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Analytical Traceability of Organic Foods of Animal Origin

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To achieve a species-appropriate farming, a special feed composition is stipulated in producer guidelines for organically raised livestock like cattle or fish. Increased production costs and decreased output result in higher sales prices and a risk for conventionally produced foods fraudulently being labelled as organic. Hence, the protection of consumers and producers requires analytical methods for the authentication of organic foods. The work performed at MRI aimed at detecting differences between organic and conventional production or wild caught animals by fatty acid and stable isotope ratio analysis.

With respect to stable isotopes, the most relevant effects related to organic foods of animal origin are 1) differences in $\delta^{13}C$ between C3 and C4 plants, 2) differences in $\delta^{15}N$ between organic and synthetic fertilizers or legumes, 3) the increase of $\delta^{13}C$ and $\delta^{15}N$ along the food chain, and 4) a relative decrease of $\delta^{13}C$ in animal fat compared with protein. In general, the isotopic signature of animal feed affects the isotopic signature of animal foods.

Organic aquaculture according to regulation (EC) 710/2009 stipulates a limited stocking density, a limited use of pharmaceuticals, and a ban of synthetic dye stuffs, GMO and synthetic pesticides or fertilizers. Vegetable feeding stuffs must originate from organic farming and animal feeding stuffs (fish meal, fish oil) from organic aquaculture or sustainable fisheries. Most notably, feed for carnivore species must not contain more than 60% feeding stuffs of vegetable origin.

In a study analysing Pangasius from organic and conventional aquaculture over a period of 18 months, a higher percentage of fish meal in organic aquaculture feed was reflected in elevated $\delta^{15}N$ and $\delta^{13}C$ in the defatted fish filet. This facilitated a clear differentiation between organic and conventional fish. Corresponding results were also obtained for Brown trout from aquaculture. The replacement of animal feed with cheaper vegetable feed in conventional aquaculture could as well be established for Salmon, showing significantly lower $\delta^{15}N$ and $\delta^{13}C$ in protein of conventional products. However, additional distinction between organic and wild salmon required analysis of $\delta^{13}C$ in lipids instead of protein. The effective differentiation of these three origins was independent of processing such as smoking or marinating.

Because of the lower percentage of fish oil in conventional aquaculture feed, the content of the long chain ω3 fatty acids EPA and DHA was significantly lower in conventional salmon. These FA are of particular interest with respect to human nutrition. Because of similarly elevated levels of these ω3 fatty acids, organic and wild fish mostly could not be distinguished. However, linoleic acid, which is a main component of vegetable oils, allowed distinguishing between wild, organic and conventional salmon by its increasing content. Similarly, organic and conventional salmon could also be distinguished by the higher oleic acid content in conventional fish.

Organic milk production is characterized by a higher percentage of pasture feed (incl. hay, grass silage) throughout the year and less concentrates (max. 40 – 50 %) in the ration compared with conventional husbandry. In a 18 months study on German whole milk samples from retail, organic milk showed an elevated level of α-linolenic acid (ALA) compared with conventionally produced milk, which allowed to define a minimum level for organic milk of 0.50%. Sometimes, ALA contents higher than 0.50% can occur in conventional milk samples if milk production is less performance-oriented, such as in alpine regions or in Ireland.

As a C4 plant maize shows significantly higher $\delta^{13}C$ values than other feed plants like grass or clover. The higher use of maize silage in conventional milk production is reflected by the elevated level of $\delta^{13}C$ in milk fat. Hence, a maximum limit of -26.5‰ allowed to authenticate organic milk samples with high selectivity. There was a slight decrease during summer in both production forms because of higher availability of pasture feed in the growing season. The combination of ALA and $\delta^{13}C$ in milk fat can increase robustness of organic milk authentication by better preventing manipulation. The $\delta^{13}C$ signature of maize is not only found in milk fat but in milk protein as well, with an upward shift of 3‰ but a close correlation. This allows authentication of reconstituted organic milk products like cream cheese or curd, which could contain milk components from a different origin.

Because of the use of organic manure instead of synthetic fertilizers in organic feed production, $\delta^{15}N$ in milk could be expected to be higher in organic than in conventional milk. However, the opposite result was obtained. This can be explained by the high percentage of pasture feed in organic milk production, which contains a lot of clover. This leguminous plant fixes air N_2 having a low $\delta^{15}N$ of zero. Although there is a tendency to lower $\delta^{15}N$ in organic milk, it's not clear enough for a differentiation from conventional milk. However, the combination of $\delta^{15}N$ and $\delta^{13}C$ in milk protein is suitable to authenticate organic milk by just a single stable isotope analysis.

As the organic producer guidelines are similar for milk and beef, we found lower $\delta^{13}C$ and slightly lower $\delta^{15}N$ in organic beef as well. However, because analyses were based on individual animals instead of bulk milk, a higher variation was established in beef. Organic beef also showed elevated ALA contents.

In conclusion, the special composition of organic feed is reflected in organic animal products. Feed in organic aquaculture of carnivore fish contains a higher percentage of fish-based proteins and lipids. Organic production of milk and beef is characterized by a higher percentage of pasture feed / legumes, less concentrates and less maize silage in the ration. These characteristics can be detected by stable isotopes and fatty acid analysis, while the combination of parameters or methods can increase robustness of authentication.

Because of the potential variability of feed composition, limits for distinction of organically from conventionally or wildly produced animal foods must be maintained in practice, which requires continuous update of data bases or direct comparison with latest authentic reference samples. 100 percent correct assignment is not always achievable, but available methods at least recognize a large part of conventional products as „non-organic“.

Selected references

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