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Investigate of Milk Protein in Cattle

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Description

The 6 main milk proteins in cattle are encoded by highly polymorphic genes characterized by several non-synonymous and synonymous mutations, with up to 47 protein variants identified. Such an extensive variation was used for linkage analysis with the description of the casein cluster more than 30 years ago and has been applied to animal breeding for several years. Casein haplotype effects on productive traits have been investigated considering information on the whole casein complex. Moreover, mutations within the noncoding sequences have been shown to affect the specific protein expression and, as a consequence, milk composition and cheese making. Milk protein variants are also a useful tool for breed characterization, diversity, and phylogenetic studies. In addition, they are involved in various aspects of human nutrition. First, the occurrence of alleles associated with a reduced content of different caseins might be exploited for the production of milk with particular nutritional qualities; that is, hypoallergenic milk. On the other hand, the frequency of these alleles can be decreased by selection of sires using simple DNA tests, thereby increasing the casein content in milk used for cheese making. Furthermore, the biological activity of peptides released from milk protein digestion can be affected by amino acid exchanges or deletions resulting from gene mutations. Finally, the gene-culture coevolution between cattle milk protein genes and human lactase genes, which has been recently highlighted, is impressive proof of the nonrandom occurrence of milk protein genetic variation over the centuries.

Among ruminants, milk protein genes have been thoroughly investigated in cattle and goats, and a noticeable genetic variation has been identified and characterized. The importance of such an extensive genetic variation for animal breeding is mainly the consequence of the effects of milk protein variants on milk composition and cheese making properties. These effects are related to functional modifications of the protein, mainly AA exchanges or deletions, which affect the biological properties of the coded protein. In addition, milk protein variants were used for breed characterization, biodiversity investigations, and evolution studies on both animal resources and milk protein genes. For such studies, an interesting approach is to consider the whole CN haplotype instead of individual genes coding for the 4 caseins.

In this review, we will concentrate our attention on the bovine species, aiming both to emphasize the pioneer work and exhaustive reviews that have already been carried out on the subject in the past 30 year and to elucidate some of the main aspects affecting animal breeding and human nutrition, with special focus on innovative scientific approaches. Fatty acids, n-3 as well as n-6, are essential for normal physiological functioning and for the health of humans and all domestic species. It is important to emphasize an adequate linolenic acid (LNA) intake; the n-6:n-3 fatty acid ratio is not a useful concept, and it detracts from increasing absolute intakes of n-3 PUFA. In humans, when LNA is consumed in adequate amounts and without excessive n-6 fatty acids, conversion to eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids can maintain normal physiological functioning and health. However, conversion of LNA to EPA is more limited in humans than in rodent models, and conversion to DHA is even more limited. Stearidonic acid bypasses the limiting step in synthesis of EPA, but not DHA, from LNA. Therefore, development of gene-modified oil crops to increase content of stearidonic acid supply holds promise to increase EPA synthesis in humans. Quantitative synthesis of EPA and DHA from LNA in domestic animals has not been reported, but conversion is limited in these as well, although perhaps not for some aquatic species. In humans, evidence is clear that increased intake of the fish oil fatty acids, especially DHA, will improve physiological and health outcomes during pregnancy and lactation, stresses of the immune system, cardiovascular disease, cancer, and some mental and emotional conditions. At least 200 mg DHA should be consumed daily by pregnant and lactating women. Certain feed supplements increase the n-3 fatty acid content of animal products, including eggs, meat from major domestic species, and milk. Feeding flax (linseed or linseed oil) increases LNA content of products 2- to 3-fold, and in some products, EPA is also increased, with the exception of eggs, in which DHA, but not EPA, is increased. The increase is adequate to have a positive effect on the n-3 fatty acid intake of the general public. To change EPA, and especially DHA, significantly in animal products, fish oil or marine algae products must be fed. To achieve 2- to 3-fold increases in ruminant tissues and milk, supplementation with rumen-protected linseed or marine oil products is necessary. At higher levels of n-3 PUFA incorporation, effects on product quality (oxidative stability, sensory characteristics) and costs of production and segregation of modified from conventional products in the production and distribution streams must be considered. It seems possible that niche markets for products containing greater amounts of n-3 fatty acids can be developed without expensive protection processes and risks of decreased product quality.