IMPROVING INPUTS FOR ORGANIC FARMING

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1. Executive summary

The socio-economic consequences of changes in vitamin supply to organic livestock were assessed for the two cases of a) reduced vitamin E supply to organic dairy cows and b) new product availability and reduced supply of vitamin B2 to organic poultry in Europe.

The feed vitamin market including production and subsequent processing in feed mixtures is almost completely controlled by premix producers and feed mills. As a consequence, farmers have only small influence on these processes and are, if at all, only indirectly affected by changes in the formulations. Therefore, the assessments were mainly carried out on the level of feed producers.

During the RELACS project, a proposal for reduction of Vitamin E supplements to dairy cows in organic systems has been developed, which differentiates between different production phases and diets of the cows. Based on the market price for vitamin E, we calculated the potential changes in feed costs. Since the concentration of vitamin E in feeds is generally on the level of a micronutrient, the total costs for Vitamin E supplement per cow and year amount to approximately 3€ per cow and year. With the proposed change in supplementation, this cost can be potentially reduced by 2€ on average, if the diet is grassland-based. The cost reduction has small influence on the overall profit margins of a dairy farm. Since only about 40% of the European organic dairy farms would match the requirements for the proposed reduction of supply, the overall economic impact at the European market scale amounts to approximately 1.5 mio €; this is also a negligible small amount.

With regard to Vitamin B2, we analysed the situation based on two different approaches, i.e.: (a) the availability and price of a riboflavin product that is not based on GMO organisms, and (b) the proposed changes in supplementation levels for poultry, which were developed within RELACS. Since the newly available commercial European product (Ecovit R) has still issues with its legal status and is more expensive than former sources of riboflavin, the current situation on the European organic feed market and feeding practice is complicated and intransparent and strongly affected by several political and economic aspects. These are described within this report, and suggestions for further actions are presented.

The European market situation for riboflavin would presumably change if additional alternative products of other suppliers would be available. One approach in this direction was made in RELACS task 6.5 with the lab-scale development of a riboflavin producing yeast wildtype which has a high production efficiency. However, this riboflavin producing yeast wildtype has TRL4 and its economic feasibility needs to be confirmed. Another product is currently under evaluation by EFSA. However, information on its status regarding manufacturing (i.e. GMO/non-GMO) and registration as feed is not publicly available and it is not clear if the product complies with requirements for organic farming.

2. Introduction

Vitamin supplements in organic livestock are considered as contentious inputs if they are either of synthetic production or of GMO-based origin. The former is mostly true for all lipophilic vitamins (A, D, E), the latter can be an issue in the production of B-vitamins. In the case of B-vitamins, GMO-free production is feasible, but under pressure due to higher costs compared to GMO-based vitamins on a level, which is economically relevant.

Therefore, it is a target to reduce the inputs of such vitamins in the nutrition of organic livestock. However, this must not compromise health and welfare of the animals. Therefore, reductions in the supplementation levels must be based on experimental evidence for health security of the chosen dosages.

The socio-economic consequences of reductions in the supply of vitamins to livestock feeds need to be evaluated with respect to impacts on the stakeholders along the agri-food production chain.

This report describes the expected or existing socio-economic implications for adapted recommendations of Vitamin E supplementation to dairy cows and Vitamin B2 supplementation to poultry.

During RELACS, the activities were focused on feasibility of reduction of vitamin use and on provision of non-GMO alternatives. As the performance and well-being of livestock was not to be compromised by definition, ecological effects due to alternative feeding regimes or alternative vitamin manufacturing are expected to be minimal with respect to the overall impact of livestock production.

3. Socio-economic impacts of changed recommendations regarding Vitamin E supplementation to organic dairy cows

Based on a literature review, surveys of vitamin E status on organic dairy farms, experiments with vitamin E supplementation conducted within organic dairy farming systems, and the diet of major organic dairy farming types in Europe, RELACS has made a proposal for recommendation for dairy cows in organic dairy production (Table 1). Organically managed cows and heifers should be supplemented during transition period, i.e. late gestation and early lactation. It is suggested that for dairy cows that are more than 30 days in lactation, where grazing pasture or grass clover silage is the main forage, no extra vitamin E supplementation is required. For grazing organically managed cows and heifers during the transition period, the supplementation can be reduced by about 50% relative to organic cows on conserved forages.

Production stage	Pasture	Grass/legume silage	Other conserved forages
Gestating, last 30d	15/25/25	25/25/80	25/25/80
Lactating, <30 DIM	15/15/8	15/15/25	25/15/25
Lactating, > 30 DIM	0/15/8	0/15/25	15/15/25

RELACS/INRA feeding systems for ruminants, 2018/National Research Council, 2001

Table 1. Suggested Vitamin E supplementation to dairy cows in organic production (IU/kg DMI) as compared to other recommendations.

Where grazing pasture or grass clover silage is the main forage, RELACS recommendations of vitamin E supplementation are about 90% lower than the National Research Council 2001 and INRA 2018 recommendations when calculated over the whole production cycle, i.e. the period between one calving and the next (Table 2). If other conserved forages are the main constituents of the diet, the RELACS recommendations are similar to the INRA 2018 and 50% lower than National Research Council 2001.

The cost of vitamin E supplementation is presented Table 2. Total cost per cow and production cycle is approximately 0.20 € if the RELACS recommendation is used for cows grazing pasture or grass clover silage as the main forage. This is between 1.50 and 3.00 € less than the INRA 2018 and the National Research Council 2001.

The total and relative costs of Vitamin E supplementation per cow are, however, so small, that they are negligible on farm scale.

On the overall European production scale, where approximately 250 tons of Vitamin E per year are fed to dairy cattle (Varga et al., 2022), the proposed reduction, which can be applied to estimated 40% of European organic dairy cows, results in approximately 90 to reduction of Vitamin requirement for the organic sector. Based on the market price of 16€ per kg of pure Vitamin E, a total market volume of roughly 1.5 mio € is "saved" or "lost", depending on the perspective. Again, this is a negligible small amount with regard to the total volume of organic feed and dairy markets.

Since vitamins are produced and mixed on the industrial level of feed mills and premix producers, and the economic value of Vitamin E is small as indicated above, we expect no effects on the socio-economic indicators on farms.

Standard	Period	Basal diet	DMI	Days/	Vit E supplementation				Costs, €[a]	
			kg/d	period	IU/ DMI	IU/ BW	IU/ day	IU/ period	Period	Total
NRC, 2001	Gestation	Conserved forage	10	60	80	1.6	800	57600	0.92	
	Lactation		20	305	20	0.8	400	146400	2.34	3.26
	Gestating	Grazing	10	60	25	0.5	250	18000	0.29	
	Lactation		20	305	8	0.3	160	47580	0.76	1.05
INRA, 2018	Gestation		10	60	25	0.4	250	15000	0.24	
	Lactation		20	305	15	0.5	300	91500	1.46	1.70
RELACS	Gestation	Grass clover silage	10	60[b]	25	0.4	250	7500	0.12	
	Lactation, early		15	30	15	0.4	225	6750	0.11	
	Lactation, >30DIM		20	275	0	0.0	0	0	0.00	0.23
	Gestation	Hay/haylage/whole crop silage	10	60[b]	25	0.4	250	7500	0.12	
	Lactation, early		15	30	25	0.6	375	11250	0.18	
	Lactation, >30DIM		20	275	15	0.5	300	82500	1.32	1.62
	Gestation	Grazing	10	60[b]	15	0.3	150	4500	0.07	
	Lactation, early		15	30	15	0.4	225	6750	0.11	
	Lactation, >30DIM		20	275	0	0.0	0	0	0.00	0.18

[a]The price of vitamin is assumed to 8 €/kg of Vitamin E 50 adsorbate, containing 500 g vitamin/kg product as *all-rac*-tocopheryl acetate (500 000 IU), which were the world market price in April 2021.
[b]Supplementation is suggested to be given during the 30 last days of gestation

Table 2. Estimated costs of vitamin E supplementation to dairy cows during a production cycle of gestation and lactation assuming total dry matter intake (DMI) of a dairy cow of 600 kg body weight (BW) for different standard recommendations (NRC 2001, INRA, 2018) and the RELACS suggestion

4. Socio-economic implications of the current status of Vitamin B2 availability and new recommendations regarding supplementation of organic poultry

4.1. Dietary riboflavin in European organic livestock production

Feeds for non-ruminant livestock must contain added riboflavin for reasons of animal health and welfare. It is considered unlikely at present that all added riboflavin in organic nutrition is produced without the help of GMOs in all EU countries. We describe the current availability of riboflavin produced without the help of GMOs in Europe, and the reasons why it is not (cannot be) used by feed producers in the EU.

Furthermore, we suggest levels and ways of action to overcome this unsatisfying situation.

As a conclusive recommendation of action, we suggest:

- Enforcement of the requirement for riboflavin produced without the help of GMOs would provide necessary security for current producers to take the financial effort for the EFSA registration of Ecovit R – the newly available European Riboflavin product – as a feed additive.
- A clear decision in the ScoPAFF regarding the status of Ecovit R would push the start of a registration process at EFSA, if the organic associations actively support the use of yeast-based vitamin B sources not produced with the help of GM micro-organisms in livestock feeds.
- All European organic associations need to develop a common understanding that the Vitamin B supply to organic livestock on the basis of yeast fermentation products from European organic producers is a better option than vitamin sources from overseas, where controllability and reliability may be limited. This would also be useful also for future issues of availability regarding, for instance, Vitamin B12.

4.2. Importance of riboflavin in animal nutrition

Riboflavin (Vitamin B2) is a water-soluble vitamin, essential to monogastric animals, which has its major functions as a cofactor in flavin enzymes in energy and lipid metabolism, particularly due to its involvement in redox reactions in aerobic cells. Further, riboflavin has significant functions in the nervous system, skin and mucosa. Dietary riboflavin deficiency in birds causes damages in neuronal tissues, which lead to paralysis and paroxysm of legs and feet, described as 'curled-toe paralysis'. Skin lesions, in particular of feet, are further symptoms of riboflavin deficiency in poultry. Also, impaired hatchability and retarded growth of chicks may be the result of insufficient riboflavin supply via parent animals and rearing diets (all references in Leiber et al., 2021a). Thus, the sufficient supply of poultry (and pigs) with riboflavin is an indispensable element of livestock nutrition across all production systems. The main species affected, and therefore investigated, are poultry. Nonetheless, swine and other non-ruminants also rely on dietary riboflavin.

4.3. Riboflavin sources for organic livestock in Europe

Since B vitamins are of microbial origin, they are usually produced by genetically modified bacteria or yeast strains. However, in organic agriculture the use of genetically modified organisms is excluded on all levels of production, by regulation (Council of the European Union 2018), and production chains therefore rely on alternative vitamin products. In recent years, the availability of vitamin B2 produced with non-genetically modified micro-organisms has drastically decreased.

Regarding riboflavin, the European organic feed industry relied for several years on the product of one single producer from China, which was certified by InfoXgen. In autumn 2018, the Chinese producer stopped on short notice the supply, and after a few months riboflavin not produced with the help of GMOs was not available anymore in Europe. A certain risk of supply gap had been foreseen; and already in 2012 FiBL Germany and FiBL Switzerland started a project together with an organic producer of bakery yeast (Agrano GmbH & Co. KG, Riegel am

Kaiserstuhl, Germany) to develop fermentation techniques for a riboflavin producing yeast strain (*Ashbya gossypii*). Since 2016 this has been supported by a grant of the German Federal Ministry of Agriculture. During 2018/2019 a product of *Ashbya gossypii* fermentation, rich in riboflavin, could be scaled up to commercial production. This is not an isolated vitamin but the whole fermentation product, containing several nutrients besides rather high riboflavin concentrations. First proof of equivalence of this product as a riboflavin source for poultry was recently published (Lambertz et al., 2020a,b) and further feeding experiments with this product revealed no deficiency symptoms of hens, parent animals or broiler chicken, if applied in sufficient concentration (Lambertz et al., 2021; Leiber et al., 2022b). Recently, a granulate of this product came to the market (Ecovit R, Agrano GmbH & Co. KG, Riegel am Kaiserstuhl, Germany). In Switzerland, it is since 2019 regularly added to organic feeds, with success. An experiment with the granulate at FiBL Switzerland did not reveal any problems with parent hens, breeding eggs and hatching, when supplemented at 4.0 mg/kg feed (Leiber et al., 2022b).

Thus, after a short supply gap in 2018/2019, there is an organically certified riboflavin source not produced with the help of GMOs available on the European market, which, however, is almost not used, for reasons explained below.

4.4. Legal situation of Ecovit R

The Standing Committee on Plants, Animals, Food and Feed of the European Commission (ScoPAFF) suggested to treat Ecovit R as a feed additive, which would have required approval by EFSA. The producer was so far reluctant to start the expensive approval procedure due to economic constraints and due to the fact that the product is not purified riboflavin but a yeast extract containing also other nutrients. Therefore, the producer claimed to consider Ecovit R as a feedstuff, a status, which would not need EFSA approval. After repeated considerations in the Standing Committee, the question of the legal status remains open (IGFA 2020), but it is tolerated that some member states put it on their positive lists for feedstuffs; as in the case of Germany.

4.5. What is used as riboflavin source?

The only country where Ecovit R is currently used is Switzerland, where all feed mills agreed to accept it as the standard source of riboflavin for organic feedstuffs.

In the member states of the European Union, there is currently no reason to presume that riboflavin not produced with the help of GMOs is applied in organic feeds. The legal basis is different – in some countries the national organic certifiers or the ministries of agriculture tolerated the use of GMO-derived riboflavin. In other cases, GMO-derived riboflavin is allowed through veterinary advice. In conclusion, the basis of riboflavin supplementation in organic livestock feeding in Europe is rather unclear. What is clear is that the only supplier for a GMO-free riboflavin product on the European market, Agrano, states that currently, their only demanding market is Switzerland.

On this basis, we have reasons to doubt that all riboflavin in organic animal feed in the EU is currently produced without the help of GM micro-organisms.

4.6. Market situation / price

The core limitation, why the available organic GMO-free product from Europe (Ecovit R) is not being sold more successfully, is its price. Currently the market price of Ecovit R is 60€/kg. One kg is needed to reach the necessary concentration per ton of poultry feed. That results in extra cost (compared to conventional GMO-based riboflavin) of 20-30€ per ton of poultry feed, which is about 3-4% of the overall feed price, a share of margin which matters. Solely for this reason, feed mills are reluctant to use Ecovit R as long as they have their alternatives, and as long as the market is not harmonized by strict advice from certification bodies, on European and national levels. Since a price increase of 30€ per ton of feed would not be tolerated by farmers, who have alternative cheaper feed suppliers, a change is only possible, if all suppliers do the same, as happened in Switzerland.

Within RELACS, the Thuenen Institute in Braunschweig, Germany, characterized a further wild type yeast strain, which has a riboflavin producing capacity comparable to *Ashbya gossypii*; the latter is used for Ecovit R by Agrano. Thuenen Institute agrees to publish the specifications in a scientific publication, which makes it accessible (as well as *Ashbya gosypii* is) to any producers of yeast. That means that there is not necessarily a monopoly with Agrano, if only the market situation would be secure enough by a clear and binding implementation of the existing European regulations on the ban of GMO derivatives in organic food production chains.

Due to that situation, clear statements from feed mills can be retrieved only informally, and they would not deliberately discuss the issue at a round table in the given situation, but we received responses sounding: "if the organisations would force the whole sector, we would use the product not produced with the help of GMOs".

4.7. Options to reduce costs by adapting requirement recommendations

It was assumed that the currently used riboflavin concentrations are too high for organic poultry production (Leiber et al., 2021a). For this reason, experimental work was conducted to test lower riboflavin supply levels under organic conditions (Lambertz et al., 2020b, Lambertz et al., 2021; Leiber et al., 2021a; Leiber et al., 2021b). The results of the experiments show possibility to supply lower concentrations of riboflavin to organic poultry, as summarised in two RELACS practice abstracts (https://relacs-project.eu/resources/practical-guidelines/). Some feed mills in Germany and Switzerland are already working with lower riboflavin dosages along the values, which can be recommended from the experiments. These reductions are in the range of 30%; thus they should have impact on the economic constraints outlined above.

Further, there are options to improve the native concentrations of riboflavin in the feeds, for instance by offering silages to the poultry (Witten & Aulrich, 2019). Such measures would allow to supply lower added riboflavin. However, these practices are farm-individual and would require individually tailored vitamin premixes from the feed mills – a long way to go, and a small path so far.

To repeat: no addition of riboflavin to poultry diets is not an option, since this would result in immediate severe health impairment.

4.8. Political action

As we described in the sections above, there is the unsatisfying situation that in Europe, despite availability of a sound source for riboflavin not produced with the help of GMOs, almost exclusively, derivates produced with the help of GMOs are used in organic livestock nutrition (https://www.europarl.europa.eu/doceo/document/E-9-2020-001759_EN.html).

On the basis of more than 15 confidential interviews with representatives of feed mills, the organic poultry sector organisations, organic certifying organisations and researchers, we conclude that the situation can be solved, if on legislative level the ministries/agencies of European member states, and on the level of organisations, the national organic organisations together with IFOAM organics would speak one voice and firmly require implementation of the ban of GMO-derived riboflavin from organic livestock diets. With regard to animal health and welfare, this is possible, because the non-GMO option exists, and the knowledge is open for further yeast producers, who would be willing to enter this business.

As a conclusive recommendation of action, we suggest:

- Ultimate requirement for riboflavin not produced with the help of GMOs would provide necessary security for the current producer to take the financial effort for the EFSA accreditation of Ecovit R as a feed additive.
- A clear decision in the ScoPAFF regarding the status of Ecovit R would push the start of an accreditation process at EFSA, if the organic associations actively support the use of yeast-based GMO-free vitamin B sources in livestock feeds.
- The development of a common understanding of all European organic associations that the Vitamin B supply to organic livestock on the basis of yeast fermentation products from European organic producers is a better option than vitamin sources from overseas, where controllability and reliability are poor by experience, would be of great help also for future issues of availability regarding, for instance, vitamin B12.

Otherwise, we suggest to start urgently a discussion about new definition boundaries for the use of substances produced with the help of GM micro-organisms in organic process-chains, in order to get rid of this existing conflict between organic regulations and practice.

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