Editorial

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Consolidated properties and new perspectives for polyunsaturated fatty acids in ruminant diet

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Editorial

Nowadays, it is easy to misunderstand the big amount of information coming from media and other sources about human health and foods, creating public confusion about the effects of fat and fatty acids in animal products. Fruits and vegetables have always been considered beneficial for human health, but bioactive components are also present in animal-derived foods, such as milk and dairy products. In particular, there is an increasing awareness of the health effects of specific polyunsaturated fatty acids (PUFA) such as n-3 and conjugated linoleic acid (CLA) fatty acids, the latter found predominantly in products of ruminant origin. Different nutritional strategies have been proposed in order to enrich dairy products with beneficial PUFA and ameliorate the human diet without any kind of change in consumer's eating habits. Very interestingly, recent studies have also highlighted a possible role of dietary lipids in the mitigation of enteric methane emissions, a crucial environmental issue.

Manipulating milk fat content

The interest in manipulating the milk fat content started at the beginning of 80s and the pressure to reduce total fat content and its saturation has lasted until now with different strategies. One example is the chance to supplement ruminant diets with n-3 PUFA such as eicosapentaenoic acid (EPA 20:5 n-3) and docosahexaenoic acid (DHA 22:6 n-3) from marine sources, but it is important to take into account their low transfer rate into milk, due to their ruminal biohydrogenation and low intestinal digestibility.[1]

The n-6/n-3 fatty acid (FA) ratio in Western diet has increased drastically in the last 100years due to the relevant consumption of vegetable oils rich in n-6 FA.[2] This shift in the ratio has been associated with health disorders, such as cardiovascular diseases, arthritis, psoriasis and colitis[2,3] and various neuroendocrine conditions. Recommendations of nutritionists are for a ratio of n-6/n-3 PUFA less than 5, but unfortunately this ratio in animal products is between 10 and 15. In fact, n-3 PUFAs cannot be synthetized by animals because desaturation of fatty acids does not occur at positions greater than D9[4] and the conversion of C18:3 n-3 into its long-chain derivates (EPA and DHA) is limited by metabolic factors, due also to the excessive dietary intake of n-6 FA, in particular of C18:2 n-6.[1]

Several studies investigated the addition of fish oil and marine algae in ruminant diet as a way to enhance EPA and DHA content in milk.[5–11] In dairy cows, fish oil seems to have a toxic effect on ruminal microorganisms, reducing fat content and conferring off-flavours due to fatty acid oxidation.[12] Other aspects, both economic and environmental, have to be taken in account when using fish oil as a source of n-3 PUFA, such as the relevant cost and the sustainability of fish stocks.[1] Therefore, it is crucial to consider alternative sources, for example marine algae rich in DHA,[8,13,14] linseed[15] and camelina[16,17] both rich in C18:3 n-3 (ALA, alpha-linolenic acid), the precursor for EPA and DHA. Another natural dietary source of n-3 PUFA is green pasture. Pasture is able to enrich milk fat in ALA, CLA[9,18,19] and also in EPA and DHA.[20–22] Nevertheless, the possibility to enhance DHA and EPA in milk is limited.[9] In a study with dairy goats, apparent transfer efficiency of EPA and DHA from fish oil to goat milk ranged from 7 to 14% and 7 to 8% respectively.[23] A possible solution to limit ruminal biohydrogenation is the use of ruminal protected sources of PUFA. Doreau & Ferlay[15] showed the possibility to take advantage of the natural constitution of linseeds, thanks to partially protected lipids when whole seeds are fed. Alternative rumen protection strategies include heating feeds at high temperature, using calcium salts of fatty acids or encapsulating the lipids in a matrix of rumen-inert protein.[24,25]

During the last two decades, several studies, firstly in vitro, and subsequently on humans, have been proving different biological activities of CLA (conjugated linoleic acid) found in food products of ruminant origin. These studies highlighted that CLA can positively affect human health, such as diminishing cancer, atherosclerosis, diabetes and obesity.[26]

CLA belong to a series of positional and geometric isomers of linoleic acid, with conjugated double bonds. Important for their benefits for humans, they are present in products of ruminant origin. The most predominant form is rumenic acid (cis-9, trans-11 CLA), which represents more than 90% of total CLA in ruminant milk fat. Milk usually contains 0.2 - 0.9% of CLA and its concentration differs among ruminant species, depending also on stage of lactation.[27–29] Diet is the most significant factor affecting the milk content of cis 9-trans 11 CLA and of its precursor, trans-11 C18:1 (vaccenic acid). Milk CLA can be enhanced by feeding sources rich in PUFA, such as pasture, plant oils, oilseeds, fish oil, marine algae, and rumen protected CLA. Linseed, oleic-rich sunflower oil and soybean oil all proved to be effective in increasing secretion of cis-9, trans-11 C18:2 in milk fat.[10,30–34] Numerous studies have also evidenced that fresh pasture feeding can increase milk CLA content compared to diets based on conserved forages.[18,19,21,35] Marine oils, rich in EPA and DHA, have been shown to be more effective than vegetable oils at increasing CLA concentration in ruminant milk. In dairy cows, CLA proportion increased in milk from 0.2-0.6% to 1.5-2.7% when diets were supplemented with 200-300g/d fish oil[9] and in dairy goats supplementation with 47g/d fish oil enhanced milk fat CLA content from 0.6% to 1.93%.[36] The inclusion of soybean oil in combination with fish oil in goat's diet also proved to be effective, resulting in an enhancement of CLA content in milk (4.04 vs 0.57%).[37]

Reducing emissions of greenhouse gases

Mitigation of greenhouse gases emission is a social and environmental priority. Methane (CH_4) is a potent greenhouse gas produced in the rumen due to the metabolic activity of bacteria, the methanogenicarchaea, which use hydrogen (H_2) and carbon dioxide (CO_2) as substrates.[38] High concentrations of H_2 are toxic for microbial enzymes, affecting their activity and ruminal fermentation, so the formation of CH_4 sustains the efficiency of ruminal degradation with the dissipation of H_2.[39] Different dietary interventions have been studied to address this issue and dietary lipids are considered among the best for enteric methane mitigation.[38,40] Substitution of dietary carbohydrates with lipids can reduce methane emission and decrease rumen protozoa which are producers of hydrogen, the precursor of methane.[15] Interestingly, linseeds rich in n-3 PUFA have been shown to reduce methane yield more efficiently than saturated (calcium salts of palm oil, tallow) and unsaturated sources containing oleic acid (rapeseed) or linoleic acid (sunflower, cottonseed).[15,38] Very recently, the possibility to reduce methane production by adding fish oil in low-starch diets has been demonstrated.[41] Also increasing doses of coconut and fish oil quadratically decreased concentration of methane *in vitro*.[42] However, studies in this field are still very limited and more investigations are needed in order to find the best way to reduce methane emission with a systematic strategy including animal nutrition.

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Conflict of interest

Author declares that there is no conflict of interest.

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