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Q&A REVIEW

The Future of Milk Protein as a Functional Food

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1. I have some milking Holstein cows that are producing milk with low solid contents. Is that because I am not providing enough K-caseins? Or how I could fix that? If a cow is producing low solids during the year then it could be genetic. If solids are low only part of the year then it could be nutrition, lower intakes of protein in the feed can depress the protein content in the milk. K-caseins are not provided in the feed as they are only made in the udder by the cows from individual amino acids. Higher nutritional quality feed could improve solids if the feed quality was not high enough.

2. China currently doesn't allow ultra-filtered milk (Fairlife as an example) for import...are they looking to do research on this in China or why not allow it? Not sure of the specific regulations that China has about importing ultra-filtered milk. In the US a product like Fairlife is not considered standard fluid milk (according to the standard of identity) because ultrafiltration is not part of the processes listed in those regulations. I believe Fairlife is sold as "ultra-filtered milk", which is not a federal definition. China and many Asian countries often import various types of milk, especially long-shelf-life products, like UHT and more recently some "fresh" milk.

3. What is the milk intolerance issue caused by, not lactose, protein, what the cows eat? Milk intolerance is a somewhat vague term and it usually refers to a person saying they cannot take or tolerate milk. There are several, specific recognized issues related to milk consumption. Lactose maldigestion, or intolerance, relates to pain/bloating after consumption of milk products containing lactose. The milk of all mammals contains lactose, including human milk which actually contains much more lactose than cow's milk. Lactose is a disaccharide (made up of two small sugars). In our stomachs we produce an enzyme called lactase that splits the lactose into its two component sugars which can be quickly absorbed. In some individuals the amount of lactase enzyme activity decreases as they get older, so they may not have enough lactase to digest large quantities of lactose at one time (one meal). In lactose-free products, manufacturers actually add lactase enzyme to hydrolyze the lactose for us before we consume the milk. Milk intolerance is not about what the cows eat. Milk intolerance may be an allergy to some proteins in milk (discussed below). Milk intolerance may be a mild version of cows milk protein allergy.

4. What is responsible for allergy in milk products? Some of the proteins in milk contain very specific segments in their amino acid chain (sequence) that triggers an allergic (immune) reaction in some sensitive individuals. Think of a barcode that only some sensitive individuals recognize. The body apparently thinks that these peptides are harmful (like "toxins"). The milk proteins involved can include several of the caseins as well as beta-lactoglobulin. Cow's milk protein allergy can occur in about 5-8% of all infants but most children grow out of this reaction once they reach teenage years. The number of adults with this diagnosed condition is low (as opposed to self-diagnosis where numbers are higher). Milk protein allergy is an important topic in infant formula as that product may be the only, or dominant, food for infants so it is critical that they can safety digest it.

5. There was some research done in the past by USDA investigating the ability of milk protein to be used as a renewable plastic source for food packaging. Is this still a viable area of research? Two potential materials in milk could be made into plastics. The caseins in milk were once widely used as adhesives or glues (and materials like buttons) before commercial chemical-based (oil) adhesives became the dominate form over 70 years ago. One issue was casein-based adhesives lacked water resistance without another treatment (which is a big issue if the application gets wet). Another interesting option is to ferment the lactose into polylactic acid which can then be made in recyclable plastics. These plastics tend not be resistant to heat so this currently limits their application unless treated in some way. Caseins have very high nutritional quality for food uses but fermenting the lactose in various dairy by-products is a viable and ongoing area of research.

6. When communicating with the normal consumer that may have or think they have a reaction (pain, allergy) when drinking milk, what is your suggestion for them when considering/comparing A2 milk or the new cow milk brands with high protein and low sugars (lactose), like Fairlife? If they actually do have cow's milk protein allergy then they need to look at other milks like goat milk, but they should be aware that cow's milk protein allergy is relatively rare in adults. A2 milk contains all the milk proteins in regular milk. A2 milk differs in the type of genetic variant of one of the caseins but not clear if that minor change (one amino acid) impacts potential allergenicity. There is some research suggesting that A2 milk can alter gut motility and that might be a factor in why some people say they feel better drinking A2 milk. Solid scientific evidence of a clear benefit is still lacking, but studies are underway. Milks with low or no-lactose would be helpful for the many individuals that have lactose maldigestion. Bear in mind nearly everyone has some residual lactase enzyme activity, the issue for some is not enough enzyme activity to quickly hydrolyze large amounts of lactose consumed in one dose. A2 milk has the same amount of lactose as regular fluid milk so it would not benefit individuals with lactose maldigestion.

7. From an evolutionary standpoint, why do you think cows produce alpha-s casein, but humans do not? Cows have much higher requirements for providing caseins (high protein) and lots of calcium and phosphate compared to humans. The alpha-s caseins can have much higher levels of phosphorylation so that allows them to bind more calcium/phosphate than beta-caseins. The rate of development is much faster in calves than in infants.

8. At what temperature do whey proteins denature? The main whey protein, beta-lactoglobulin denatures at around 158° F.

9. Are any of the proteins damaged when the raw milk/whey is processed into a concentrate/isolate? If so, how much is damaged/lost through processing? Manufacturers try to limit the amount of heating which can cause denaturation (which is a change in its structure). Denaturation does not reduce the nutritional quality of a protein. Pasteurization is the main heating process in whey processing and that can often cause about 5% whey protein denaturation.

10. Are there any breed differences noted in relation to quality of milk protein concentrate or milk protein isolate? There may be differences in the ratio of individual milk proteins in milk powders due to the differences in the protein profile in milk. Slight differences in the protein profile could cause some variation in the functional properties of milk powders.

11. When milk protein percent increases in a herd, do all milk protein fractions increase proportionally? There can be some variations in the profile of milk proteins as the herd milk protein content increases, but in general most fractions increase proportionally.

12. Does milk urea nitrogen (MUN) play any role in milk protein quality or cheese yield? Not a positive one. This type of nitrogen is lost in the whey and not recovered in cheese. MUN is not a protein and higher levels of this in milk represent poorer milk quality (from the perspective of wanting more of milk nitrogen being true proteins).

13. Soy protein vs milk protein comparisons, which is better and why? Soy protein has higher quality than most other plant proteins. However, soy protein is still inferior to milk protein by most rigorous measures of protein quality.

14. Have you seen A2 casein levels of milk from Gyr breed? How is that in comparison with Jersey, Guernsey and Ayrshire cows? I believe that the Gyr breed contains mostly the A2 casein variant.

15. What is responsible for the increase in products that are non-dairy milk sources, such as almond milk? Various factors I believe are involved: lack of innovation in traditional fluid milk (e.g., non-dairy beverages often has many flavored options with various interesting packaging formats); the concerns about lactose maldigestion for some individuals; for others they may think that dairy production is less sustainable than plants (although I believe that when you factor in the quantity of high quality nutrients that can be obtained from dairy I think the sustainability difference between dairy and plants is small, in terms of green house gases the main contributor (>70%) is fossil fuels); the biggest competitor to fluid milk has been water (despite its widespread use of non-recyclable plastic bottles).

16. Once I had problem with cows where milk was coagulating (alcohol test). It was not related to bacteria, temperature, or something similar. It got better after 10-12 days, but still could not find the reason why this happened and what would be mode of development. Do you have any information on that? Milk with a lower pH would coagulate easier, another factor is higher levels of calcium ions. Calcium ions can vary dependent on the citrate level in milk (citrate can complex with calcium ions reducing the coagulation risk), and citrate levels in milk can be altered by changes in feed (which impacts the rumen fermentation process).

17. Is it possible to alter the proportion of caseins and whey protein in the milk through the diet? Probably not significantly. Poor nutrition and late-lactation can cause changes in the ratio of caseins to whey protein but that is a combination of lactation, poor feed quality/nutrition and the approach of involution (milk shutdown).

18. Are there differences in nutritional and physiological value between natural and denatured proteins? Usually denatured proteins have similar nutritional properties. In some cases denatured protein may exhibit faster digestion as in the case of whey proteins. Immunoglobulins might lose some potential biological activity (immune functions) at pasteurization conditions (partial denaturation). Caseins are very stable to heat as some may consider them as unstructured (or already denatured).

19. Natural milk is a rich source of various essential amino acids. However, when the milk protein or whey protein are isolated from the milk, industrial methods are applied for separating protein from the milk. My question is - how safe or healthy are these proteins to be consumed? Is there any possibility to disturb the metabolic activities in the human body from the processing method? Because many nutritionists alert about the industrial milk derived protein for health safety. Especially, for human intestinal disorder diseases? Most processes used to isolate whey or milk protein involve filtration which is a simple physical separation process, mainly based on size differences. It does not use extreme conditions of pH nor strange chemicals. There is no safety risk with filtering milk, it just concentrates the proteins that are already present. I do not see real or proven risks to human digestion from most processing techniques, which usually try to minimize denaturation and keep the proteins close to their original native state. Filtration may slightly alter some proportions of proteins in the final powder.

20. Lots of individual novel proteins in milk (lactoferrin, alpha lactalbumin, etc.) are being used for human medicine and impacts. Are these the most valuable future for milk components? Isolated, individual proteins are becoming an important ingredient in many nutritional products like infant formula. However, they often represent minor or sometimes even trace amount of the overall protein content. Thus, I still believe that the main milk proteins will continue to play an important future role.

21. Perfect Day claims to be making cow proteins (casein and whey) in flora (so animal or dairy protein without cows). Your thoughts? They are making some individual milk proteins using genetic engineering of industrial microorganisms. This approach provides the basic protein sequence but does not provide the post-translation modifications that play such a major role in the behavior of milk proteins. Those modifications include phosphorylation (needed to bind calcium) and glycosylation (to stabilize the casein particles, which is hydrolyzed during digestion to allow clotting in the stomach). These modifications are performed by special enzymes within the mammary gland of the udder that are poorly understood. The industrial fermentation approach thus does not reproduce the same casein structures that are critical for its functionality. I have a similar concern about the inability of the fermentation process to replicate the native milk fat globule structures and thus could alter the biological behavior.

22. You touched on AA to protein for healthy aging. For those of us in the 50+ age bracket, can we meet our AA needs in our daily food intake or do we need to be taking an AA supplement? AA supplements can be challenging to consume due to taste. It would also require a lot of AA supplements. Higher amounts of protein are needed as we get older as we become less efficient at muscle synthesis. More high quality protein in our daily food intake is what I would recommend. Whey proteins have the highest levels of branched chain amino acids which are key to muscle synthesis. Older individuals are at risk of sarcopenia, loss of muscle mass.

23. What is the market for alpha, beta and kappa casein? Are there manufacturing processes setup to separate these? Is there potential for growth? There are processes that have been researched and a couple have been commercialized to some extent. But this area has lots of growth potential in order to customize properties and food/nutritional applications. For example, beta-casein is the main casein in human milk so it could be isolated from cows milk and used to fortify novel infant formula or human nutritional products.

24. Lactose is so high in % in dairy milk or whey. Are there new opportunities or anything researchers are working on, to bring more value to lactose? There is a lot of research on utilizing lactose. Mainly it can be purified and sold as isolated lactose for food or pharma applications. Lactose can be fermented to various ingredients, one issue is that corn starch can be a cheaper feedstock for many fermentations.

25. Are any differences in A2 concentration in pasture vs TMR based diet? Whether a cow produces A1 or A2 variant is due to her genetics so I doubt if diet changes the proportion or A1/A2. Diet can definitely impact the amount of protein (including casein) produced in the milk.