A2 milk - Advantages and Challenges in the Manufacturing of Dairy Products

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Abstract
A2 milk is characterized by a difference in the amino acid at position 67 of the β-casein polypeptide chain, which releases much smaller amounts of bioactive opioid peptide β-casomorphin - 7 upon digestion. Milk consumption may lead to discomfort due to the presence of A1 beta-casein protein. A2 milk is the preferable alternative for people with mild lactose intolerance or lactose sensitivity because it does not include A1 protein, which is thought to be kinder to the digestive system. The need for healthy and minimally processed dairy products, the growing awareness of dairy-related sensitivities, as well as the growing interest in organic and natural food options are some of the major reasons driving the expansion of the A2 milk market. The purpose of this review is to present the advantages and challenges of using A2 milk in the manufacturing of dairy products.

Keywords: bovine milk, A2 milk vs A1, dairy products.

1. Introduction

Milk is regarded as one of the staples of Western diets because of its high nutritional value. Milk and milk products have been the subject of much debate in recent years. Companies have been marketing "A2 milk" as a healthier option than "A1 milk", being produced by cows with a specific genetic trait [1].
Based on the type of beta-casein present in the milk, it is graded as an A1 or A2 type of milk. A2 milk is characterized by a difference in the amino acid at position 67 (A1 histidine and A2 proline) of the β-casein polypeptide chain, which releases much smaller amounts of bioactive opioid peptide β-casomorphin 7 during gastrointestinal digestion (figure 1) [2].
According to published research, A2 milk differs from A1 milk in that it contains more polyunsaturated fatty acids and has smaller fat globule diameters [3]. Milk and milk products' physicochemical, nutritional, and sensory qualities are influenced by milk fatty acids and fat globule size [4].
The considerable differences observed across milk casein haplotypes indicate that casein polymorphism has a strong influence. The degree of globule size differential affects renneting, cheese texture, color, flavor, and butter texture, which makes these results interesting. Certain authors discovered that, when generated by the same breed of dairy cow and in the same environmental conditions, A2 animals had higher fat percentages than A1 genotype cows [5].
Many consumers prefer plant-based milk like soy milk, almond milk, rice milk, and coconut milk due to ethical and health reasons [6,7].
It is anticipated that the A2 milk market in North America will grow rapidly by 2029 as consumers choose to purchase milk Types that have extra benefits above regular milk. Similarly, the dairy industry's R&D efforts are anticipated to fuel strong market expansion in Europe. This scenario

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encourages health authorities worldwide to implement certain policies and /or practices [6].

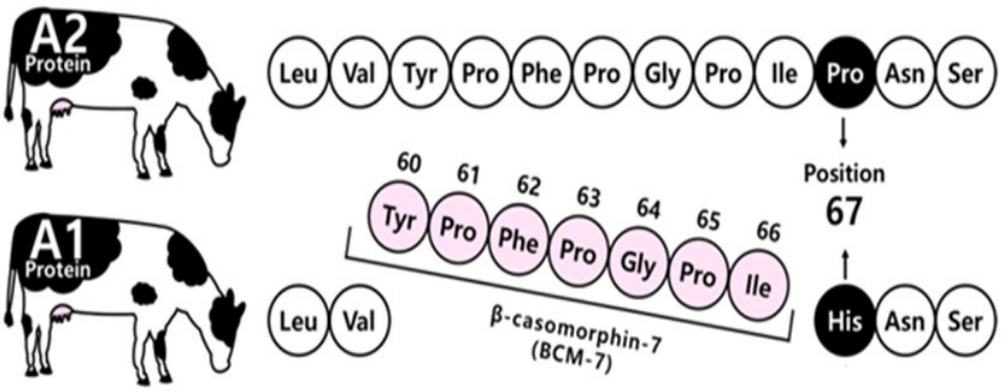

Figure 1. Diference in the amino acid sequences of A1 and A2 variants and formation of β-casomorphin-7 *[2]*

Digestive discomfort is mainly associated with lactose malabsorption, which affects approximately 65% of the adult population worldwide. After consuming milk, people who are lactose intolerant have a variety of digestive symptoms, including bloating, abdominal pain, changes in stool frequency, and changes in stool consistency. The dairy sector has a chance to spur expansion with targeted offers of differentiation, products that could be able to boast unique qualities like lower allergen counts and certain nutrient profiles.

Results and Discussions

A2 milk opens doors for the development of functional dairy products targeting lactose-sensitive individuals. As consumer demand grows, we can expect to see a wider range of A2 dairy options on the shelves.

In figure 2 is presents of the advantages, disadvantages and challenges of A2 milk in the dairy industry.

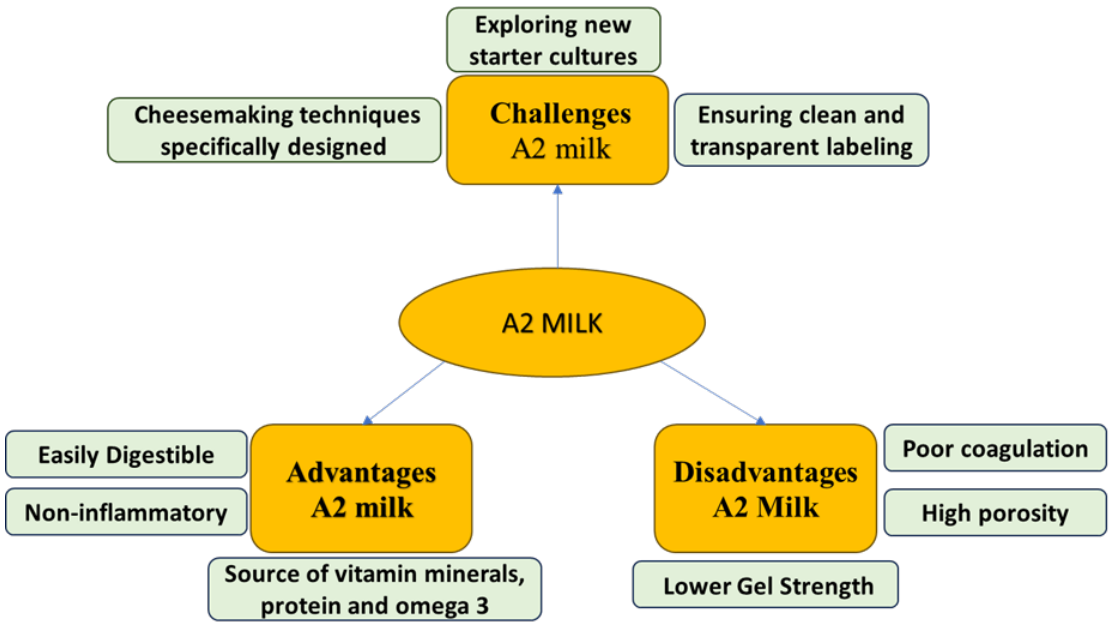

Figure 2. Schematic presentation of the advantages, disadvantages and challenges of A2 milk in the dairy industry

Advantages and disadvantages of A2 Milk for consumers and processors

Cheese production accounts for the largest share of raw milk produced in the world representing more than 75 %. The protein-to-fat ratio and the quality of casein's composition determine whether milk is suitable to consume raw. One crucial factor in milk's selection process that influences its technical qualities is the protein composition of β-casein [8].

In various countries, the number of cows who carry the A2A2 genotype is increasing, which has resulted in the mass production of "A2 milk" [9]. As a result, more research is required to determine the best manner to use this milk to manufacture dairy products, particularly hard cheese. To comprehend the possible impact of β-casein A2 on cheesemaking and the connection between genetic polymorphism and raw material qualities used in cheesemaking, scientific research on this subject is crucial.

A2 milk is mainly manufactured in New Zealand, Australia, North America, India, China, and Europe as there is a growing consumer demand for this type of dairy product. India has a large number of bovine-producing healthy A2 milk [10].

The process of producing dairy products using A2 milk needs to be apart from the process of producing products from A1 cows because there is a very high possibility of A1 protein contamination, the cows must be milked separately, the milk must be stored in separate tanks, transported and processed separately. For the entire procedure to be lucrative, sizable prospective markets and a premium milk price are thus required.

A2 milk is marketed towards those who may experience digestive discomfort from regular cow's milk [5,11]. This potential benefit hinges on the difference in a single amino acid in the beta-casein protein:

A1 beta-casein: During digestion, this protein can break down into a fragment called BCM-7, which some studies suggest might trigger digestive issues in lactose-intolerant individuals.

A2 beta-casein: This protein lacks the specific structure that produces BCM-7, potentially making it easier to digest for some people.

Therefore, A2 milk might be a better option for those who experience bloating, gas, or other digestive problems after consuming regular milk. It has been reported that the presence of proline in the milk protein has a major impact on protein hydrophobicity, thus leading to less ordered structures, which influence both casein micelle size, emulsifying and foaming properties, and clot formation.

Yogurt made from A2 milk may be more delicate and prone to curdling, but probably also more quickly digested. It is observed that milk containing A2A2 β-casein has the highest values for gel firmness and gel firming rate [6, 12, 13].

Disadvantages **-** From a technological point of view, A2 milk is not recommended for the production of cheese because the production process is less efficient. One of the most frequently investigated aspects of A2/A2 milk was its poorer clotting ability than A1/A1 and A1/A2 milk.

A2 milk is more effective than A1 milk in forming emulsions, but they were less stable than those formed with variants A1 and B. In some studies, the results have suggested undesirable characteristics in the technological properties of products obtained from A2 milk, such as noncoagulation or poor coagulation of milk to obtain cheese [14,15]. Likewise, when using A2 milk for yogurt production, more porosity in the food structure was reported, as well as a lower gel strength [6,16].

It was revealed that due to its composition, A2 milk has a higher percentage of total proteins and fat than A1 milk [17]. A recent work found slight differences in the amino acid composition of A2 and A1 milk, showing that A2 milk had a higher amount of leucine than A1 milk but lower overall amino acid content [3].

Challenges of A2 Milk in Manufacturing

While some customers may benefit from A2 milk's distinctive qualities, dairy producers face difficulties as a result of these attributes. Using inventiveness, investigation, and transparent correspondence, the sector can surmount these obstacles and unleash the complete possibilities of A2 milk, providing customers with an increased assortment of goods that fulfill their desired advantages.

Because organic products are becoming more and more popular, "organic A2 milk" is another promising trend in sales performance for the

upcoming years [6]. Therefore, we believe that this approach can also serve as a basis for future research, especially considering the potential applications of A2 β-casein as a macromolecule film and the increasing need for bioactive peptides in health and medicine [6]. Since cows on organic feed are not fed pesticides, it has been discovered that organic milk is safer and healthier than traditional milk.

It is also anticipated that the growing popularity of clean-label products will contribute to the expansion of the organic A2 milk market. Farmers in many regions of the world are being incentivized to produce A2 milk to meet the growing demand for what is considered to be a healthier alternative to conventional dairy. Although the existing research is inconclusive, sales of A2 milk have increased in some parts of the world at a premium price that is much higher than that of regular milk (~+39% cost).

Mendes and collaborators sustain that A2 milk did not influence the sensory characteristics of cheese. However, different texture sensory profiles were observed, with the A2 product being characterized as a softer and creamier cheese [18].

Processing challenges: A2 milk's properties can make cheesemaking and yogurt production more challenging, requiring adaptations and potentially impacting yield. Processors might need to invest in research and development to adapt existing processes for A2 milk production.

Processors must ensure transparent labeling and avoid unsubstantiated health claims about A2 milk. This could involve exploring new starter cultures, fermentation methods, and even cheesemaking techniques specifically designed for A2 milk. Standardization and Transparency - Establishing clear standards for A2 milk products is crucial. Transparency regarding milk source, processing adaptations (like the use of thickeners), and potential texture differences can manage consumer expectations.

Cheesemaking woes: A2 milk generally exhibits poorer curd formation and firmness compared to A1 milk.

This can be problematic for cheese production, particularly varieties that rely heavily on these properties, like cheddar or mozzarella. Cheesemakers might need to adapt their processes or use blends of A1 and A2 milk to achieve desired results [6].

Yogurt inconsistencies: A2 milk may produce yogurt with a looser texture and increased susceptibility to curdling. Manufacturers might need to adjust fermentation parameters or use thickening agents to achieve the desired consistency. Although some studies point to the possible advantages of A2 milk, more investigations are required to completely comprehend its impacts on human health and the long-term consequences on the quality of dairy products. As A2 milk keeps gaining popularity, teamwork is essential [18].

Processors can use innovation to solve manufacturing issues, and customers can make well-informed decisions based on reasonable expectations and research. This collaboration may open the door to a time when A2 milk can potentially benefit more people without sacrificing the quality of the product or the confidence of customers.

Conclusions

A2 milk and its derived products, ranging from cheese to yogurt, will be an important element of a healthy and balanced diet for a large number of people in the future.

To meet the growing consumer demand for dairy alternatives that are more easily digestible and healthier, further research on A1 and A2 β-casein is needed to propel industry growth and innovation.

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