of conventional A1/A2 milk and A2, but it is not yet possible to say with certainty that conventional A1/A2 milk harms human health. Not to mention the risk of seriously damaging the conventional A1/A2 milk chain." Therefore, it is clear that it is necessary to bring the consumer to understand what A2 milk is and its difference in relationship to conventional, more with the aim of capturing the consumer who does not consume dairy products and not to replace conventional A1/A2 milk, even because the vast majority of people consume and have no problem at all.

At this point, the statements of the producers (P1, P2, P3, P4, P5) always tended to distance themselves from the researchers (PQ1, PQ2 and BL), who are all doctors in areas directly linked to the milk chain and A2 milk. While the researchers emphasize that there are no guarantees that people who have problems when ingesting conventional A1/A2 milk do not feel any discomfort with A2, producers point out that A2 milk is moving to replace, even partially, conventional A1/A2 milk. All the producers interviewed reported cases of people, especially children, who had digestive discomfort when ingesting conventional A1/A2 milk and ingesting A2 did not present the symptoms.

Despite successful reports, researchers and the literature still recommend caution. Nobly, the cases are more related to digestive discomforts, an aspect in which the scientific literature already has more concrete results (HE *et al.*, 2017; NGUYEN *et al.*, 2018; BARBOSA *et al.*, 2019; SHENG *et al.*, 2019).

Also making a parallel between the ideal and the real, it is pertinent to add that the national (and even global) production of A2 dairy is very small compared to conventional milk. The quota already available is conventional A1/A2 milk, it means, this is the milk that currently presents elastic supply both in genetic terms (dairy A2A2 cows) and in terms of production, certification, processing, and distribution of dairy products. In short, there are no A2 dairy products to supply the market because there are not enough A2A2 cows, no producers, not even industries prepared for this. The interviewee P2 assures that "in the background needs a public

policy so that milk is what it represents, a chain that generates a very fast revenue, demands labor, moves the economy".

The researchers who were interviewed ask for caution in how this differentiation between conventional and A2 milk is presented to consumers. Attention is required in how this information is passed to the large consumer mass so that there is no unfavorable situation to the entire dairy chain, reflecting in damage to employment, income, in short to the whole economy, already weakened by the negative externalities caused pandemic the Covid-19.

CONCLUSIONS

In conclusion, it is necessary to rescue the objective of this study, which was to evaluate the potential of A2 milk as an upgrading strategy for milk producers in Brazil. The goal was successfully achieved, and the question raised at the beginning of this work was answered. The production of A2 milk represents a potential opportunity for upgrading to Brazilian milk producers, following a global trend, that of food premiumization, which therefore includes the milk chain.

However, it is worth noting that caution is needed for producers to enter the A2 milk chain because the market is still incipient, formalization implies significant costs and financial return may not materialize in the short term. For producers who have herds of breeds that have a higher genotype frequency of A2A2, it is interesting to seek the selection of A2A2 animals, even without the commercialization of A2 milk. Thus, they can benefit when this market has greater strength, being able to sell A2 milk and A2A2 genetics, that is, an upgrading per product that will generate an aggregate of value and a more concrete and substantial financial return.

However, for decapitalized producers, with low production volume, in inland regions and far from large markets, herds predominantly A1A1/A1A2 and low technological level, the potential of A2 milk as upgrading is lower due to the fragility already in the conventional milk chain. For producers in this scenario designed the A2 milk someone will become an opportunity of upgrading from the moment the state participates and in a solid and direct way of the milk chain A2 as a whole, formulating and implementing public policies that subsidize at some level of participation the genotyping of the herds, the dissemination of the A2 milk differential through specific campaigns and programs, creation of credit lines with low interest rates and longer grace period, leveraging the A2 milk chain. Otherwise, there will be a reproduction of the inequalities and bottlenecks present in the conventional dairy chain.

It was clear that the A2 milk chain is not intended to replace the conventional one. The A2 milk chain represents yet another choice for consumers, especially those who no longer consume dairy products because they have low tolerance. From the nutritional point of view, plant beverages do not have the same nutritional value as well as the balance and proportion of nutrients adequately as dairy products, which reinforces the relevance of the development of the A2 milk chain.

The methodology applied in this study was effective to answer the questions raised and achieve the objective. The theoretical framework of the Global Value Chain was adequate to guide the research, direct semi-structured interviews, data surveys, showing, once again, great academic plasticity and relevance for different studies, especially in the context of globally fragmented and highly dynamic markets.

More research is needed to better clarify the effects of BCM-7 on the human body, its hypothetical relationship with the pathogenesis of various diseases, as well as strategies that promote the better development of the A2 milk chain in Brazil, so that it does not reproduce the contents already existing in the conventional chain.

ACKNOWLEDGMENT

The authors thank the Coordination for the Improvement of Higher Education Personnel (CAPES) for granting a research grant at the master's level. The present work was carried out with the support of the Coordination for the Improvement of Higher Education Personnel - Brazil (CAPES) – Financing Code 001.

References

ABRALEITE. Abraleite - Associação de produtores de leite. Available in:<https://www.abraleite.org.br/>. Accessed: 30 Nov. 2021.

ACETO, M. *et al*. Role of Lanthanides in the Traceability of the Milk Production Chain. Journal of Agricultural and Food Chemistry, v. 65, n. 20, p. 4200–4208, 2017. DOI: 10.1021/acs.jafc.7b00916

ASLEDOTTIR, T. *et al*. Release of β-casomorphin-7 from bovine milk of different β-casein variants after ex vivo gastrointestinal digestion. International Dairy Journal, v. 81, p. 8–11, 2018. DOI: 10.1016/j.idairyj.2017.12.014

BAMBER, P.; FERNANDEZ-STARK, K. & GEREFFI, G. Peru in the Mining Equipment Global Value Chain opportunities for upgrading. Durham, North Carolina, USA: 2016. Available from: <https://dukespace.lib.duke.edu/dspace/bitstream/handle/10161/11605/2016_01-29_ Duke CGGC_Mining Equipment GVC report_Peru.pdf?sequence=1>. Access: 29 Jul. 2021.

BARBOSA, L. O. S.; AGUILAR, C. & MACIEL, L. Participação de Minas Gerais e do Brasil na cadeia produtiva global do café. Economy & Region, v. 9, n. 1, p. 147–166, 2021. DOI: 10. 5433/2317-627X.2021v9nlp147

BARBOSA, M. G. *et al*. Leites A1 e A2: revisão sobre seus potenciais efeitos no trato digestório. Segurança Alimentar e Nutricional, v. 26, n. June, p. 1–11, 2019.

BARNETT, M.P.G. *et al*. Dietary A1 β-casein affects gastrointestinal transit time, dipeptidyl peptidase-4 activity, and inflammatory status relative to A2 β-casein in Wistar rats. International Journal of Food Sciences and Nutrition, v. 65, n. 6, p. 720–727, 2014. DOI: 10.3109/09637486.2014.898260

BEBAMAISLEITE. Beba mais leite -Selo vacas A2A2. Available in: <http://www.bebamaisleite.com.br/noticia/selo-vacas-a2a2>. Accessed: 29 Nov. 2021.

BENTIVOGLIO, D. *et al*. Is there a promising market for the A2 milk? analysis of Italian consumer preferences. Sustainability (Switzerland), v. 12, n. 17, p. 1–16, 2020. DOI: 10.3390/su12176763

BISUTTI, V.; PEGOLO, S.; GIANNUZZI, D.; MOTA, L.F.M.; VANZIN, A.; TOSCANO, A.; TREVISI, E.; AJMONE MARSAN, P.; BRASCA, M. & CECCHINATO, A. The β-casein (CSN2) A2 allelic variant alters milk protein profile and slightly worsens coagulation properties in Holstein cows. Journal Dairy Science, v. 105, n. 5,, p. 3794-3809, 2022.

BRASIL. Instrução Normativa Nº. 51 de 18 de setembro de 2002, 2002. Available in: <https://www.crmvgo.org.br/legislacao/leite/INM00000051.pdf>. Accessed: 13 Oct. 2021.

BROOKE-TAYLOR, S. *et al*. Systematic review of the gastrointestinal effects of A1 compared with A2 β-casein. Advances in Nutrition, v. 8, n. 5, p. 739–748, 2017. DOI: 10.3945/na.116.013953

CAROLI, A.M.; CHESSA, S. & ERHARDT, G.J. Invited review: milk protein polymorphisms in cattle: effect on animal breeding and human nutrition. Journal Dairy Science, v. 92, n. 11, p. 5335-2461, 2009.

CATANZARO, R.; SCIUTO, M. & MAROTTA, F. Lactose intolerance: an update on its pathogenesis, diagnosis, and treatment. Nutrition Research, v. 89, n.5, p. 23–34, 2021. DOI: 10.1016/j.nurres.2021.02.003

CENDRON, F.; FRANZOI, M.; PENASA, M.; DE MARCHI, M.; CASSANDRO, M. Effects of β- and κ-casein, and β-lactoglobulin single and composite genotypes on milk composition and milk coagulation properties of Italian Holsteins assessed by FT-MIR. Italian Journal of Animal Science, v. 20, n. 1, p. 2243 - 2253, 2021.

CHOI, J. The global value chain under imperfect capital markets. The World Economy, v. 43, n. 8, p. 484–505, 2020. DOI: 10.1111/twec.12897

DALY, J. *et al*. Jamaica in the Arabica Coffee Global Value Chain Prepared by Global Value Chains Center. Durham, North Carolina, USA: Duke Center on Globalization, Governance and Competitiveness, 2018.

DANILOSKI, D. *et al*. Health-related outcomes of genetic polymorphism of bovine β-casein variants: a systematic review of randomised controlled trials. Trends in Food Science & Technology, v. 111, n. February, p. 233–248, 2021.

BY GAUDRY, D. K. *et al*. Milk a1 β-casein and health-related outcomes in humans: a systematic review. Nutrition Reviews, v. 77, n. 5, p. 278–306, 2019. DOI: 10.1093/nutrit/nuy063

DÍAZ-LÓPEZ, A. *et al*. Dairy product consumption and risk of type 2 diabetes in an elderly Spanish Mediterranean population at high cardiovascular risk. European Journal of Nutrition, v. 55, n. 1, p. 349-360, 2016. DOI: 10.1007/s00394-015-0855-8

DUARTE-VÁZQUEZ, M. *et al*. Production of cow's milk free from beta-casein a1 and its application in the manufacturing of specialized foods for early infant nutrition. Foods, v. 6, n. 7, p. 1–15, 2017. DOI: 10.3390/foods6070050

DUIFHUIS-RIVERA, T.; LEMUS-FLORES, C.; AYALA-VALDOVINOS, M.Á.; SÁNCHEZ-CHIPRÉS, D.R.; GALINDO-GARCÍA, J.; MEJÍA-MARTÍNEZ, K. & GONZÁLEZ-COVARRUBIAS, E. Polymorphisms in beta and kappa-casein are not associated with milk production in two highly technified populations of holstein cattle in méxico. The Jounal of Animal & Plant Sciences, v. 24, n. 5, p. 1316-1321, 2014.

FAO - Food and Agriculture Organization of the United Nations; Global Dairy Platform INC & IFCN Dairy Research Network. Dairy Development's Impact on Poverty Reduction. OTTE, M.J. & FELIS-ROTA, A. FAO, GDP and IFCN, Chicago, Illinois, USA. License: CC BY-NC- SA 3.0 IGO, 2018. FAO - FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. Gateway to dairy production and products. FAO, 2021. Available in: <http://www.fao.org/dairy-production-products/>. Accessed: 28 Jun. 2021.

FARRELL, H.M. *et al*. Nomenclature of the proteins of cows' milk: sixth revision. Journal of Dairy Science, v. 87, n. 6, p. 1641–1674, 2004.

FERNANDEZ-STARK, K.; BAMBER, P. & GEREFFI, G. Peru in the high quality cotton textile and apparel global value chain: opportunities for upgrading. Durham, North Carolina, USA: Duke Center on Globalization, Governance and Competitiveness, [s.n.], 2016.

FERRETTI, L.; LEONE, P. & SGARAMELLA, V. Long range restriction analysis of the bovine casein genes. Nucleic Acids Res, v. 18, n. 23, p. 6829–6833, 1990.

GEREFFI, G. What does the COVID-19 pandemic teach us about global value chains? The case of medical supplies. Journal of International Business Policy, v. 3, n. 3, p. 287–301, 2020.

GEREFFI, G. & FERNANDEZ-STARK, K. Global value chain analysis: A Primer. Durham, North Carolina, USA: Center on Globalization, Governance & Competitiveness (CGGC), 2011. Available in: <https://gvcc.duke.edu/wp-content/uploads/2011-05- 31_GVC_analysis_a_primer.pdf>. Access: 15 Jun. 2021.

GEREFFI, G. & FERNANDEZ-STARK, K. Global value analysis: A Primer. Durham, North Carolina, USA: Center on Globalization, Governance & Competitiveness (CGGC),2016. Available in: <https://gvcc.duke.edu/wp- content/uploads/Duke_CGGC_Global_Value_Chain_GVC_Analysis_Primer_2nd_Ed_2016.pdf>. Access: 12 Jul. 2021.

GLOBALVALUECHAINS.ORG. Concept and tools _ Global value chains. Available in: <http://www.globalvaluechains.org/>. Access: 26 Jun. 2021.

GORKHALI, N.A. *et al*. The global scenario of A1 , A2 β-casein variant in cattle and its impact on human health. Global Journal of Agricultural and Allied Sciences, v. 3, n. 1, p. 16–24, 2021.

HE, M. *et al*. Effects of cow's milk beta-casein variants on symptoms of milk intolerance in Chinese adults : a multicentre, randomised controlled study. Nutrition Journal, v. 2, p. 15–35, 2017.

HONG, J.; ZHOU, C. & WANG, R. Infl uence of local institutional profile on global value chain participation: an emerging market perspective. Chinese Management Studies, v. 14, n. 3, p. 715–735, 2020.

HORNE, S. Whatever happened to A2 milk? Farmers Weekly. 2020. Available in:<https:/www.fwi.co.uk/business/markets-and-trends/whatever-happened-to-a2-milk>. Access: 25 Apr. 2022.

HORNER, R. & NADVI, K. Global value chains and the rise of the Global South: unpacking twenty-first century polycentric trade. Global Networks, v. 18, n. 2, p. 207–237, 2018.

IFICF - INTERNATIONAL FOOD INFORMATION COUNCIL FOUNDATION. Backgrounder: functionalfoods. In: Food Insight media guide. Washington (DC): IFICF Foundation, 1998.

JOSHI, S. K. *et al*. Indian cow and A2 beta-casein: a scientific perspective on health benefits. Journal of Conventional Knowledge and Holistic Health, n. 5, n. 1, p. 1-6, january, 2021.

LAMBERS, T.T.; BROEREN, S.; HECK, M.; BRAGT, M.; HUPPERTZ, T. Processing affects beta-

casomorphin peptide formation during simulated gastrointestinal digestion in both A1 and A2 milk. International Dairy Journal, n. 121, Article 105099, 2021. DOI: 10.1016/j.idairyj.2021.105099.

LECERF, J.M. Dairy products and health. Medecine des Maladies Metabolites, v. 14, n. 8, p. 676–677, 2020.

LIFE SCIENCE WEEKLY. The a2 Milk Company ™ Announces Strong Results and Significant Increase in Distribution to Major US Retailers Capitalizing on Rising Consumer Demand. p. 1–2, 2018.

LIU, C. & ZHAO, G. Can global value chain participation affect embodied carbon emission intensity? Journal of Cleaner Production, v. 287, n. 10, march, p. 125069, 2021.

LOWE, M. & GEREFFI, G. A Value Chain Analysis of the U . S . Beef and Dairy Industries. Durham, North Carolina, USA: Center on Globalization, Governance & Competitiveness (CGGC), 2009. Available in: <https://gvcc.duke.edu/wp- content/uploads/CGGC_BeefDairyReport_2-16-09.pdf>. Access: 7 Jul. 2021.

MENDES, M. O.; MORAIS, M. & RODRIGUES, J. F. DE. A2A2 milk: Brazilian consumers' opinions and effect on sensory characteristics of Petit Suisse and Minas cheeses. LWT - Food Science and Technology, v. 108, n. 3, p. 207–213, 2019.

MILAN, A.M. *et al*. Comparison of the impact of bovine milk β-casein variants on digestive comfort in females self-reporting dairy intolerance : a randomized controlled trial. Am J Clin Nutr, v. 111, n. 1, p. 149–160, 2020.

MILKPOINT. Leite A2 já tem mercado de R$ 100 milhões. Giro Notícias, 2019. Available from: <https://www.milkpoint.com.br/noticias-e-mercado/giro-noticias/leite-mais-digerivel- ja-tem-mercado-de-r-100milhoes-226414/>. Accessed: 15 Nov. 2021.

MORENO-BRIEVA, F. & MARÍN, R. Technology generation and international collaboration in the global value chain of lithium batteries. Resources, Conservation & Recycling, v. 146, n. 7, p. 232–243, 2019. DOI: 10.1016/j.resconrec.2019.03.026

NGUYEN, H. T. H. *et al*. Differences in the yoghurt gel microstructure and physicochemical properties of bovine milk containing A 1 A 1 and A 2 A 2 β-casein phenotypes. Food Research International, v. 112, n. June, p. 217–224, 2018. DOI: 10.1016/j.foodres.2018.06.043

OJALA, M.; FAMULA, T.R. & MEDRANO, J.F. Effects of milk protein genotypes on the variation for milk production traits of Holstein and Jersey cows in California. Journal of Dairy Science, v. 80, n. 8, p. 1776-1785, 1997.

PATEL, S. *et al*. Understanding functional implication of β-casein gene variants in four cattle breeds characterized using AmpliSeqapproach. 3 Biotech, v. 10, n. 9, p. 414, 2020. DOI: 10.1007/s13205-020-02410

POLASTRINI, A. & PEDROZA FILHO, M.X. Certificações como estratégia de upgrading na cadeia de valor do leite em Palmas/TO. Revista Desafios, v. 8 , n. 2, p. 119 - 138, 2021.

POLASTRINI, A.; PEDROZA FILHO, M.X.; OLIVEIRA, N.M. Gargalos da cadeia leiteira de Palmas - TO: abordagem de Cadeia Global de Valor. Informe Gepec, v. 24 , n. 2, p. 195 - 212, 2020.

PRECEDENCE RESEARCH. PRECEDENCE RESEARCH. Available in: <https://www precedence research.com/a2-milk-market>. Access: 3 Jul. 2021. RAMAKRISHNAN, M. *et al*. Milk containing A2 b-casein only, as a single meal, causes fewer symptoms of lactose intolerance than milk containing A1 and A2 b-caseins in subjects with lactose maldigestion and intolerance: a randomized, double-blind, crossover trial. Nutrients, v. 12, n. 12, p. 3855, 2020.

SHASHANK, C. *et al*. A1 and A2 beta casein: Twin faces of milk. Journal of Pharmacognosy and Phytochemistry, v. 7, n. 4, p. 221–224, 2018.

SANGSOPHA, J. *et al*. Dietary sources of melatonin and benefits from production of high melatonin pasteurized milk. Journal of Food Science and Technology, v. 57, n. 6, p. 2026– 2037, 2020. DOI: 10.1007/s13197-020-04236-5

SHENG, X. *et al*. Effects of conventional milk versus milk containing only A2 β-casein on digestion in chinese children: A randomized study. Journal of Pediatric Gastroenterology and Nutrition, v. 69, n. 3, p. 375–382, 2019. DOI: 10.1097/MPG.0000000000002437

SIENKIEWICZ, M.; SZYMANKA, P. & FICHNA, J. Supplementation of Bovine Colostrum in Inflammatory Bowel Disease: Benefits and contraindications. Advances in Nutrition, v. 12, n. 2, p. 533–545, 2021.

SOKOLOV, O. *et al*. Autistic children display elevated urine levels of bovine casomorphin-7 immunoreactivity. Peptides, v. 56, p. 68–71, 2014. DOI: 10.1016/j.peptides.2014.03.007

TALAEI, M. *et al*. The association between dairy product intake and cardiovascular disease mortality in Chinese adults. European Journal of Nutrition, v. 56, n. 7,p. 2343-2352, 2017.

THE A2 MILK COMPANY. The A2 Milk Company Limited. USA: [s.n.], 2020. Available in: <https://thea2milkcompany.com/results>. Access: Jul 8. 2021.

THE TIMES. Milk that's easier to drink gives dairy market a case of the shakes. n. Mla 8, p. 1, 2018. Available in: <Milk that's easier to digest gives dairy market a case of the shakes | News | The Times>. Access: 2 Oct. 2021.

THIRUVENGADAM, M. *et al*. β-Casomorphin: A complete health perspective. Food Chemistry, v. 337, 2021.

VON OPPENKOWSKI, M.; HASSLER, M. & ROESLER, T. Informal markets and global value chains–the disembedding of Romanian dairy smallholders. European Planning Studies, v. 27, n. 5, p. 995–1012, 2019.

YADAV, S. *et al*. Oral feeding of cow milk containing A1 variant of β-casein induces pulmonary inflammation in male balb/c Mice. Scientific Reports, v. 10, n. 8053, p. 1–9, 2020.