Réseau laitier canadien
Canadian Dairy Network

Beta Casein, A2 Milk and Genetics

How lucky we are to be involved in an industry that produces something unparalleled in its nutrition and processing diversity? Milk is often touted as 'nature's most perfect food', and with good reason thanks to its combination of essential nutrients, proteins and healthy fats. In recent years, a specific milk protein, beta casein, has received attention from a group of scientists, human nutritionists, consumers, and as a result, also from some dairy cattle breeders. Why the buzz about beta casein and what are you to do about it as dairy producers?

A1 and A2 Beta Caseins in Milk

Beta casein is a protein made up of a chain of 224 amino acids, that makes up around 30% of all milk proteins. There are two main versions of beta casein: A1 and A2. The A1 version has only one amino acid that is different from the A2 version. As a result, the digestion of dairy products from A1 and A2 beta casein proteins differs.

Some studies suggest around 25% of people are sensitive to one of the proteins that are released upon the digestion of A1 milk. A proportion of people who believe they have a lactose intolerance might be sensitive to A1 beta casein. One human study showed that more gastrointestinal discomfort occurs following the consumption of A1 milk compared to A2 milk.

Scientific results claiming human health risks beyond digestion are where things get murky. Some scientists and proponents of A2 milk suggest the A1 protein could be responsible for some chronic diseases in humans. The problems with these claims are that the majority of results have been from rodent trials which cannot be definitively extrapolated to humans; the few existing human studies have small sample sizes; and subsequent research has not been able to replicate important results. For these reasons, the evidence about the association of A1 milk with chronic diseases is currently too weak for any strong conclusions to be made. And so, the A1/A2 debate continues.

Niche Marketing

Whether the debate has been settled or not, companies have started to capitalize on the niche marketing of A2 milk. The a2 Milk Company, based in New Zealand, licenses and markets all A2 milk products. The company mainly sells in Australia and China, and more recently, the United States, where A2 milk sells for about the same price as organic milk.

In Canada, all milk is currently from a combination of cows with various beta casein profiles. To serve this market, if one were to be developed in Canada, producers would need to ship A2 milk by only keeping cows that produce such milk or diverting milk from these cows into a separate tank. Also, A2A2 sires have become a niche market for AI organizations catering to producers and markets that consider this trait important.

Beta Casein and Dairy Cattle Breeding

So how can one create more cows producing A2 milk, if this was one of the breeding goals in a specific herd? A cow's ability to produce A1 or A2 milk is entirely dependent on her genetic make-up and it is impossible to feed or manage our way to more A2 milk. Dairy animals possess a genotype expressed as either A1A1, A1A2 or A2A2, with each copy of the beta casein allele leading to the production of the corresponding type of beta casein. A2A2 cows are the only ones that can be considered producers of "A2 milk" since A1A2 cows will produce milk with a mixture of A1 and A2 beta casein. An animal's genotype can only be determined via genetic testing,

which is currently available nationally through Holstein Canada. On the sire side, many AI companies test their bulls for beta casein variants and make the results public. Possible offspring combinations when beta casein genotypes of both parents are known are illustrated in Table 1.

Table 1: Possible Combinations when Mating Animals of Various Beta Casein Genotypes

Parent 2 \ Parent 1		A1	A2
		A1	A2
A1	A1A1	A1A2
A1	A1A1	A1A2
50 % A1A1 50% A1A2		

Parent 2 \ Parent 1		A1	A2
		A1	A2
A2	A1A2	A2A2
A2	A1A2	A2A2
50% A1A2 50% A2A2		

Parent 2 \ Parent 1		A1	A2
		A1	A2
A1	A1A1	A1A2
A2	A1A2	A2A2
25% A1A1 25% A2A2 50% A1A2		

Parent 2 \ Parent 1		A2	A2
		A2	A2
A1	A1A2	A1A2
A1	A1A2	A1A2
100% A1A2		

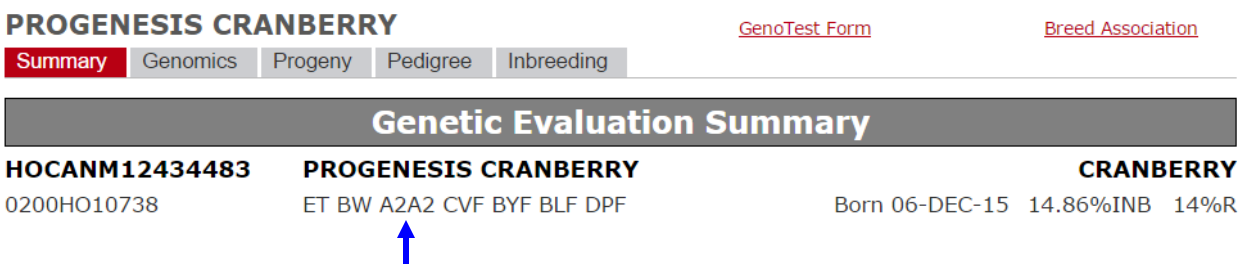
Mating two animals that both have the A2A2 genotype will result in 100% A2A2 progeny, just as an A1A1 mated to another A1A1 will lead to 100% A1A1 progeny.

Results for nearly 6,000 beta casein tests have been made available to CDN by its AI members. Estimated beta casein genotype frequencies by breed are presented in Table 2. Approximately 35% of Holstein sires are homozygous for the A2 variant. Half of all Holstein sires have an A1A2 genotype while the remaining 16% of sires are homozygous for the A1 variant. There are, however, several popular A2A2 sires in the Holstein breed that are increasing the frequency of the allele in the breed at a significant pace. Breeds with a higher frequency of the A2A2 genotype include Jersey, Brown Swiss and Guernsey.

Table 2: Estimated Beta Casein Genotype Frequencies by Breed

Breed	Beta Casein Genotype			No. Animals Tested
	A2A2	A1A2	A1A1	
Holstein	35%	49%	16%	4,603
Ayrshire	23%	48%	29%	287
Jersey	65%	32%	3%	752
Brown Swiss	57%	38%	5%	107
Guernsey	53%	19%	28%	145

For sires from an AI company that submits beta casein results to Holstein Canada, the genotype will display on the CDN website among the list of genetic test results, as seen in the image below.



As dairy cattle breeders and advocates for our industry, we must be responsible stewards in terms of providing consumers with products that do not adversely affect human health. Then again, we can't change the direction of genetic selection programs at the drop of a hat in order to respond to health claims that have not been fully substantiated. Since beta casein has a genetic basis, there is no quick fix. Breeding cattle to produce exclusively A2 milk will take time. An aggressive approach could include propagating only progeny from females tested to be A2A2. A more passive approach could include only selecting A2A2 mating sires. If the latter were used, the frequency of A1 beta casein in milk would halve with each generation, or about every five years.

Either way, both of these options would imply a substantial genetic sacrifice in terms of genetic diversity and genetic progress for production, health, fertility and conformation traits since many superior sires and females that carry the A1 allele would not be permitted to contribute to future generations. Therefore, at this stage in time, it is not recommended to limit sire usage to only those with the A2A2 genotype. However, giving such sires a preference when deciding between two bulls that are comparable for all other traits important to your breeding goals could be an acceptable strategy, and would lead to a steady increase in A2 milk production in your herd over time.

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