

Dynamics in the Bioeconomy: Markets for Amino Acids and Insect Biomass

Dynamiques de la bioéconomie : marchés des acides aminés et de la biomasse d'insectes

Dynamik in der Bioökonomie: Märkte für Aminosäuren und Insektenbiomasse

Viktoriya Sturm

Roots of the dynamics

Bioeconomy, as a concept, penetrates the entire economy and triggers different dynamics in the markets. On the one hand, it is about bio-based production, that is, a manufacturing process in which biogenic resources (or biomass) are used as feedstock for the production of various bio-based products. The partial substitution or even complete displacement of fossil resources as a required production input is an important advantage seen in it, and the reduction of greenhouse gas emissions is the most prominent expected positive environmental effect. On the other hand, bioeconomy is about using biological knowledge to develop novel organisms and establish new production processes that can even lead to the emergence of new economic activities. Combined, both aspects of the bioeconomy can help to address the major challenges of the 21st century by offering new solutions to the global challenges we are facing (BMBF & BMEL, 2020; EC, 2018a).

Although the bioeconomy has only recently reached the EU policy agenda and gained general attention, a closer look at different economic activities reveals that bio-based production and use of biological knowledge has already been taking place in many sectors for a while. For example, manufacturing of chemicals

and pharmaceuticals via fermentation has a long history, and is a nice example where the use of biological feedstock (i.e. sugar) as production input and the production technology (use of bacteria) is directly related to the bioeconomy. Established activities and markets with a direct link to the bioeconomy are also experiencing a boost from the recent upswing of the bioeconomy. Production of free amino acids is an illustrative example: the large-scale production of such bio-based amino acids as lysine and threonine, which are mainly used as feed additives, started in the 1960s and the late 1980s, respectively (Toride, 2004). In the case of free amino acids, it is not the progress in their production technologies, but rather advances in animal feeding, achieved on the basis of biological knowledge, that are changing demand and creating a new dynamic in the free amino acids market, including the production and market entry of new free amino acids ('new products').

The bioeconomy is also unfolding in very traditional sectors such as agriculture, for example, through the emergence of new economic activities. Insect rearing and processing of insect biomass are examples of such activities that are new, at least for Europe. At the beginning of the century, there were only some firms rearing insects, mainly for pet food. With the

founding of Hermetia (Germany) in 2006, Protix (The Netherlands) in 2009 and Ynsect (France) in 2011, a new era has begun. Over time, further companies have joined and the upscaling of production has started, but the focus and the markets targeted by producers has also changed. Besides the rearing of live insects, the processing of insect biomass becomes increasingly important and, alongside the pet food and food markets, the animal feed market turns out to be a key targeted market. Insect meal, obtained by processing live insects, is the most interesting product: as a storable, protein-rich product, it can become a valuable, regular ingredient of animal feed.

“ La nécessité de rendre l'alimentation animale plus durable stimule les marchés des acides aminés libres et de la biomasse d'insectes. ”

The markets for free amino acids and insect biomass illustrate the dynamics in the bioeconomy. This is particularly evident in the animal feed market, the main consumer of products from both

of these markets, providing needed amino acids which may be deficient in certain feed formulations.

Regulations in the animal feed markets

The animal feed market is a major target market for free amino acids and insect biomass. Therefore, legal regulations in this market have a great influence on the corresponding free amino acids and insect biomass markets. They determine whether and under which conditions products can be used in feed for different animal species and production systems (e.g. organic production).

Definitions for feed ingredients and rules for placing them on the market for feed stipulated in the EU legislation (EC, 2018b) have a great influence on the relevant markets. According to the EU legislation, free amino acids are classified as feed additives, whereas products from insect biomass (i.e. insect meal) are feed materials. The classification of products from processed insect biomass to feed materials in the EU legislation is an advantage for producers of these products, as the rules for placing feed materials on the market in the EU are much less stringent than those applied for feed additives: less time and money are required to place products on the market. The results of the survey undertaken among its members by FEFANA – ‘the united voice of the specialty feed ingredients business in Europe’ – shows that it might take up to 3 years on average for a feed additive to reach the market, although, sometimes even a longer timeframe (about 5 years) is required (FEFANA, 2019). For placing a new feed material on the feed market only 6–12 months are needed. Also, the costs associated with the placing of a new feed material on the market (about 500–600 EUR) are quite low in comparison to the costs associated with the placing of a new feed additive on the market (about 0.5 million EUR) (Sturm, Banse and Salamon, 2021).

However, this advantage could not be fully exploited by the insect industry for a long time because of the

restrictive EU regulation on the use of processed animal proteins (PAPs), including insect meal, as animal feed. It was only in July 2017 that insect proteins from seven insect species were approved for feeding aquaculture animals (EC, 2017), followed by approval in poultry and pig feed from September 2021 (EC, 2021).

“ Die Notwendigkeit, Tierfutter nachhaltiger zu gestalten, gibt den Märkten für freie Aminosäuren und Insektenbiomasse einen positiven Impuls. ”

With regard to the use of free amino acids and insect biomass in different production systems, it should be highlighted that while free amino acids are widely used in animal feed, their use is prohibited in organic farming. The use of insect biomass in organic farming is not prohibited, but in order to be used in organic farming, insects or products derived from insects must be certified. While insect production is already eligible for organic certification in certain non-EU countries (e.g. USA, Canada and Switzerland), EU insect producers are not eligible for (public) organic certification, due to the absence of the EU organic standards for their products (Sturm, Banse and Salamon, 2021).

Amino acids market

The industrial production of free amino acids has an almost 60-year

history (Toride, 2004). It started with the manufacture of methionine by chemical synthesis in the late 1950s and 1960s. In the 1960s, the production of lysine fermentation began, followed by production of threonine and tryptophan in the late 1980s. In 2000, the global production of these four main free amino acids was estimated at 1–1.2 million tons (Table 1). In 2019, the global production of these four free amino acids increased to 3.7–4.7 million tons. The underlying production process remained the same: methionine is still produced by chemical synthesis using fossil resources as a feedstock, while other amino acids are produced through fermentation and are, therefore, bio-based products. Due to the fact that the bio-based lysine is by far the most important free amino acid in terms of volume, the bio-based share in the total global production is up to 70 per cent.

In the EU, in 2011, production of four main free amino acids used as feed additives took place (Table 2). In terms of volume, lysine was the most important one and the bio-based share in the total production was 70 per cent. In 2020 the picture changed significantly: Although, the total production of free amino acids increased, it happened because of considerable extension in production of fossil-based methionine. Production of bio-based amino acids declined and the bio-based share was only 14 per cent. Actually, bio-based production takes place in a single plant in France, originally owned by Ajinomoto and acquired by METabolic EXplorer (METEX) in May 2021. METEX produces lysine and tryptophan as well as small quantities of isoleucine, leucine and arginine

Table 1: Estimated global production of amino acids in 2000, 2011 and 2019, in tons

| Amino acid | 2000 | 2011 | 2019 |
|------------|-------------------|-----------|-----------------------|
| Methionine | 500,000 – 600,000 | >900,000 | 1,100,000 – 1,600,000 |
| Lysine | 500,000 – 600,000 | 1,700,000 | 2,400,000 – 2,800,000 |
| Threonine | 30,000 | 260,000 | 200,000 – 260,000 |
| Tryptophan | 1,000 | 5,500 | 10,000 – 17,000 |

Source: Sturm, Banse and Salamon (2022).

through a fermentation process. Threonine is no longer produced at all in the EU.

Table 2: Estimated production of amino acids in the EU in 2011 and 2020, in tons

| Amino acid | 2011 | 2020 |
|------------|----------|----------|
| Methionine | >150,000 | <675,000 |
| Lysine | 320,000 | <100,000 |
| Threonine | >80,000 | 0 |
| Tryptophan | >2,500 | <7,500 |

Source: Hirth and Busch (2014); Sturm, Banse and Salamon (2022).

This observed reduction in the production of bio-based amino acids cannot be explained through the developments in demand in the EU. Demand for lysine over the last decades has risen and reached approximately 500,000 tons/year in 2019, and due to a large gap between production and demand, the EU relies heavily on imports, mainly from Asia to meet the demand (Sturm, Banse and Salamon, 2021). As for threonine, in 2009, the total EU demand was estimated at about 74,000 tons and was completely covered by the production in the EU (about 76,000 tons)

(ECOSYS, 2011). Since then, the demand for threonine in the EU has grown to about 120,000 tons, but no production takes place in the EU any more: both producers (Evonik and Ajinomoto) stopped production of threonine in the EU and moved production to Asia. As a result, the EU is in a situation of permanent dependency on imports of threonine from third countries, especially from China.

The production of tryptophan as well as of some further 'new-comers' among free amino acids, such as valine, isoleucine, leucine and arginine, takes place in the EU. The use of these amino acids in feed is currently uncommon; in most cases, benefits from adding them to the feed could only be achieved if the deficiency of the previous limiting amino acids (i.e. lysine, methionine, threonine, tryptophan) is compensated for. But even a widespread use of these amino acids in animal feed would not result in a demand comparable to that of methionine, lysine, threonine and tryptophan, as they are 'speciality' amino acids and would be added to feed in even smaller quantities.

Market for insect biomass

Insect farming is a relatively new but fast-growing sector in the EU. Hermetia (Germany), Protix (The Netherlands) and Ynsect (France) are pioneers in this sector in Europe. Over the last decade, the number of companies founded in the EU for the breeding of insects and processing of insect biomass has increased significantly (47 companies were identified as of February 2021), however, most of them are still in the so-called 'PowerPoint phase' or in 'the pilot phase'. To date, only two companies – The Netherlands' Protix and the French Ynsect – have upscaled their production (Sturm, Banse and Salamon, 2021). Protix has demonstrated industrial-scale production in a way that is scalable and multipliable in 2019: the company opened a production facility in Bergen op Zoon, where up to 100,000 tons/year of vegetable remnants are fed to larvae of the black soldier fly. About 200 tons of 'waste' per day is used at this facility to produce about 15 tons of high-value ingredients per day. The facility features full automation and a modular design. Ynsect is currently



Methionine is usually the first limiting amino acid in poultry diets. In conventional farming, free methionine is added to feed as an additive, but this is prohibited in organic farming. In organic farming, insect biomass could be used as an alternative source of methionine © Thünen-Institute/Beate Butner.

building a large-scale plant in Amiens (France), which claims to be the world's largest vertical farm and will produce up to 200,000 tons/year of feed ingredients. Besides insect protein meal intended mainly for farmed fish and domestic animals, the company produces fertiliser based on insects' dejections.

The market for insect biomass, especially insect meal, is just emerging. Therefore, data on this market are also very limited. As data on the production of live insects and products processed from insect biomass are not reported in official statistics in the EU, the survey of producers is the only currently available option to collect some information. The International Platform for Insects as Food and Feed (IPIFF) conducted a survey of producers and provides some first figures on the size of the insect industry/the size of the market for insects and products thereof in the EU. According to the conducted questionnaire, the IPIFF estimated that approximately 5,000 tons of insect protein were produced in Europe in 2019 (IPIFF, 2020). IPIFF forecasts that the sector will achieve a significant volume growth in the next few years, and production could achieve 2–5 million tons by 2030 (IPIFF, 2020). For such ambitious growth, industrial up-scaling is absolutely necessary.

Drivers of the dynamics

A closer look into the markets of free amino acids and insect biomass provides valuable insights into different dynamics in the bioeconomy and their drivers. The markets under consideration are quite different. Drivers on the supply side also vary. On the demand side, however, some similarity in driving forces could be identified. As application of products from both markets in animal feed plays an important role, impulses that emanate from the animal feed market are relevant for both considered markets. One such impulse is the demand for feed ingredients that can increase the sustainability of animal feed.

The free amino acids market is in general a well-established market



Use of insects in food: Insect Bar 'Bug-Break' © Michael Welling.

with international trade playing an important role. Fermentation processes used to produce such bio-based amino acids as lysine and threonine have already reached a high level of maturity, the demand for both amino acids is high enough to enable large-scale production and competition between producers is already tight. Therefore, keeping production costs low has become essential. The EU is disadvantaged as a production location due to higher production costs and stricter environmental standards, which have already led to a partial or complete relocation of the production of lysine and threonine abroad, to Asia.

“ The need to make animal feed more sustainable is giving a positive boost to the free amino acids and insect biomass markets. ”

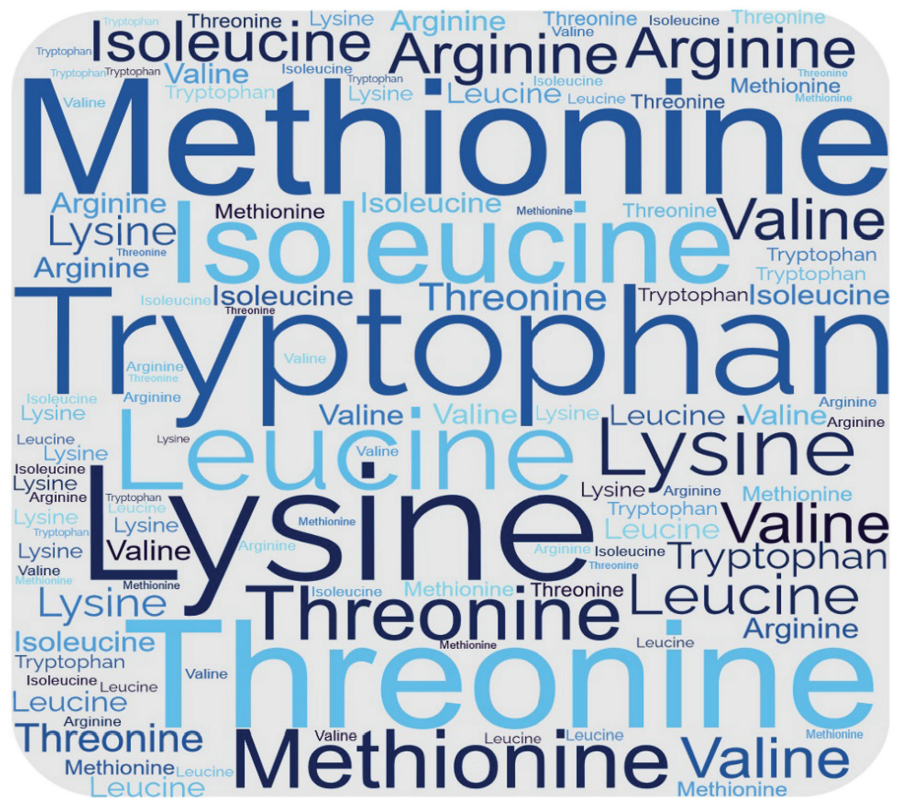
However, as a result of continuing advances in animal nutrition, the use of further free amino acids in animal feed is being considered. This induces new dynamics in the free amino acid market, including the production and market entry of further free amino

acids. Production of such 'new' free amino acids currently takes place in the EU, and relocation of production is presumably not an issue at the moment, as a demand is low and comes mainly from the EU, where the required knowledge-based animal nutrition is common practice. However, as soon as the benefits from the use of these free amino acids in animal feed become more tangible, it is expected that global demand will grow and production will be scaled up with a risk of relocation of EU-based production to other places, as observed in the case for lysine and threonine.

The market for insect biomass, e.g. insect meal, is just emerging in the EU. Development of technologies, legislative steps undergone, as well as financial support in frames of different projects will help the industry to take off. However, to achieve the ambitious projected growth, industrial up-scaling is absolutely necessary. The main factors that would help producers to take their business to the next level are: authorisation of new feed substrates for insects such as former foodstuffs, and investments in automation, e.g. development of feeding machines for the insect market (insects are mainly hand-fed every day and this is labour-intensive) (Sturm, Banse and Salamon, 2021).

The up-scaling will help to lower the prices of products derived from

insects (e.g. as insect meal). To date, the prices for insect meal are high in comparison with other sources of protein, especially soybean meals. Therefore, even after the authorisation of insect protein for use in poultry and swine feed, the market for aquaculture feed will remain of most importance, as the willingness to pay is higher there. The integration of insect meal in the formulation of feed for poultry and swine would also take a while. Besides the price disadvantage, the industry faces a low willingness to integrate insect-derived ingredients in the feed formulation. The market in which insect-derived products might penetrate easier is the market for organic feed for poultry (and swine). Here, the willingness to pay is higher and producers are looking for additional sources of protein. This can be partly explained by the restriction on use of free amino acids. However, to be used in organic farming, insects or products derived from insects should be certified. While insect production is already eligible for organic certification in certain non-EU countries (e.g. USA, Canada and Switzerland), EU insect producers are not eligible for (public) organic certification, due to the absence of EU organic standards for their products (Sturm, Banse and Salamon 2021).



AminoAcids -Wordcloud © the Author.

At this point it is worth noting that although the feed market is currently the main target market for both free amino acids and insect biomass, they are not competitors or substitutes; their use in feed formulation serves different purposes (precise balancing of specific amino acids vs. general enrichment of feed with protein).

Each has a role to play and deserves attention when considering how to make animal feed more sustainable. Furthermore, in the future, other markets may increase their uptake and have a greater impact on both markets under consideration; for example, amino acids may increasingly be used for industrial



The EU is in a situation of permanent dependency on imports of threonine from third countries. © Thünen-Institute/Christina Waitkus.

purposes and insects/insect biomass for pet food and human nutrition.

Policy recommendations

Free bio-based amino acids are important ingredients of sustainable knowledge-based animal feeding. Their shortage, as occurred during the trade disruption caused by the Covid pandemic, can have negative effects. To ensure their supply even in times of trade disruptions, at least some production in the EU might be desirable. In order to stop the production leakage of bio-based amino acids and encourage their production in the EU, policy measures could be taken to level out cost disadvantages for EU producers that meet higher environmental

standards. The possibility of making the placing of feed additives on the EU market less costly and time-consuming should also be explored.

Live insects and insect-derived products such as insect meal are alternative sources of protein. Their use in animal feed would not only increase the EU's self-sufficiency with respect to protein-rich feed materials, but would also contribute to the EU's agricultural circularity. The development of legal bases for the production and use of these products brought more transparency to the market and confidence for its participants. Further steps, for example, the development of EU organic standards for producers, should be

addressed. With regard to funding of projects aimed to boost the production and use of alternative proteins, it should be acknowledged that live insects and insect-derived products are only one of many possible sources for alternative proteins that the bioeconomy provides. It is important to pay attention to all alternatives, as no single product can provide a solution on its own. Ultimately it is not only technological advancements, but also their acceptance by users, that decides their penetration in the market.

Funding information

Open Access funding enabled and organised by Projekt DEAL.


Further Reading

- BMBF & BMEL (2020). National Bioeconomy Strategy. Federal Ministry of Education and Research (BMBF) & Federal Ministry of Food and Agriculture (BMEL), Berlin. Available online at: https://bioeconomie.de/sites/default/files/2022-01/BMBF_Bioeconomy-Strategy_en_accessible_n.pdf (Accessed: 07 February 2023).
- EC (2017). Commission Regulation (EU) 2017/893 of 24 May 2017 amending Annexes I and IV to Regulation (EC) No 999/2001 of the European Parliament and of the Council and Annexes X, XIV and XV to Commission Regulation (EU) No 142/2011 as regards the provisions on processed animal protein. Brussels, EC. Available online at: <http://data.europa.eu/eli/reg/2017/893/oj> (Accessed: 08 February 2023).
- EC (2018a). *A sustainable bioeconomy for Europe. Strengthening the connection between economy, society and the environment: Updated bioeconomy strategy*. Publications Office of the European Union, Luxembourg.
- EC (2018b). Regulation on the placing on the market and use of feed. Consolidated text. No. 767/2009. Brussels, EC. Available online at: <http://data.europa.eu/eli/reg/2009/767/2018-12-26> (Accessed: 08 February 2023).
- EC (2021). Commission Regulation (EU) 2021/1372 of 17 August 2021 amending Annex IV to Regulation (EC) No 999/2001 of the European Parliament and of the Council as regards the prohibition to feed non-ruminant farmed animals, other than fur animals, with protein derived from animals. Brussels, EC. Available online at: <http://data.europa.eu/eli/reg/2021/1372/oj> (Accessed: 08 February 2023).
- ECOSYS (2011). *Die Wettbewerbsfähigkeit der Bundesrepublik Deutschland als Standort für die Fermentationsindustrie im internationalen Vergleich (The competitiveness of the Federal Republic of Germany as a location for the fermentation industry in international comparison)*, ECOSYS GmbH, Schopfheim. Available online at: <https://www.fnr-server.de/ftp/pdf/berichte/22003310.pdf>.
- FEFANA (2019). *Evaluation of the EU feed additive regulation: FEFANA's members experience*, FEFANA, Brussels. Available online at: https://fefana.org/wp-content/uploads/2019/08/2019-08-30-FEF_factsheet_data_collection_Survey.pdf.
- Hirth, T. and Busch, R. (2014). Chemikalien, in: *Marktanalyse nachwachsende Rohstoffe (Chemicals in: Market Analysis of Renewable Resources)*, ed. FNR, Fachagentur Nachwachsende Rohstoffe e.V. (FNR), Gülzow-Prüzen, pp. 116–198.
- IPIFF (2020). *The insect sector milestones towards sustainable food supply chains*. IPIFF Secretariat, Brussels. Available online at: <https://ipiff.org/the-insect-sector-milestones-towards-sustainable-food-supply-chains/>.
- Sturm, V., Salamon, P. and Banse, M. (2021). Dynamics on the markets for feed grade amino acids and insect biomass. BioMonitor: Technical insights. Available online at: <https://biomonitor.eu/wp-content/uploads/2022/01/Dynamics-on-the-Markets-for-Feed-Grade-Aminoacids.pdf>.
- Sturm, V., Banse, M. and Salamon, P. (2022). The role of feed-grade amino acids in the bioeconomy: Contribution from production activities and use in animal feed. *Cleaner Environmental Systems*, 4: p. 100073. Available online at: <https://www.sciencedirect.com/science/article/pii/S2666789422000046>.
- Toride, Y. (2004). Lysine and other amino acids for feed: Production and contribution to protein utilization in animal feeding, in: *Protein Sources for the Animal Feed Industry. Expert consultation and workshop, Bangkok, 29 April–3 May 2002*, FAO, Food and Agriculture Organization of the United Nations (ed), Rome, pp. 161–165.

Viktoriya Sturm, Thünen Institute of Market Analysis, Braunschweig, Germany.
Email: viktoriya.sturm@thuenen.de


Summary

Dynamics in the Bioeconomy: Markets for Amino Acids and Insect Biomass

 While the bioeconomy permeates all sectors, respective markets are subject to different dynamics. Markets for bio-based amino acids and insect biomass illustrate this. The global and EU markets for bio-based amino acids are well-established and growing. However, the increase in production in the EU of some 'new' amino acids is much smaller than the decrease in production of well-established lysine and threonine that has resulted from the relocation of the production of these amino acids from the EU to Asia (an effect of higher production costs and stricter environmental standards in the EU). The result is that overall production of amino acids has decreased significantly.


The market for insect biomass is just emerging in the EU. Production is low, but companies are starting to upscale. The animal feed market is a major target market for free amino acids and insect biomass. Free amino acids are classified as feed additives and placing them on the feed market is costly. Insect meal is a feed material and placing it on the market is quite straightforward, although its use in feed for poultry and pigs was approved only in September 2021. Free amino acids are common ingredients of animal feed, but their use is prohibited in organic farming. The use of insect meal in organic farming is not prohibited, but a corresponding certification is not yet developed in the EU.

Dynamiques de la bioéconomie : marchés des acides aminés et de la biomasse d'insectes

 Bien que la bioéconomie concerne tous les secteurs, les marchés respectifs sont soumis à des dynamiques différentes. Les marchés des acides aminés d'origine biologique et de la biomasse d'insectes en sont une illustration. Les marchés mondiaux et européens des acides aminés d'origine biologique sont bien établis et en croissance. Cependant, l'augmentation de la production dans l'Union européenne (UE) de certains 'nouveaux' acides aminés est bien inférieure à la diminution de la production de lysine et de thréonine (qui sont des 'anciens' acides aminés), résultant de la délocalisation de la production de ces 'anciens' acides aminés de l'UE vers l'Asie (du fait de coûts de production plus élevés et de normes environnementales plus strictes dans l'UE). Le résultat est que la production globale de 'tous' les acides aminés a considérablement diminué.

Le marché de la biomasse d'insectes vient tout juste d'émerger dans l'UE. La production est faible, mais les entreprises commencent à monter en gamme. Le marché de l'alimentation animale constitue un marché cible majeur pour les acides aminés libres et la biomasse d'insectes. Les acides aminés libres sont classés comme additifs alimentaires et leur mise sur le marché des aliments pour animaux est coûteuse. La farine d'insectes est une matière alimentaire et sa mise sur le marché est assez simple, même si son utilisation dans l'alimentation des volailles et des porcs n'a été autorisée qu'en septembre 2021. Les acides aminés sont des ingrédients courants dans l'alimentation animale, mais leur utilisation est interdite en agriculture biologique. L'utilisation de farines d'insectes dans l'agriculture biologique n'est pas interdite, mais une certification correspondante n'a pas encore été développée dans l'UE.

Dynamik in der Bioökonomie: Märkte für Aminosäuren und Insektenbiomasse

 Während die Bioökonomie alle Sektoren durchdringt, unterliegen die jeweiligen Märkte einer unterschiedlichen Dynamik. Die Märkte für biobasierte Aminosäuren und Insektenbiomasse veranschaulichen dies. Der globale und der EU-Markt für biobasierte Aminosäuren sind gut aufgestellt und wachsen. Allerdings ist der Anstieg der Produktion einiger 'neuer' Aminosäuren in der EU viel geringer als der Rückgang der Produktion von etablierten Lysin und Threonin, verursacht durch die Verlagerung der Produktion dieser Aminosäuren aus der EU nach Asien (eine Folge der höheren Produktionskosten und der strengeren Umweltstandards in der EU). Dies hat dazu geführt, dass die Gesamtproduktion der Aminosäuren erheblich zurückgegangen ist.

Der Markt für Insektenbiomasse ist in der EU noch in der Entstehungsphase. Die Produktion ist gering, aber die Unternehmen beginnen, sie hochzufahren. Der Tierfuttermarkt ist ein wichtiger Zielmarkt für freie Aminosäuren und Insektenbiomasse. Freie Aminosäuren werden als Futtermittelzusatzstoffe eingestuft und ihr Inverkehrbringen auf dem Futtermittelmarkt ist kostspielig. Insektenmehl ist ein Futtermittel-Ausgangserzeugnis und sein Inverkehrbringen ist recht einfach, obwohl seine Verwendung in Futtermitteln für Geflügel und Schweine erst im September 2021 zugelassen wurde. Freie Aminosäuren sind übliche Bestandteile von Tierfutter, aber ihre Verwendung ist im ökologischen Landbau verboten. Die Verwendung von Insektenmehl im ökologischen Landbau ist nicht verboten. Allerdings ist eine entsprechende Zertifizierung in der EU noch nicht entwickelt.

summary