Casein is the group of insoluble proteins found in milk. Whey is the group of soluble proteins. Casein comes in three types: α-casein, β-casein and κ-casein with β-casein occurring in three variants: A1, A2 and B. The B variant is minor.

Most cow's milk contains a mixture of A1 and A2 β-casein. A2 milk refers to milk that only contains the A2 variant of β-casein.

Milk from Guernsey, Jersey, Asian cattle, human milk, and other dairy animals such as sheep, goat, donkeys, yaks, camel and buffalo contain mostly A2 β-casein.

Holstein Friesians cows are the black and white dairy cattle that originated in the Netherlands. More recently, Holstein refers to stock that has been further developed in America whereas Friesians refer to the traditional European stock. These breeds contain significantly more A1 β-casein. [1]

β-casein from cows contains 209 amino acids. The only difference between A1 and A2 variants is one amino acid at position 67. A1 milk contains histidine at position 67 whilst A2 contains proline. A peptide containing seven amino acids, β-casomorphin-7 (BCM-7), is formed when A1 milk is digested but not when A2 milk digested. [2]

β-casomorphin is a casomorphin which is a biological active opioid.

Robert Elliott observed a much lower rates of type 1 diabetes amongst Polynesian children that were raised on the Polynesian islands compared with those raised in Auckland. He attributed this to the differences in the β-casein profile. [3]

Elliott was the lead author of a conference paper that examined the effects of feeding casein to non-obese diabetic (NOD) mice. The conclusion was that "the induction of diabetes by casein in the NOD mouse appears to be restricted to casein containing the A1 variant of beta-casein". [4]

An experiment was performed independently at three centres (Ottawa, London and Auckland) in an attempt to duplicate these results. The diets for the mice were coded so that the researchers were not aware of nature of the diets fed to the mice. [5]

The conclusion of this paper was:

> These findings show that it is not likely that diabetes could be prevented solely by removing or altering the cows' milk component of the diet […].

The above conclusion did not prevent Elliott and Hill from applying for US and New Zealand patents. Patents have been issued, listing Robert B Elliott and Jeremy P Hill as the inventors. The US patent has been assigned to New Zealand Dairy Board and the A2 Corporation Limited. The patent claims that:

> The invention is based on the discovery that certain variants of β-casein may induce Type-1 diabetes in susceptible individuals while other variants do not. The invention consists of the selection of non-diabetogenic milk producing cows and recovering and processing their milk and milk products. Another aspect of the invention is selectively breeding cows which produce the non-diabetogenic milk. [6]

The a2 Milk Corporation was established to "pioneer the scientific understanding of the A2 protein type so more people can enjoy the nutritional goodness that only comes from real and natural milk". [7]
Note that it does not assist people who are lactose intolerant.

Elliott was a co-author of a paper [8] that surveyed more than "75 foods and over 100 nutritive food supply variables" and compared those to heart disease rates (in 18 countries) and type 1 diabetes rates (in 19 countries). [9]

Cow milk proteins	Correlation	Note
Milk & cream protein g/day	0.68	
Cheese protein g/day	0.23	
A1 protein in milk & cream g/ay	0.92	
A2 protein milk & cream g/day	0.47	
Ratio A1 protein to total beta casein in milk and cream	0.47	
Ratio A2 protein to total beta casein in milk and cream	0.47	
Milk consumption (L/capita)	**0.73**	[10]

Cow milk proteins and correlation with type 1 diabetes

Below are some observations relating to the published data.

- Elliott's initial hypothesis was that the lower rates of type 1 diabetes in Polynesian children raised in the Pacific Islands was attributed to the differences in the β-casein profile – that is, differences in A1 and A2 proteins.
- Dozens, if not hundreds, of studies have shown that the duration of breast feeding protects infants from type 1 diabetes. The importance of feeding infants breast milk has not been considered in this paper. (There is always the rather unlikely possibility that the benefits of breast milk results from its high in A2 casein content.) [10] [11] [12]
- The food consumption figures are derived from national consumption estimates. This does not necessarily correlate to the milk consumption of children that was observed in the initial 1992 study.
- Infant formula derived from cow's milk frequently contains increased whey and reduced casein components in an effort to "humanise" cow's milk. This will not be reflected in the milk protein consumption figures.
- Milk and cream consumption has a greater impact on incidence of type 1 diabetes than cheese consumption.
- A1 and A2 values were estimated by breed from dairy science literature.
- The correlation between A1 protein and diabetes was 0.91 which is a strong correlation. The correlation between A2 protein and diabetes is 0.47, a moderate correlation. Both correlations are positive – that is, the more A1 protein and the more A2 protein, the incidence of type 1 diabetes increases. Neither are protective.
- The correlation with the ratio of *A1 protein* to *total β-casein* (in milk and cream) to the

incidence of diabetes is, at best, only moderate, at 0.47.
- This is exactly the same as the correlation with the ratio of *A2 protein* to *total β-casein* to the incidence of diabetes (in milk and cream), which is supposed to be protective. A higher *A2 β-casein ratio* results in a higher incidence of type 1 diabetes.
- Consumption of milk, without any regarding for the protein content, shows a strong correlation of 0.73.
- As a generalization, 90% indicates a very strong correlation, 70-90% a strong correlation and 50-70% a moderate correlation.

Professor Boyd Swinburn prepared a 43-page report [13] for the New Zealand Food Safety Authority. His conclusion:

> The evidence does not support such dietary changes [replacing A1 β-casein with A2 β-casein] as a recommended clinical approach with a known likelihood of benefit.

Professor Stewart Truswell conclusions is:

> The A1/A2 milk hypothesis was ingenious. If the scientific evidence had worked out it would have required huge adjustments in the world's dairy industries. This review concludes, however, that there is no convincing or even probable evidence that the A1 β-casein of cow milk has any adverse effect in humans. [14]

Footnotes

1. Pasin, G. (2017) *A2 Milk Facts – California Dairy Research Foundation* [online]. Available from: http://cdrf.org/2017/02/09/a2-milk-facts/ (Accessed 18 December 2017).
2. Truswell, A. S. (2005) The A2 milk case: a critical review. *European Journal of Clinical Nutrition*. 59 (5), 623–631.
3. Elliott, R. (1992) Epidemiology of diabetes in Polynesia and New Zealand: child health

research unit. *Pediatric and adolescent endocrinology*. 2166–71.
4. Elliot, R. et al. (1997) '*The role of beta-casein variants in the induction of insulin-dependent diabetes in the non-obese diabetic mouse and humans*', in 1997 International Dairy Federation.
5. Beales, P. et al. (2002) A multi-centre, blinded international trial of the effect of A1 and A2 β-casein variants on diabetes incidence in two rodent models of spontaneous Type I diabetes. *Diabetologia*. 45 (9), 1240–1246.
6. Elliott, R. B. & Hill, J. P. (2002) *Method of selecting non-diabetogenic milk or milk products and milk or milk products so selected*. United States Patent 6451368
7. The a2 Milk Company (2017) About us – The a2 Milk Company [online]. Available from: https://thea2milkcompany.com/about-us/ (Accessed 27 December 2017).
8. Laugesen, M. & Elliott, R. B. (2003) Ischaemic heart disease, Type 1 diabetes, and cow milk A1 β-casein. *The New Zealand Medical Journal*. 116 (1168), 1–19.
9. AT=Austria; AU=Australia; CA=Canada; CH=Switzerland; DE=Germany; DK=Denmark; FI=Finland; FR=France; GB=United Kingdom; HU=Hungary; IL=Israel; IS=Iceland; IT=Italy; JP=Japan; NO=Norway; NZ=New Zealand; SE=Sweden; US=United States; VE=Venezuela
10. Blom, L. et al. (1989) The Swedish childhood diabetes study — social and perinatal determinants for diabetes in childhood. *Diabetologia*. 32 (1), 7–13.
11. Verge, C. F. et al. (1994) Environmental factors in childhood IDDM: a population-based, case-control study. Diabetes Care. 17 (12), 1381–1389.
12. Dahl-Jorgensen, K. et al. (1991) Relationship Between Cows' Milk Consumption and Incidence of IDDM in Childhood. *Diabetes Care*. 14 (11), 1081–1083.
13. Swinburn, B. (2004) Beta casein A1 and A2 in milk and human health. *Report to New Zealand Food Safety Authority*.
14. Truswell, A. S. (2005) The A2 milk case: a critical review. *European Journal of Clinical Nutrition*. 59 (5), 623–631.