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IMPACT OF A2 MILK ON HUMAN HEALTH AND THE DAIRY INDUSTRY - A REVIEW

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Abstract: In recent years, a new type of cow's milk, called "A2 milk," has been introduced to the market. This type of milk was first marketed in New Zealand and has since gained a presence in the markets of several countries. It mainly contains two types of β-casein: the A1 and A2 variants. In recent years, researchers have studied the possible implications of the composition of the β-casein protein fraction for the manifestation of a new intolerance: milk protein intolerance. Casein is the main component of milk proteins, of which approximately 30-35% is beta-casein. A2 beta-casein has proline at position 67 of the protein amino acid chain, while A1 beta-casein has histidine at that position; this is associated with a possibility of gastrointestinal discomfort due to β-casomorphin-7 (BCM-7) released during gastrointestinal digestion. The purpose of this review is to provide an update on the impact of A2 milk on human health as well as on its many technological qualities for the production of dairy products with improved health benefits for consumers.

Key words: bovine, A1 and A2 milk, human health, dairy products.

INTRODUCTION

Milk is an essential nutritional food product for a significant number of people. It is obtained from the secretion of mammary gland of mammals and is mostly made up of water (about 87%), but it also contains lactose, triglycerides, high-quality proteins, minerals (calcium, magnesium, selenium), and vitamins (riboflavin, vitamin B12, pantothenic acid). Milk proteins are classified into three types based on their solubility potential: caseins (approximately 80%), whey proteins, and fat globule membrane proteins (Jiménez-Montenegro *et al*, 2022; Priyadarshini *et a*l, 2018).

The most prevalent protein is beta-casein, which has a good content of amino acids. The bovine beta-casein gene can undergo twelve different mutations; A1 and A2 are the most common genetic alterations. A single nucleotide mutation causes the A1 and A2 forms of beta-casein to change at amino acid position 67, where A2 milk contains proline and A1 milk contains histidine (Figure 1).

This polymorphism results in a significant conformational alteration in the secondary structure of the expressed casein protein. The bioactive peptide beta casomorphin 7 (BCM7) is produced when the A1 version of β-casein (raw or processed milk) is digested by the digestive tract using proteolytic enzymes (Sodhi *et al*, 2012; Petrat-Melin *et al*, 2015). Due to increased price volatility, rising production costs, and a recent deregulation process brought about by the elimination of milk quotas, the dairy industry in Europe has been engulfed in a serious crisis in recent years (Beldycka-Bórawska *et al*, 2021; Pouch *et al*, 2018). Furthermore, plant-based milk alternatives, which are frequently promoted as a healthier, more environmentally friendly, and animal-friendly option for bovine milk, are replacing their consumption in various consumer groups. The dairy industry must figure out how to become more profitable in this situation (Beldycka-Bórawska *et al*, 2021). One option is to include milk in the diets of consumers who do not currently eat it. In this instance, those who have unfavorable responses after consuming milk and dairy products are one of the key segments of the population that could increase their consumption of milk and dairy products. Lactose malabsorption, which affects roughly 65% of the adult population worldwide (Semwal *et al*, 2022), is the primary cause of digestive problems. Lactose-intolerant people have a variety of digestive symptoms after consuming milk, including abdominal pain, bloating, changes in stool frequency, and changes in stool consistency. Another strategy for dairy profitability is to look for new products with higher added value, such as milk or dairy products with health advantages (Fernández-Rico *et al*, 2022).

The purpose of this review is to provide an update on the impact of A2 milk on human health as well

as on its technological qualities for obtaining dairy products.

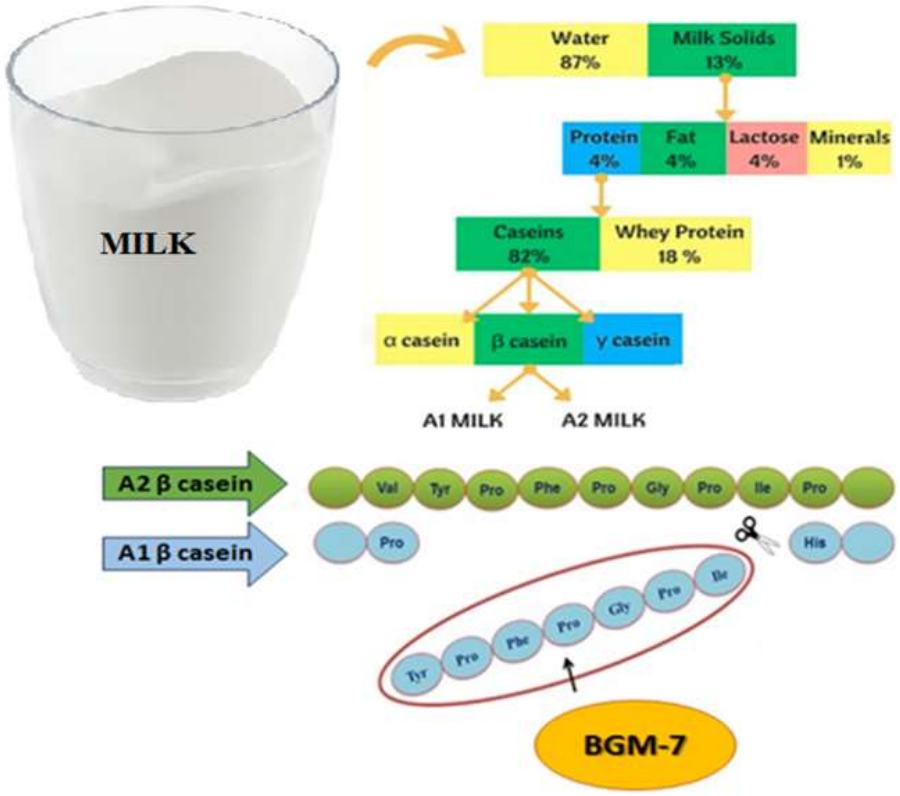

Figure 1 The composition of cow's milk and formation of β-casomorphin-7

The differences between A1 and A2 milk beta-casein

A2 milk is cow's milk that includes exclusively the A2 beta-casein protein type. According to the literature, cows generated only the A2 beta-casein protein and not the A1 beta-casein protein more than 10,000 years ago, before they were domesticated. A natural single-gene mutation occurred at Holsteins approximately 8,000 years ago, leading to the synthesis of the A1 beta-casein protein in this breed. Mutations in the beta-casein gene resulted in 12 genetic variations, the most prevalent of which are A1 and A2. Because Holsteins are used to increase the production of other breeds genetically, the mutation was passed on to too many other breeds (Sodhi *et al*, 2012).

The A1 beta-casein form gradually became dominant in milk. While dairy herds in much of Asia, Africa, and parts of Southern Europe still have a large proportion of A2 milk-producing cows, the A1 variant of the protein is more widespread in cattle in the Western world (Jiménez-Montenegro *et al*, 2022).

On chromosome 6 of the bovine genome is the beta-casein. The A1 allele of the gene is noted if β has the CCT codon that codes for the proline located at the 67th position in the casein chain and if the gene in this locus encodes histidine via the CAT code rather than the CCT code from the A2 allele. Because of this, bovines with the A1A1 genotype make A1 milk, or, to put it another way, histidine is found at position 67 of β casein.

Animals with A1A2 genotypes produce both A1 milk, or milk containing "histidine" and β casein, and A2 milk, or milk containing "proline" and β casein. A2 milk is the term used to describe the milk produced by animals carrying the A2A2 gene (Demirel and Çak, 2018).

The beta-casein gene, which is located on chromosome 6, regulates whether cows produce A1 or A2 milk. Cows have historically produced A2 milk, which is considered safe and healthy. The 67th amino acid in the beta-casein gene was altered from proline (A2 allele) to histidine (A1 allele). A cow only has two copies of the beta-casein gene. As a result, she could have an A2A2 homozygous genotype, an A1A2 heterozygous genotype, or an A1A1 homozygous genotype.

The alleles do not have a dominant-recessive connection, meaning they are co-dominant. As a result, an A1A2 cow will generate equal amounts of A1 and A2 beta casein alleles. A2A2 cows only generate A2 beta-casein, whereas A1A1 cows only produce A1 beta-casein. A2A2 cows pass on the A2 allele to their offspring, while A1A1 cows pass on the A1 allele, and A1A2 cows have an equal probability of passing on either genes. A2A2 cows can be obtained using sperm from bulls of the A2A2 genotype (Sridharan *et al*, 2020).

The Effects of beta casomorphin -7 (BCM7) and β-Caseins from milk on Human Health

Consumption of -casein A1 has been linked to the development of diabetes mellitus, according to a study conducted on non-obese diabetics. BCM-7 affects several opioids in adults. BCM-7 has been linked to immune system inhibition, increased risk of ***type 1 diabetes, arteriosclerosis, coronary heart disease, and sudden infant death syndrome***.

Numerous neurological conditions, including schizophrenia and autism, have also been connected to it. Lactose intolerance is usually blamed for stomach discomfort after consuming dairy receptors in the endocrine, neurological, and immune systems (Şahin *et al*, 2018). Infants are more likely to absorb BCM-7 because of their underdeveloped gastrointestinal tracts compared to lactose, which impacts digestion and creates symptoms similar to lactose intolerance in some people products, such as gas, bloating, and diarrhea (Miranda *et al*, 2015; Fernández-Rico *et al*, 2022).

It is also recognized to be an oxidant of low-density lipoproteins (LDL), and it is thought that LDL oxidation plays a significant role in the development of arterial plaque. To confirm the scope and kind of BCM7 interactions with the human gastrointestinal tract and entire organism, more investigation is required for animal testing and data collection on human patients experiencing issues linked to A1/A2 beta-casein milk consumption is needed for this (Fernández-Rico *et al*, 2022).

Technological characteristics of A2 milk and impact in dairy industry

Milk from cows has been consumed by humans for thousands of years, but as dairy production and consumption have increased recently, so too have health problems related to allergies and intolerances to the protein found in cow's milk (Parashar *et al*, 2015; Rangel *et al*, 2016).

Cow's milk protein allergy is an adverse immunological reaction when the body is exposed to dietary antigens in cow's milk (Jiménez-Montenegro *et al*, 2022).

Researchers have been examining the potential effects of the -casein protein fraction's composition on the emergence of a novel sensitivity known as milk protein intolerance in the last several years. Many people who think they are lactose intolerant may not truly be experiencing this issue (Rangel *et al*, 2016).

Although the worldwide consumption of milk and dairy products is constantly increasing and is expected to continue increasing over the next decade, milk consumption has decreased significantly since the 1970s in specific geographical areas, such the United States and the European Union. Thus, the dairy industry has tried to be creative and develop new products to increase consumption. In 2003, the A2 Milk Company Limited emerged in New Zealand, commercializing both milk and dairy products (cheeses, yogurts, or creams) free of the A1 variant of β-casein. A2 milk strongly entered the market in this country and covered almost 10% of the milk market in Australia. Given the possible benefits of A2 milk for human health, in addition to avoiding the negative effects of β-casein A1, many farmers around the world have switched to A2 milk production (Mayer *et al*, 2021). This successful market trend has spread to other geographic areas, such as North America, Europe, and China. Consequently, other companies dedicated to the commercialization of semen for dairy farms have introduced the A2/A2 genotype in their sire directories as a characteristic of interest and added value for their animals. According to researchers, A2 milk as smaller fat globule diameters and higher polyunsaturated fatty acid content than A1 milk (Perna *et al*, 2016).

Milk fatty acids and fat globule size have an impact on the physicochemical, nutritional, and sensory aspects of milk and milk products. Casein polymorphism has a profound influence on the morphometric properties and fatty acid composition of milk, as evidenced by the large differences discovered among milk casein haplotypes (Fernández-Rico *et al*, 2022; Albarella *et al*, 2020). These findings are intriguing since globule size differential affects renneting, cheese texture, color, flavor, and butter texture. Some authors discovered higher rates of fat in A2 animals than in A1 genotype cows generated by the same dairy cow breed and in the same environment. Other major dairy industry processes for which a different activity was recorded from A1 and A2 milk include emulsion and foaming capacities, albeit the results published are not enough (Nguyen *et al*, 2018;

Delgado Teixeira, 2021).

Darewicz and Dziuba studied the emulsion qualities of milk containing several types of β-casein (Darewicz and Dziuba, 2007). They came to the conclusion that while A2 milk formed emulsions more effectively than A1 milk, they were not as stable as those made with the A1 and B varieties. Differences in the emulsifying abilities of the A1 and B variations are also partly due to their better-ordered structures in the absorbed state than the A2 variant (Fernández-Rico *et al*, 2022).

CONCLUSIONS

Some research supports Beta-CasoMorphin-7 (BCM7) to be a risk factor for human health bas it can potentially affect numerous opioid receptors in the nervous, endocrine and immune system.

Cows' milk A2 differs from A1 milk in terms of technological qualities. Proline in A2 is a major impact on the hydrophobicity of the protein, leading to less ordered structures that impact the size of casein micelles, emulsifying and foaming qualities, and the production of curd and rennet.

Reviews were undertaken on a regular basis, and they found that more research is needed to determine whether A2-related things are preferable to A1. Despite an increase in publications from numerous universities and academic sectors around the world in recent years, human clinical trials remain scarce.

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