Assessment of consumers' knowledge about A2 milk: paving the way for the Brazilian market

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Abstract

Bovine milk is a significant source of proteins, carbohydrates, lipids, and vitamins, playing a fundamental role in human diets. However, consumption can be restricted in individuals with disorders such as cow's milk protein allergy and lactose intolerance, which are often confused but have different origins. The aim of this study was to assess the population's knowledge of A2 milk and investigate the consumption profile of milk and its derivatives, especially regarding health. A survey was conducted using online questionnaires applied to 2,054 participants from different regions of Brazil. The questionnaires addressed milk consumption, associated dysfunctions, knowledge about cow's milk protein allergy, lactose intolerance, and A2 milk. Results showed that 62.6% of participants regularly consume milk and dairy products, and 19% associate milk consumption with health disorders. However, most were unaware of the difference between cow's milk protein allergy and lactose intolerance and the characteristics of A2 milk. Despite this, 76.4% considered it important that milk be produced exclusively from A2A2 cows. Although there is potential demand for A2 milk, lack of knowledge and limited availability remain barriers to consumption. Some consumers would pay more for A2 milk if it were more accessible. Strategies are essential to raise awareness and expand its market supply.

Keywords: dairy consumption; health benefits; marketing strategies; milk alternatives; beta-casein.

Practical Application: The results support targeted marketing and educational strategies to promote A2 milk in Brazil, encouraging its inclusion as a differentiated dairy option for consumers with sensitivities to conventional milk.

1 INTRODUCTION

Bovine milk is a significant source of proteins, carbohydrates, fats, and vitamins, which are essential for a balanced diet for children and adults. However, some people have limitations when consuming dairy products due to the constituents present in milk, especially bovine milk. Among the main limitations are cow's milk protein allergy (CMPA) and lactose intolerance, which are often misunderstood despite being distinct disorders caused by different milk components (Antunes et al., 2023; Darma et al., 2024).

The composition and quality of milk are influenced by environmental, nutritional, genetic, and physiological factors. Even milk from the same species may vary in composition due to genetic variations, resulting in differences in digestibility and absorption of nutrients by consumers. There are two types of milk on the market regarding β-casein conformation: A1 milk, which comes from cows with the A1A1/A1A2 genotype,

and A2 milk, which exclusively contains β-casein A2 (A2A2). This differentiation occurs due to substituting an amino acid at position 67 of the protein: β-casein A1 contains histidine, while β-casein A2 contains proline (Borş et al., 2024; Gard et al., 2024).

This slight change in the conformation or structure of the protein is enough to release (under digestion) a bioactive peptide known to be an agonist of the μ-opioid receptor, with morphine-like activity, called beta-casormorphin-7 (BCM-7). It can directly influence gastrointestinal physiology and affect other body parts, such as the cardiovascular, neurological, and endocrine systems (Giribaldi et al., 2022; Kaplan et al., 2022).

Complications associated with the digestion of A1 milk are related to the fact that BCM-7 can pass through the digestive system into the bloodstream, causing adverse health effects. BCM-7 release in milk with β-casein A2 does not occur or occurs at very low rates, making A2 milk potentially less harmful to disorders related to this peptide, reducing the

occurrence of the detrimental effects observed with A1 milk (Vasconcelos et al., 2023). The release of BCM-7 by the A1 and A2 variants of β-casein is still under investigation. Some studies suggest that the epigenetic effects of milk-derived opioid peptides may contribute to gastrointestinal dysfunction and inflammation in sensitive individuals (Gard et al., 2024; Nan et al., 2021). However, the results of the relationship between milk intake and metabolic diseases remain inconclusive and contradictory, which highlights the need for more research on the subject.

The global market for A2 milk is growing; however, there is still a notorious lack of knowledge among the population about this alternative product. Even dairy farmers are unaware of the importance of this market niche, which generates added value to their products. In this context, consumer behavior plays a crucial role in marketing strategies and increases the availability of products derived from A2 milk. It is fundamental to understand the actual demand for a rational distribution of these types of products in the markets. Studying consumer behavior (i.e., consumer motivations and attitudes) can provide answers to the factors that influence the process of acquiring and consuming A2 milk. Furthermore, understanding consumer preferences is essential for milk producers to effectively insert A2 milk into the market, making it more accessible and available on supermarket shelves (Bentivoglio et al., 2020; Żbik et al., 2024). Therefore, this study aims to assess the consumption frequency of milk and milk derivatives, and the population's knowledge about A2 milk and the relationship between milk consumption and health issues.

1.1 Relevance of the work

The present study provides pioneering insight into Brazilian consumers' knowledge and perceptions regarding A2 milk—a differentiated dairy product with potential health benefits for individuals who experience discomfort when consuming conventional milk. By surveying over 2,000 participants across diverse regions and socioeconomic backgrounds, the study identifies a significant knowledge gap about the distinction between cow's milk protein allergy and lactose intolerance and highlights the general unawareness surrounding A2 milk. Given the growing global interest in A2 milk and its underdeveloped market in Brazil, these findings are relevant for guiding public health communication, supporting informed consumer choices, and shaping national marketing strategies and production policies. The work contributes to aligning dairy industry innovation with consumer demand and health needs, especially in a context where A2 milk could become a strategic alternative for those sensitive to A1 β-casein.

2 METHODOLOGICAL PROCEDURES

This is an exploratory, descriptive, cross-sectional study. The Milk Quality Laboratory (LABOLEITE) of the Federal University of Rio Grande do Norte (UFRN), in partnership with the national program to stimulate dairy consumption "*BEBA MAIS LEITE*" ("Drink more milk" in English), developed a questionnaire as a tool intended to assess Brazilians' knowledge level and consumption of conventional milk and A2 milk.

2.1 Survey instrument and data collection

Data collection was performed using a structured questionnaire divided into four sections, comprising 24 questions. Multiple-choice and open questions were based on a Likert scale, offering five answer options. The participants were asked about their lifestyle habits, including frequency of milk and dairy product consumption, knowledge of dysfunctions related to milk and dairy product consumption, health conditions that restrict dairy product intake, information on familiarity with A2 milk, how it is obtained, perceptions of its health benefits, and intentions to purchase A2 products. Sociodemographic information was also collected without the participants' personal identification.

The questionnaire was distributed digitally using the Google Forms® platform in June 2020 (for 15 days). The research advertisement and questionnaire forwarding were done via messaging apps, social media, institutional emails, and websites of the study's partner programs, which focus on the dairy production chain. In addition, the user interface displayed a progress bar to inform them as they progressed through the survey questions. This tool also allows people to take part in the study anonymously, without having to log in or provide any identifying information. Participants could not be identified and were informed that the data collected would only be used for academic and research purposes, in accordance with the provisions of Law No. 13,709 of 2018, the General Law on the Protection of Personal Data (LGPD), by ticking "*I am aware that I conducted the interview anonymously for research purposes, granting the right to publish the information transmitted, and that it was answered truthfully to what was asked of me*".

Data collection was carried out in accordance with Brazilian regulations and guidelines for research involving human subjects. As no identifiable personal information was collected, and participants remained anonymous to the researchers, the study was categorized as "public opinion research with unidentified participants" (Resolution No. 510 of April 7, 2016, National Research Ethics Committee) and "market survey" (Resolution No. 674 of May 6, 2022, National Research Ethics Committee), exempting it from evaluation and approval by a Research Ethics Committee.

2.2 Sampling and statistics

It is possible that the sample is not very representative of the reference population (consumer universe). Still, using a large sample, we were able to collect the main characteristics of the population. This stage aimed to assess whether any changes needed to be made to the questionnaire.

A non-probability sampling was adopted. A total of 2,054 individuals answered the questionnaire nationwide. Categorical responses were presented as percentages, and a descriptive analysis was generated. Statistical analyses were conducted using SAS (version 9.0), with significance at $p < .05$.

The sampling error was 2.85% (95% confidence level), determined according to the following statistical model:

$$E = \sqrt{\frac{Z(\alpha/2)^2 \cdot p \cdot q}{n}}$$

In which:

E = Sampling error.

$Z_{\alpha/2}$ = Critical value corresponding to the confidence level. In this case, 1.96 (95%).

p = Population proportion of individuals in the category we are interested in studying. We considered 0.5.

q = Population proportion of individuals who do not belong to the category we are interested in studying (q = 1 - p).

n = Number of individuals in the sample.

3 RESULTS AND DISCUSSION

The responses to the questionnaire were distributed by country region, age, gender, education level, and income in Brazil (Figure 1). The highest concentration of responses was in the northeast of Brazil (43%), followed by the southeast (36%), south (13%), center-west (5%), and north (3%) regions. Out of a total of 2,054 respondents, 1,274 were women and 775 were men. The majority (85.5%) of the participants were between 21 and 60 years old. In terms of education level, only 2.2% said they had not completed high school, 22% said they had incomplete higher education, 27% had completed higher education, and 40% had a postgraduate degree. The declared income of 47% of the interviewees fell into people with a financial income of between 1 and 6 minimum monthly salaries, with 42% receiving

above 6 minimum monthly salaries, and 11% were classified from 0 to 1 minimum monthly salary, showing that the income of the participants can be a determining factor in the purchase of some products, especially those that are in short supply in neighborhood markets and in great supply in hypermarkets in city centers.

By relating the data on education level and family income, the population analyzed in this study belongs to an education and income bracket above the Brazilian average. According to the Brazilian Institute of Geography and Statistics (IBGE), 38.6% of the Brazilian population is considered to have no education or incomplete primary education, 31.4% have completed secondary education, and only 17.4% have completed higher education. In terms of family income, 11.8% of the Brazilian population lived on a quarter of a minimum monthly salary per capita, and 30% on up to half a minimum wage per capita, while only 4.1% had a per capita income of more than 5 minimum salaries (IBGE, 2021).

Regarding milk consumption, 62.6% of the participants said that they always consume milk and dairy products, and 24.2% almost always consume milk and dairy products. When asked whether the consumption of milk and dairy products could cause any illness, they stated that it certainly doesn't cause any illness (30.7%), "maybe it does perhaps it doesn't" (26.9%), probably it doesn't (19.5%), and only 8.3% answered that the consumption of milk and dairy products certainly causes some illness (Figure 2). For the affirmative answers ("certainly causes" and "probably causes"), the participants were asked an open-ended question about the name of the disease caused by the consumption of milk and dairy products. Answers related to

Figure 1. Sociodemographic and economic profile of the participants (n = 2,054).

lactose intolerance, allergies, inflammation, zoonoses, and food-borne diseases (FBD) were among the most frequently cited.

Regarding the participants' knowledge level about the difference between CMPA and lactose intolerance, 22% said they had good knowledge, 22% fair knowledge, and 12% very good knowledge, totaling 56% of those interviewed. On the other hand, 43% were distributed between little (26%) and no knowledge (17%), and only 1% had no opinion on these conditions, as shown in Figure 2. From the percentages shown, allergy and intolerance are still confused concepts, which justifies speculation about these diseases related to milk consumption.

The consumption of milk and dairy products is under constant debate as to whether it causes intestinal discomfort in children and adults. Therefore, participants were asked about any discomfort or reaction they experienced after drinking milk or consuming any dairy products during childhood and adulthood, assessing the proportions of participants who reported significant discomfort at different stages of life.

Figure 2 also shows the individual frequencies of the most common symptoms reported by those participants who affirmed having experienced discomfort after ingesting milk. Of these, 22% said that their symptoms had led them to seek medical attention, 6% had a positive diagnosis for CMPA, and 81% for lactose intolerance. In turn, vomiting, diarrhea, abdominal pain, and bloating had the highest frequencies of responses between "almost always" and "sometimes" among the symptoms presented. Of this group of participants, 81% said they had been positively diagnosed with lactose intolerance, thus justifying the characteristic symptoms of milk sugar intolerance.

Many people believe that consuming milk causes allergies, but CMPA is a sensitive factor for each immune system (McWilliams & Collins, 2014). Its incidence and dominant allergic mechanisms change with age, with IgE-mediated reactions common in childhood and non-IgE-mediated reactions in adults (Lee et al., 2024). According to Carvalho Junior (2001), substitution of breast milk during infancy causes a higher incidence of CMPA in children, as also shown by Al-Beltagi et al. (2022) in their literature review.

Another issue to consider is that many people self-diagnose with CMPA, which suggests that a considerable population is unnecessarily avoiding dairy products without a clinically proven diagnosis (Crittenden & Bennett, 2005; Rangel et al., 2016). Concerning lactose intolerance, some people have genetic conditions that promote negative regulation of lactase activity in intestinal cells after weaning. Thus, despite the continuous intake of milk or lactose, only 5 to 10% of the initial lactase activity is maintained (Al-Beltagi et al., 2022), and so milk has no power to develop tolerance since deficiency in lactase production is a pre-existing condition in some individuals. In terms of inflammation, a systematic review conducted by Nieman et al. (2020) evaluating the effects of dairy products or dairy protein interventions on inflammation markers showed that the consumption of dairy products and dairy proteins has no adverse effects on inflammation. Regarding zoonoses and foodborne diseases, not only milk but any other product of animal origin needs sanitary inspection and quality control to be marketed and distributed without posing risks to consumer health.

When respondents were asked if they knew of any alternatives on the market for people who are not intolerant but still experience
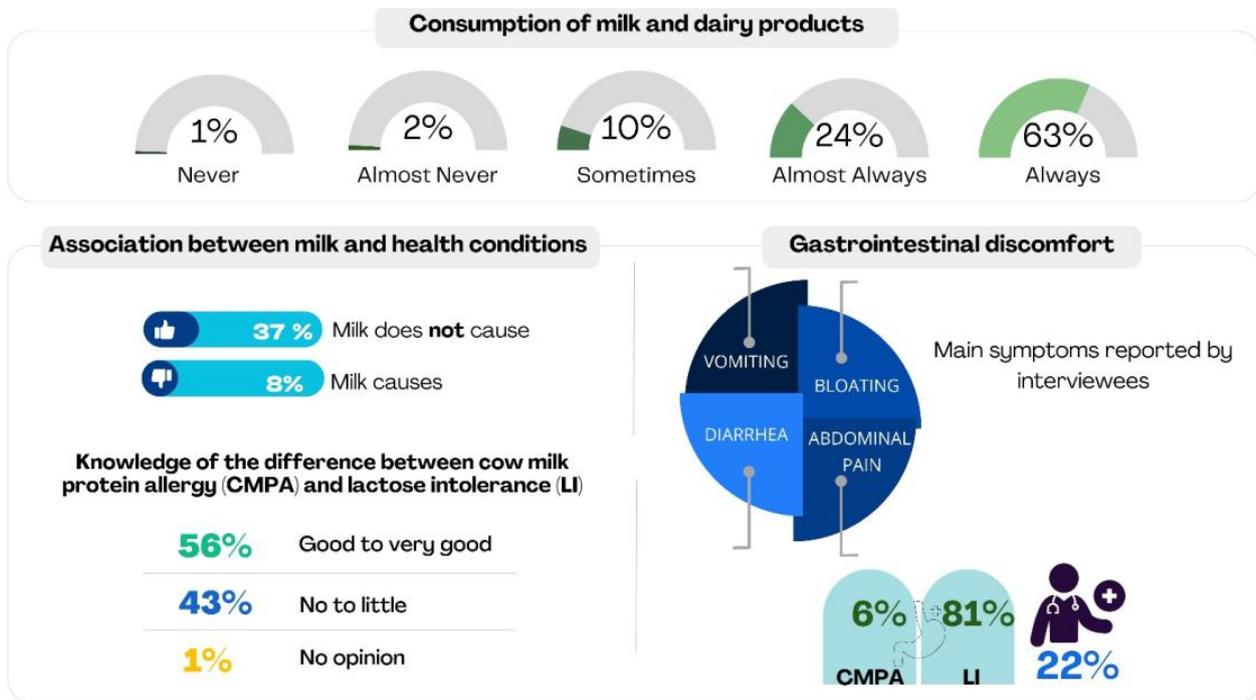

Figure 2. Frequency distribution of opinions on the consumption of milk and dairy products, the relationship between understanding dairy consumption and incidence of gastrointestinal discomfort, and main symptoms associated with medical records (n = 2,054).

some kind of gastrointestinal discomfort when consuming milk, 72.2% said they did not know of any alternatives. For those who did (27.8%), answers such as "A2 milk", "goat's milk", "soy milk", "zero lactose products," and "lactase" were mentioned. Overall, 66.1% said they had little or no knowledge of A2 milk, and 52.7% did not know that A2 milk is the original form of bovine milk and that animals can be bred to produce it naturally (Figure 3).

Bovine milk, whether A1 or A2, has lactose in its composition; however, some factors that generate intestinal discomfort are not only related to milk sugar. According to Ul Haq (2020) and Borş et al. (2024), some effects can be explained through the digestion mechanism of A1 milk: the first is that because BCM-7 is an opioid peptide, it acts by decreasing the passage rate through the intestine, and thus increases the fermentation time of lactose, and consequently gas production.

The second explanation is that many people are directly sensitive to BCMs, specifically BCM-7. According to the same author, drinking milk from other species, such as goats and buffaloes, is an option to find out if people are intolerant to BCM-7 alone, and if they do not show any reaction, they are candidates for drinking A2 milk. For those with CMPA, A2 milk may be an option, but only for those allergic to β-casein A1 (Gard et al., 2024; Ul Haq, 2020). If the individual has CMPA to other milk proteins, A2 milk should not be ingested. The lack of knowledge about A2 milk is because it is a recent subject and has little discussion, even by experts in the field, as well as the low availability on market shelves. Therefore, the population needs to be adequately informed so that people who are only sensitive to A1 beta-casein can consume milk and dairy products made from A2 milk.

Although the majority of participants do not know or know little about A2 milk, 76.4% said that it was very important, and it is important that farms only produce milk from A2A2 cows. Still, only 5.9% said that A2 milk was very or fairly available in supermarkets in their city. From this, it is clear that although potential consumers are aware of the importance of the product, there is still a lack of more widespread national distribution. When asked about the willingness to pay more for a liter of A2 milk, 50.8% of respondents affirmed that they would be willing to purchase the product, even at a higher price (Figure 3).

Another point to be discussed is dairy farmers' interest in genetic selection for their dairy herds. Considering that Brazil needs breeds with good adaptability to its edaphoclimatic characteristics, the selection of Zebu breeds interested in producing A2 milk is a resource to be worked on. According to a study by Garcia (2009), zebu breeds still produce almost entirely A2 milk. Zebu breeds, such as Gir and Guzerá, have a high frequency of the A2 allele and the A2A2 genotype in the β-casein genes (Pessoa et al., 2023; Rangel et al., 2017).

A2 milk, identified by New Zealand researchers in the 1990s, made the country a global leader in production and exports from 2003 onward. After the patent expired in 2015, the global A2 milk market expanded, being valued at US$2.30 billion in 2023 and estimated at US$2.56 billion in 2024, with a projection of reaching approximately US$7.62 billion by 2034. This growth represents a compound annual growth rate (CAGR) of 11.5% over the period from 2025 to 2034 (Precedence Research, 2025). The segment is still in its infancy in Brazil, representing less than 1% of the total milk market, with annual revenues of around R$100 million. Production takes place on a
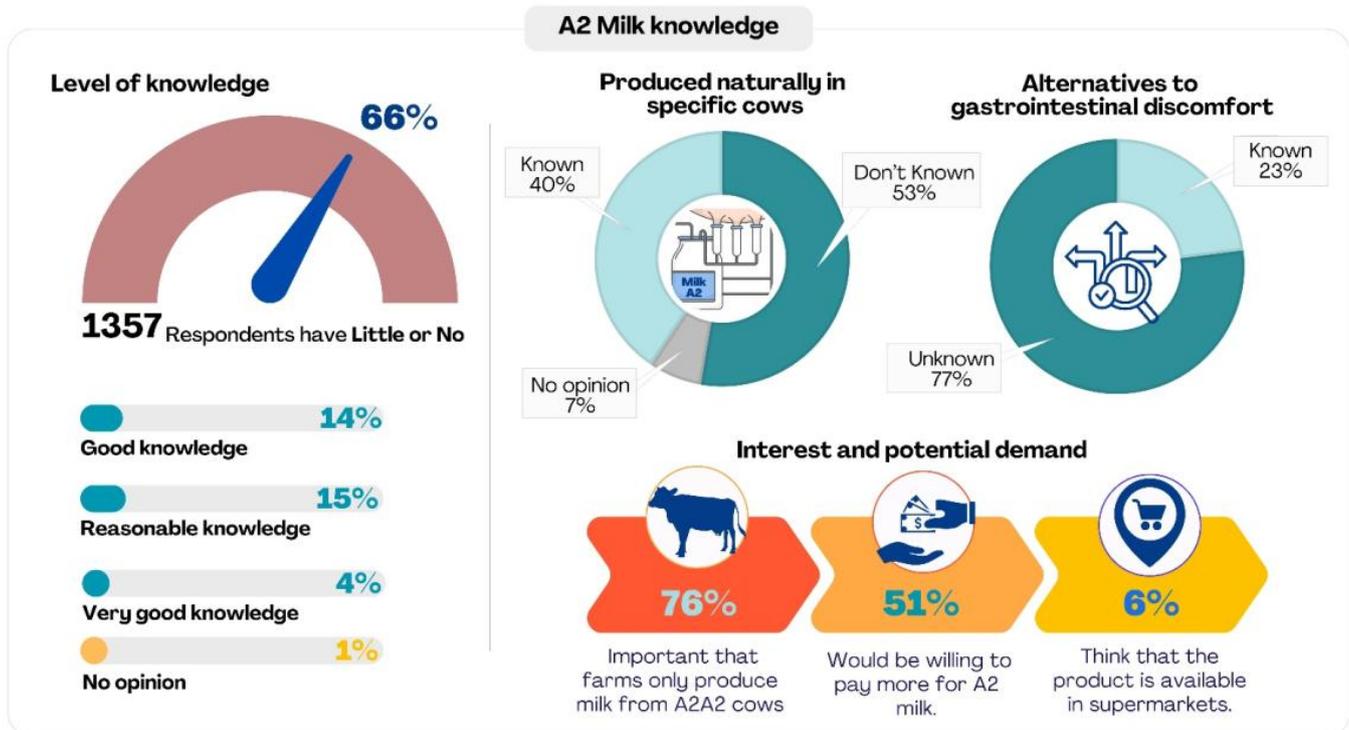

Figure 3. Frequency distribution of opinions on knowledge of A2 milk, its origin, food alternatives with functional potential, and aspects of marketing interests ($n = 2{,}054$).
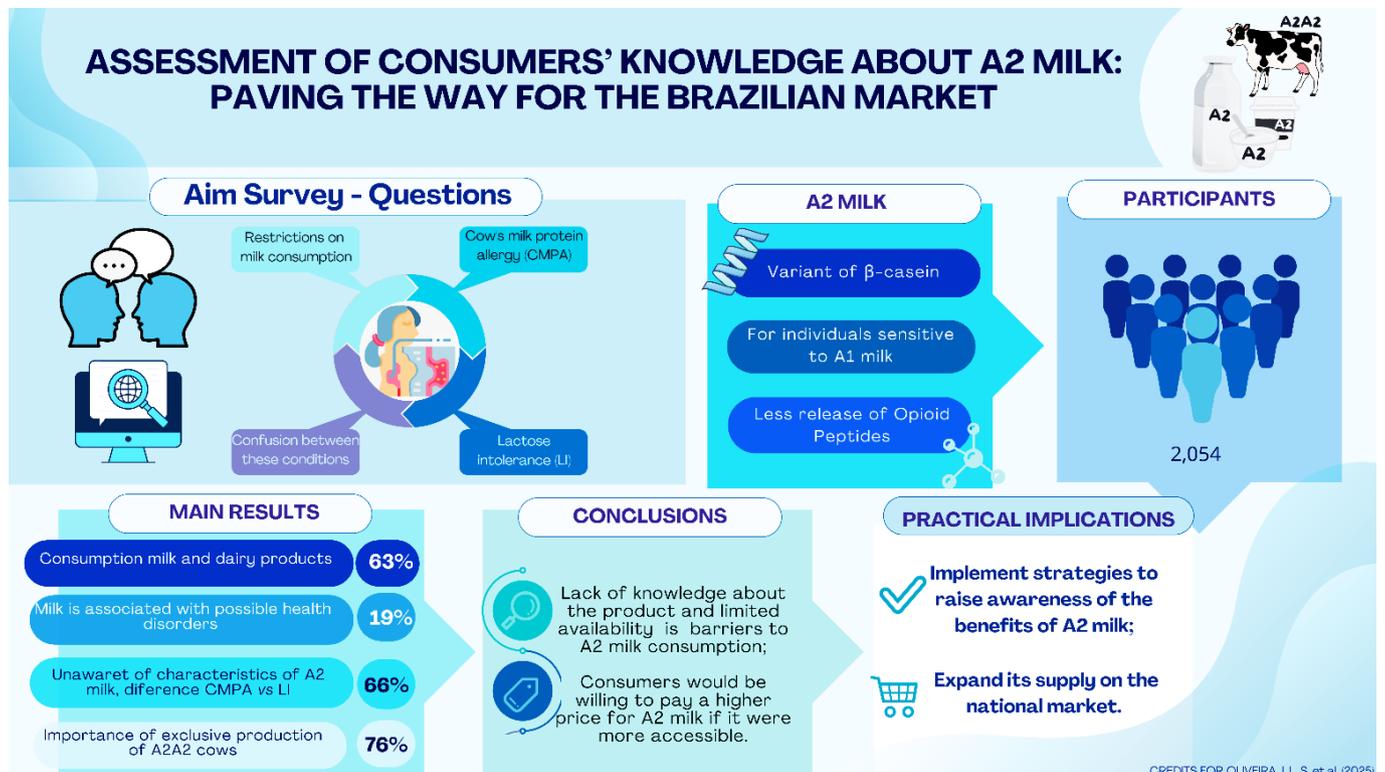
Figure 4. Illustration of the study, variables, and main results findings.

few verticalized farms with traceability; however, consumption has the potential to grow by 20% annually, driven by publicity strategies and greater consumer awareness, according to EMBRAPA's milk yearbook by Rentero (2023). The main results of the study are illustrated in Figure 4.

4 CONCLUSIONS

This study revealed a potential demand in Brazilian agribusiness since A2 milk has stood out as a promising alternative for individuals sensitive to A1 milk, thus offering a potentially more digestible option with fewer adverse effects. However, its consumption is still limited by barriers such as low availability in Brazilian markets and the lack of clear information and knowledge on the consumers' side about its health benefits, reducing its widespread acceptance. We found that consumers with a higher income and education level tend to show greater interest and willingness to purchase A2 milk, reflecting a correlation between access to information and consumption habits and pointing to significant potential demand in this segment.

Thus, it is essential to implement effective marketing strategies that highlight the advantages of A2 milk to overcome these challenges, combined with educational campaigns that clarify its benefits. In addition, robust investments in production and distribution are crucial to expanding the availability of the product, allowing it to be more accessible and present on Brazilian supermarket shelves. Combined with public awareness, these actions could significantly increase demand and consolidate A2 milk in the domestic market as a viable and beneficial choice for consumers' health.

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