State of the European Alternative Protein Research Ecosystem 2015-2024

Patent landscape analysis

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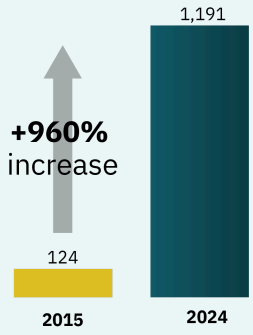
Headline statistics



Innovation in alternative proteins is undergoing tremendous growth in Europe, with an **average year-on-year growth in published patents of 32%**.

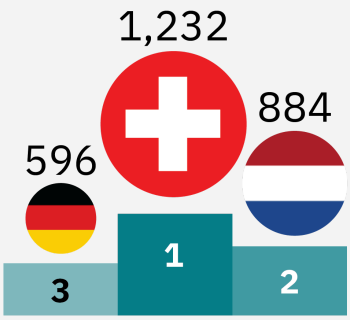
Since 2015, when 124 alternative protein patents were published, the field has seen rapid expansion, with 1,191 patents published in 2024 – a **960% increase**.

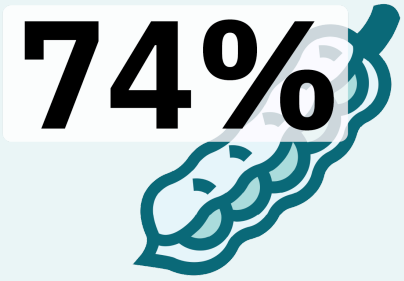
The **bulk of this output has come in the past five years**. 62% were published between 2022 and 2024, and 22% were published in 2024 alone.

Switzerland leads on alternative protein patents in Europe, with 1,232 patents from 265 families published since 2015, while Germany has the highest number of individual assignees.

398 total assignees from 25 countries have contributed to this output, including **40 public research organisations from 19 countries**.

As with academic publications, **considerable regional disparity can be observed** with five countries featuring on 72% of all patent families as assignees or co-assignees.





Plant-based has been the dominant alternative protein pillar in this timeframe, contributing **74% of total patents.**

The low number of patents related to cultivated meat and precision fermentation point to a need for more foundational research to stimulate innovation in these areas.

Meat is the most common intended end product, with 41% of patent families, while **just 1% of dedicated families relate to fish and seafood, indicating a neglected field of R&I.**

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01 Mapping the European alternative protein patent landscape

Why alternative proteins

Alternative proteins offer a promising way to help meet the projected growth in global demand for meat, while building a more sustainable food system. Plant-based and cultivated meat could help satisfy demand for meat with up to 90% less land, and fermentation can help Europe achieve a circular bioeconomy, using agricultural and food processing side streams that would otherwise go to waste.

However, in order to achieve widespread uptake, alternative proteins must compete on taste, healthiness and price, as well as being widely available to purchase. European consumers report taste and price as the main barriers to trying and continuing to purchase these products. To meet these expectations, key technological hurdles must be overcome and new innovations must have a viable route towards commercialisation.

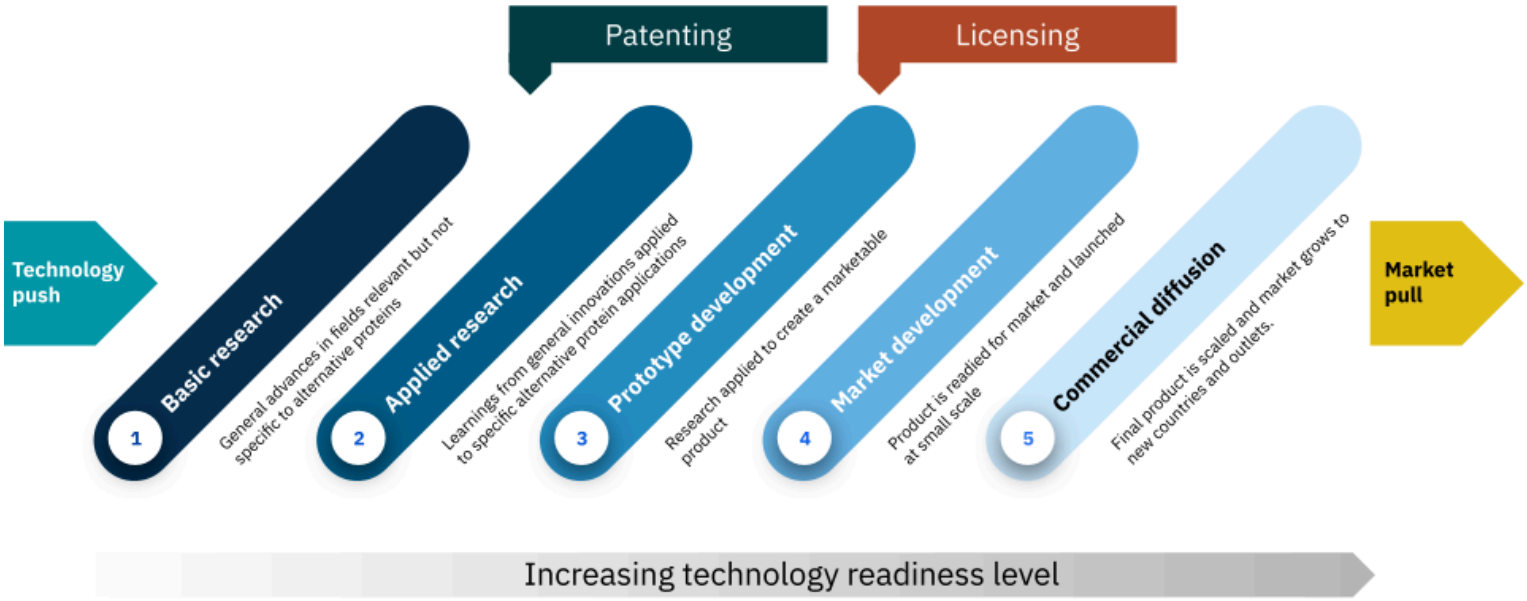
Why a thriving open innovation ecosystem is important in Europe

A thriving research and innovation (R&I) ecosystem requires the generation of new knowledge in both the public and private sectors. While the private sector is generally very effective at developing and optimising new products and processes by working with more mature technologies that are close to market, it relies heavily on foundational research in the public sphere to provide the fundamental basis behind technologies in groundbreaking new areas.

Generally termed 'technology transfer', the mechanism by which this foundational research can move from the academic lab to the industrial pilot plant can take many forms but usually involves the generation of new intellectual property (IP) and can result in licence agreements, spinout companies, and public-private partnerships (PPPs) involving collaboration with industry. Patents play an important role in defining and protecting this new knowledge so that it can be effectively utilised by its inventors.

In the private sector, protecting new IP is an important element in securing a competitive advantage and a return on investment (ROI) from R&I activities. While trade secrets are a common means through which the food industry protects its IP, filing patents is an important way to secure legal protection for new inventions that could easily be reverse-engineered by competitors. Patents are particularly important for startups given their focus on more innovative technology solutions that could be copied by larger, better-resourced companies.

Figure 1. A generalised schematic of the technology development life cycle, showing the role played by patents and licensing in facilitating technology transfer. Adapted from IRENA INSPIRE.



Patents can also provide a public benefit through the stimulation of economic activity and as a result of the requirement to disclose the technology during the patenting process. After the 20 year lifetime of the patent, this technology is then available for use by anyone with the means to do so. This stands in contrast to trade secrets which, if successfully protected, can be exploited indefinitely without the need to share details of the technology with the wider community.

However, it's important to get the balance right between public and private innovation to ensure that key technology areas are not monopolised by a small number of companies. Open-access research and patenting are not mutually exclusive activities and, given the relative immaturity of the alternative protein field and the fundamental nature of many of the technical hurdles to overcome, it would be more cost-effective to fund much of this R&I activity in public institutions, including through pre-competitive collaboration with the private sector.

The resulting IP can then be made widely available to the private sector via flexible and equitable mechanisms such as non-exclusive licensing at fair market rates, therefore stimulating more widespread and efficient innovation and providing a ROI for the public. This approach also reduces duplication of effort, promotes interdisciplinary collaboration, and can tackle the kinds of questions that industry isn't necessarily incentivised or well-equipped to address.

As a global research and innovation powerhouse accounting for over 20% of global R&I investment, Europe can be home to a thriving alternative protein open innovation ecosystem.

The EU is second only to China in terms of scientific output and is responsible for 18% of global scientific publications, while European universities occupy just over 40% of the places on the list of the world's best universities – more than any other region. Recent years have seen significant increases in public funding available for alternative protein R&I in Europe and the academic ecosystem is undergoing tremendous growth.

However, it is well documented that Europe has historically struggled to convert its scientific excellence into successful innovations in the market – the so-called 'European paradox'. This can in part be attributed to limited access to private capital, workforce talent, and scale-up infrastructure. It is also influenced by a lack of efficient mechanisms for technology transfer, and flexible, open innovation structures for generating and exploiting R&I results are required to accelerate innovation in alternative proteins and position Europe as a leader in this space.

What we hope to achieve with this analysis

The full breadth and depth of the alternative protein patent landscape in Europe has never been mapped and it is not known whether the observed increase in public sector R&I activity is resulting in greater private sector innovation.

This report aims to address this knowledge gap by evaluating the growth and development of the patent landscape in alternative proteins across Europe on the basis of published patents. While patents are not the only form that intellectual property can take, they are an important, quantitative metric that helps us to understand what innovation is happening, identify which organisations and countries are conducting it, and develop recommendations to further catalyse this growing research and innovation field.

We collated a comprehensive global dataset of published patents on topics related to alternative proteins by European organisations (defined here as those within the 27 EU member states, along with Norway, Switzerland, and the United Kingdom) during the years 2015-2024 inclusive, and analysed the key trends and themes. A full description of the methodology used, including caveats and limitations, can be found in the Methodology section.

On the basis of this analysis, this report aims to:

1. Present a thorough overview of the European alternative protein patent landscape, including overall growth, key organisations and countries, and specific fields of innovation.
2. On the basis of published patents, help current and future innovators understand how they can best contribute to the development of this field.
3. Provide recommendations for how other stakeholders, including public R&I funders, can best support the further development and growth of the space.

What we mean when we talk about alternative proteins

The Good Food Institute defines alternative proteins according to three pillars:

Plant-based meat, seafood, eggs and dairy are produced directly from plants but look, taste, and cook like conventional animal products.

Image: Mosa Meat

Image: Juicy Marbles

Cultivated meat and seafood. Foods like chicken, pork, beef and fish that are produced by cultivating animal cells directly, thus replicating the sensory and nutritional profiles of conventional meat and seafood.

Image: Perfect Day

Fermentation-made protein and ingredients. Fermentation is used in three primary ways. *Traditional fermentation* uses intact live microorganisms to modulate and process plant-derived ingredients. *Biomass fermentation* leverages the fast growth and high protein content of many microorganisms to efficiently produce large quantities of protein. *Precision fermentation* uses microbial hosts to produce specific functional ingredients which are important for the manufacture of alternative protein end products.

Key terms for understanding this report

Patent	An exclusive right granted for an invention that excludes others from making, using, offering for sale, or selling the invention. Patents benefit inventors by providing them with legal protection for their inventions. To receive this protection, they must publicly disclose details of the invention.
Patent family	A collection of patents covering the same or similar technical content disclosed by a common inventor(s) and patented in more than one country.
Priority date	Sometimes called the "effective filing date", this is the first filing date in a family of patent applications and is used to establish the novelty and/or obviousness of a particular invention relative to other art. Each patent family will only have one priority date.
Filing date	The date when a patent application is first filed in the respective patent office. As there are no global patents, there may be numerous patent filings in different jurisdictions from the same patent family, each with its own filing date.
Publication date	The date on which the patent application is published (ie, the information is available to the public). This normally occurs approximately 18 months after the filing date.
Assignee	Organisation(s) and individual(s) that have an ownership interest in the legal rights a patent offers. An assignee is often the organisation employing the inventor of the technology. An assignee can also change at a later date.
Jurisdiction	The legal territory in which a patent is sought, for example, France, Spain, etc. Each patent must be filed with a national patent office in the country where protection is sought and there are no global patents.
Patent legal status	The current legal status of the patents, eg, 'Granted', 'Active', 'Abandoned', etc.

The patenting process

There are differences between patent offices in how a patent application is processed once it has been filed, but a general overview of the process is described in the table below. For a more detailed explanation, please refer to this resource from the World Intellectual Property Organization. A detailed description of the European patent application process can be found here.

1. Formal examination	The application is examined to ensure it complies with the administrative requirements set by the patent office.
2. Prior art search	A search is conducted to identify prior art that will be relevant in determining the patentability of the claimed invention.
3. Substantive examination	A more detailed examination is carried out to ensure the claimed invention satisfies the main criteria for patentability (patentable subject matter, novelty, inventive step, industrial applicability and sufficiency of disclosure).
4. Notification	Results of the examination are sent to the applicant or their legal representative and they are given an opportunity to respond to any objections raised.
5. Publication of patent application	The patent application is usually published approximately 18 months after the filing date.
6. Granting of patent	If the outcome of the examination is positive, the patent office grants the patent
7. Publication of granted patent	The granted patent is published and the invention is disclosed to the public.
8. Pre-grant and/or post-grant opposition	Patent offices offer others the opportunity to oppose the grant of a patent, for example, if they believe the claimed invention is not new. Opposition proceedings can be held before or after the patent is granted.

02 Trends and dynamics

Patents published and granted

The number of patents published on topics related to alternative proteins by European innovators has risen each year since 2019, reaching a record high of 1,191 in 2024, albeit this was only fractionally higher than the 2023 figure. The average year-on-year growth rate in publication during this time was 32%. The number of patents granted has also risen in this time, reaching a record high of 173 in 2024 with an average year-on-year growth rate of 28%.

5,360 total patents were published in the period 2015-2024 and 709 total patents were granted during the same period. Similar to trends observed in open-access research publications, these data indicate that Europe is experiencing a period of significant and sustained growth in alternative protein R&I.

Figure 2. Summary data describing trends and metrics in alternative protein patent publications by European innovators in the years 2015-2024 inclusive.

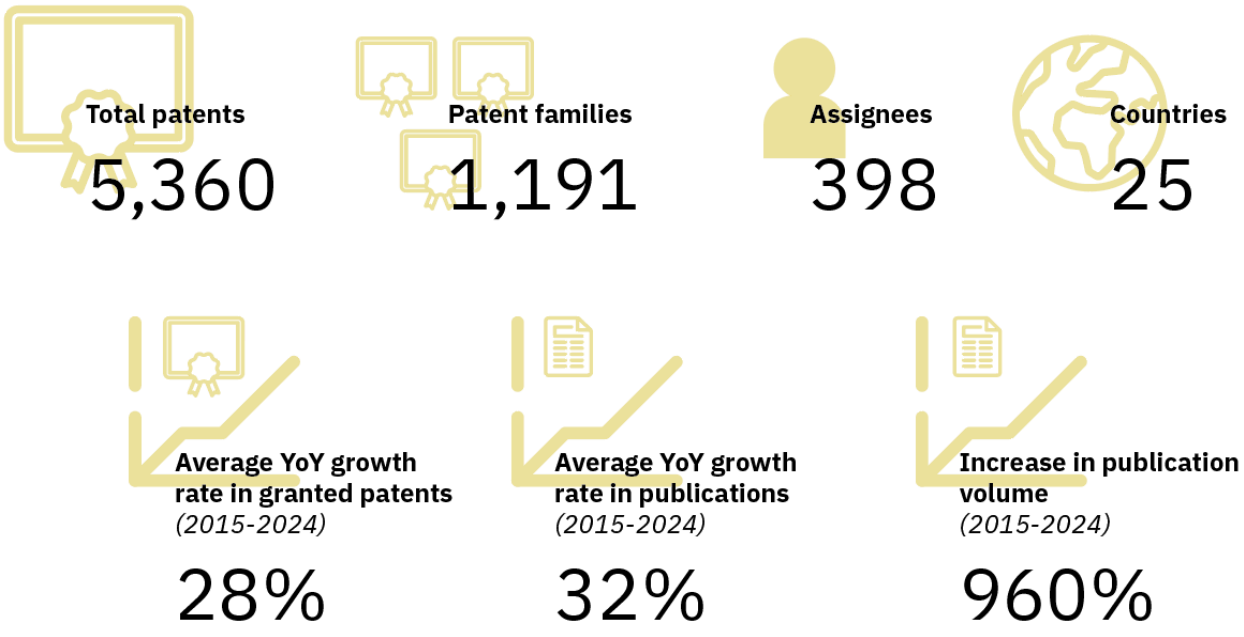
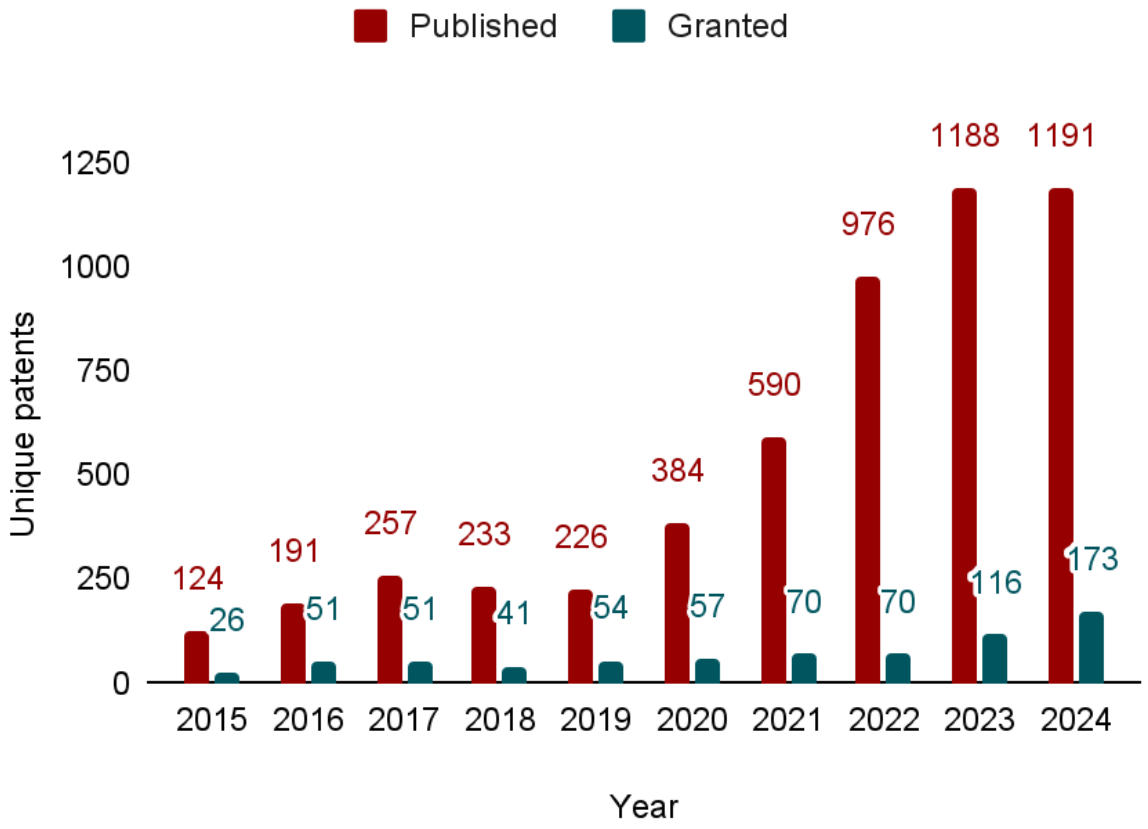


Figure 3. Number of alternative protein patents published and granted by European innovators during the years 2015-2024 inclusive.

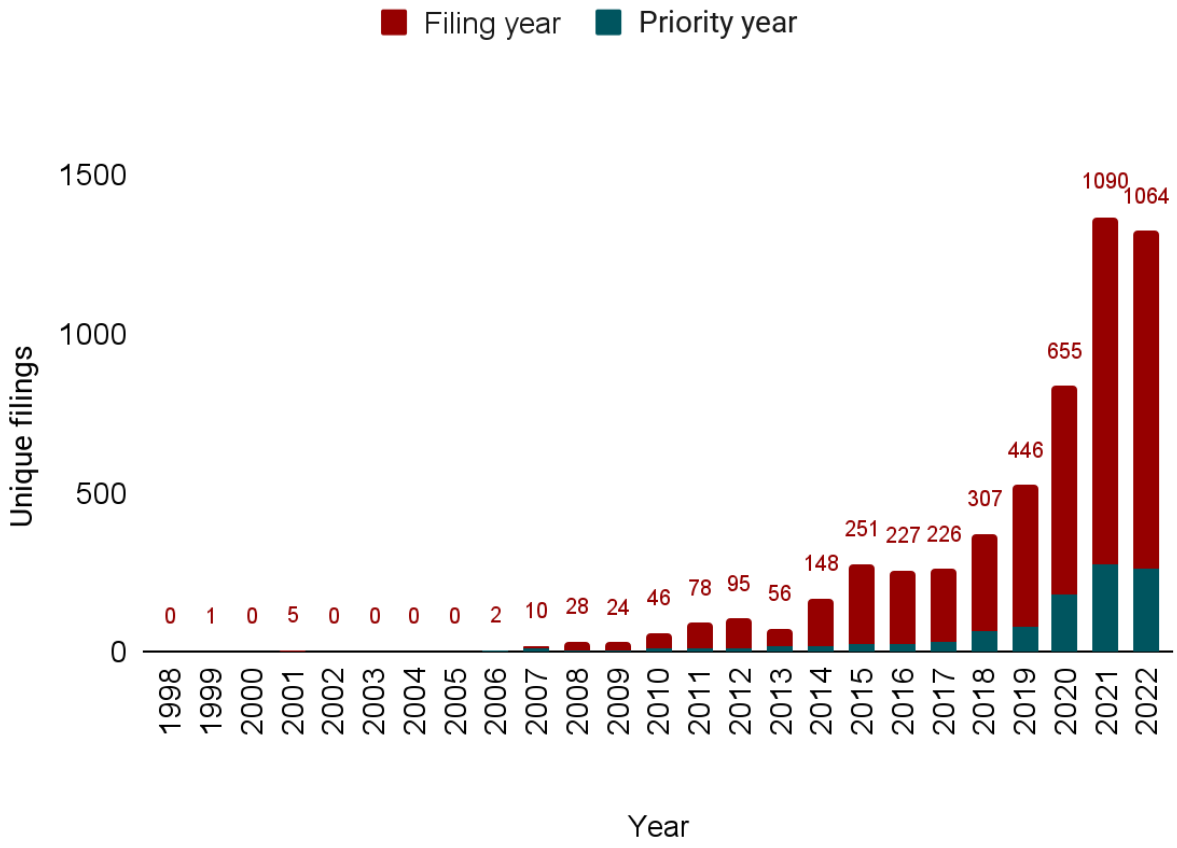


Patents filed

The number of patents filed on innovations related to alternative proteins began to rise significantly in the late 2010s, reaching a peak of 1,090 in 2021. In the 10-year period from 2013-2022, filings increased by an average of 46% year-on-year. Likewise, the number of priority filings – indicating novel technological developments – increased every year from 2012 to 2021, peaking at 278 in 2021. In the 2013-2022 period, priority filings increased by an average of 40% year-on-year. Due to the approximately 18-month lag between patent filing and publishing, 2023 and 2024 filing data are incomplete and therefore not shown.

It is interesting to note that some of the patents published during 2015-2024 have their origins as far back as the late 1990s, which can likely be explained by successive iterations on the technology and resulting patent filings in the intervening years.

Figure 4. Number of patent filings and priority filings per year in the dataset of alternative protein patents published during the years 2015-2024 inclusive.



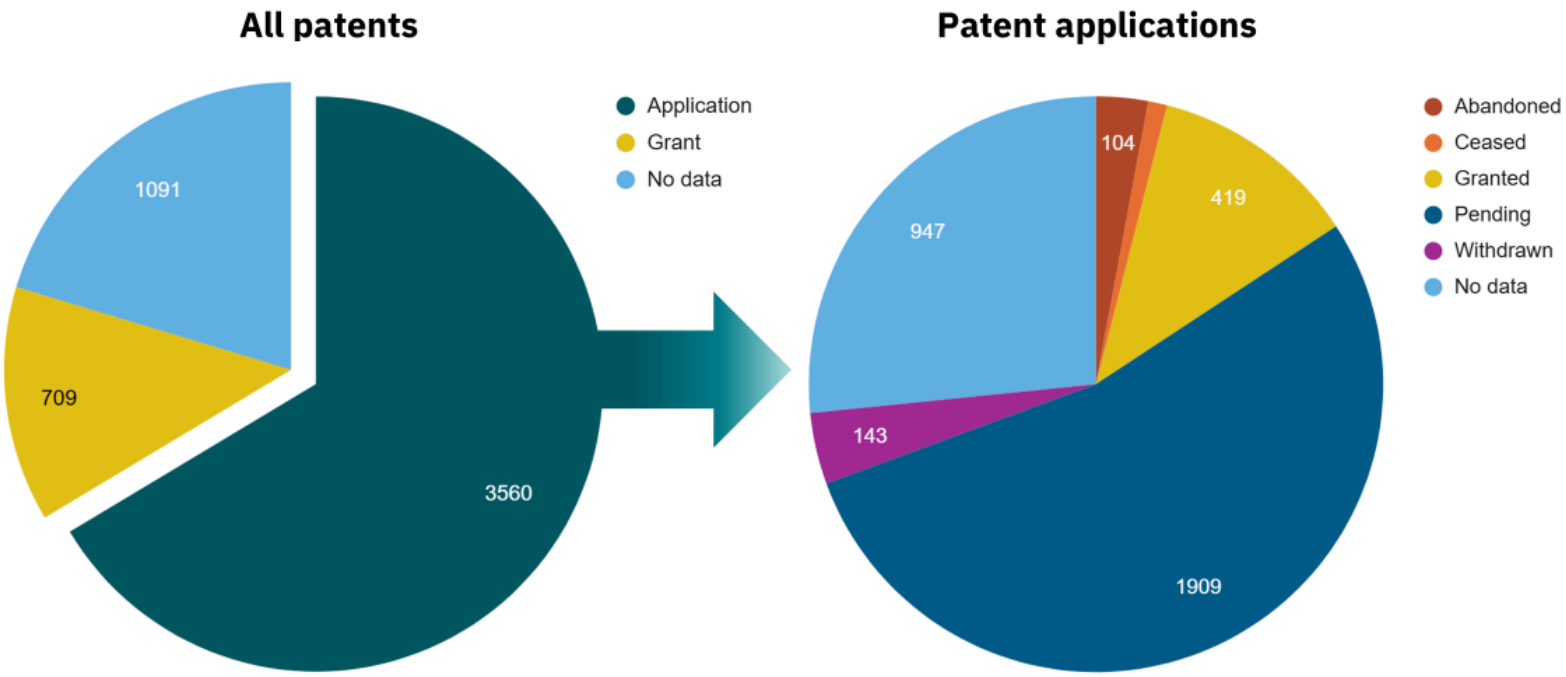
Patent legal status

Looking deeper into the legal status of the published patents identified in this analysis enables us to gain further insights into the dynamics in the alternative protein R&I ecosystem. A patent's legal status reflects the stage the invention is at in its assessment by a patent office, with two primary types of patent publications: patent applications, which have been submitted but remain under review; and granted patents, which have satisfied the requirements of novelty, inventive step and usefulness, and have therefore been granted legal protection in the jurisdiction where the patent was filed.

Of the documents in this dataset, 3,560 are patent applications and 709 are granted patents, with data unavailable for the remaining 1,091. The high number of patent applications in the dataset suggests that a very significant proportion of these patents represent recent innovations, because if they were older innovations we might expect to see a higher proportion of granted patents. 27% of the application documents have been granted since publication, while a further 1,909 (54%) are pending decisions from the respective patent office. This indicates that we can likely expect to see an increase in granted patents in the coming years as those applications are processed through the system and decisions are issued on their novelty.

Of the granted patents in this dataset (n=709), 87% are active, meaning the assignee is continuing to pay maintenance fees on the patent to retain protection over the innovation. The remaining 13% are either ceased, withdrawn, expired, revoked, not in force, or no data is available on their status. This indicates that the majority of the granted patents in this dataset remain an important element of the commercial strategy of their respective assignees because, if they were not, they would be unlikely to continue paying maintenance fees on these patents.

Figure 5. (Left) Type of publication in the total dataset (n=5,360), stratified by patent applications and granted patents. Data is unavailable for 1,091 patents. (Right) Legal status of patent applications in this dataset (n=3,560). 27% of patent applications have been granted since their publication while over 50% are pending a decision from the respective patent office. The inclusion of granted patents in the breakdown of patent applications reflects their change in status from application to granted patent since filing.



Filing jurisdictions

A key element of IP strategy for any company is determining the countries in which patents will be filed. As there are no global patents, patents must be filed in each individual country where protection is needed, which can be expensive and time-consuming. While there is no one-size-fits-all approach to filing strategy, common themes can be observed. Patents relating to core technologies, or those critical to the success of the company, are typically filed in a range of jurisdictions to encompass countries that are key markets, home to competitors, or host important R&D locations or manufacturing hubs. For technological innovations that are of less critical importance to commercial success, it may be sufficient to file in fewer countries that are of specific importance to the assignee or their competitors.

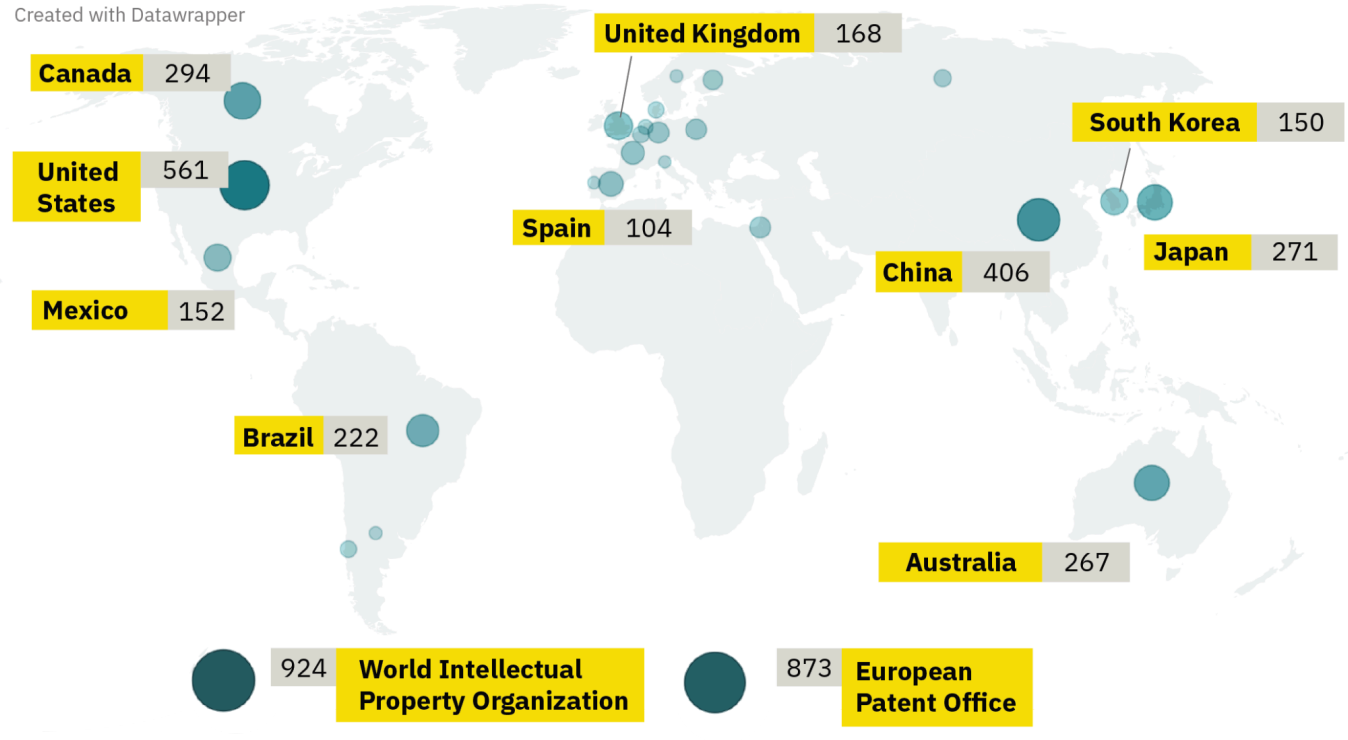
The majority of patents in this dataset have been filed with either the World Intellectual Property Organization (WIPO) (924 patents) or European Patent Organization (EPO) (873). The high number of patent filings with WIPO reflects the abundance of Patent Cooperation Treaty (PCT) filings in this dataset, which is a common route for innovators to take at the early stage of exploring the patentability of a new invention and is administered by WIPO. While PCT filings

do not result in a patent being granted, this mechanism provides a single point of entry to receive a quick opinion on the patentability of an invention when assessed against a common set of standards agreed by 158 countries worldwide. This can also serve as the basis for multiple national-level filings as it streamlines the process of meeting different administrative and legal requirements in the signatory countries and can result in significant time and cost savings.

The EPO operates a similar one-step process for the filing of patents under common standards across the 39 EPO member countries. The granting of a European patent can then be followed by validation of the patent in selected member countries. Since 2024, the Unitary Patent system also makes it possible to file for protection in 18 European countries by submitting one single request to the EPO, resulting in a more streamlined and less costly application process. The total number of countries covered under this mechanism is expected to rise to 25 in the coming years as further member countries ratify the Agreement on a Unified Patent Court.

The most popular national jurisdictions for filing patents are the United States (561), China (406), Canada (294), Japan (271), and Australia (267) reflecting the size and importance of these markets. While it is impossible to comment on the specific patent strategy of any one assignee in this dataset, these data indicate that European innovators aim to have a global stake in the alternative protein market and are designing their IP strategies with global competitors in mind.

Figure 6. Heat map of the most common jurisdictions for alternative protein patent filings in the dataset of alternative protein patents published during the years 2015-2024 inclusive.



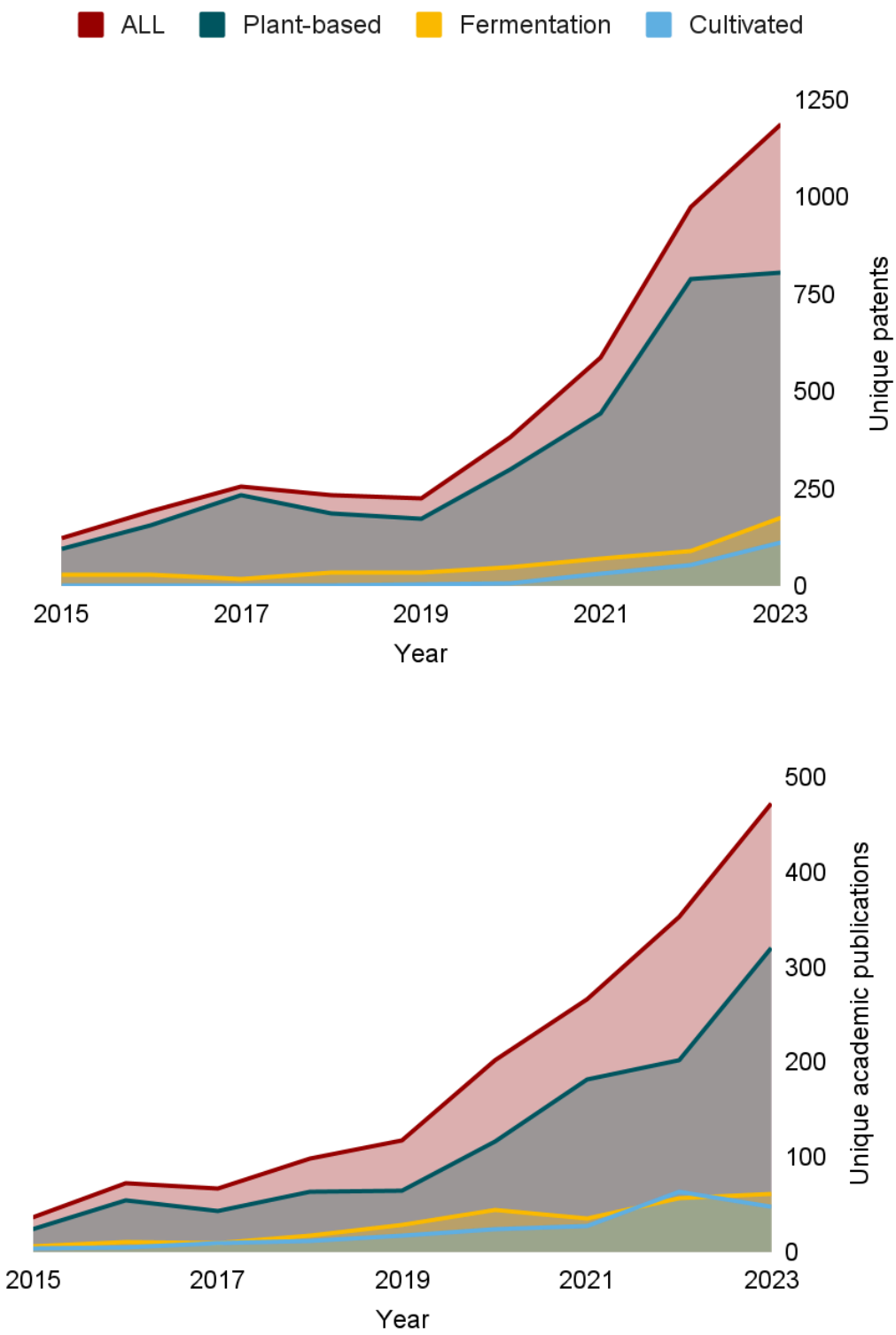
Comparison with trends in academic publishing

It is interesting to observe the similarities in patterns between patent publications and open-access academic research publications over the previous decade. Collectively, these data contribute to an overall impression that alternative proteins (and in particular research on plant-based meat, eggs, and dairy) are in a period of significant growth in R&I activity in Europe.

The increase in volume in patent publications is slightly ahead of the uptick in academic output, supporting a generally held assumption that the majority of historical R&I in alternative proteins has been applied research or experimental development done in the private sector. However, it is encouraging to observe academic outputs beginning to catch up in recent years as more public funding has become available, with patent publications increasing by 32% year-on-year from 2015 to 2024 and academic publications increasing by 36% from 2015 to 2023. Ultimately, we cannot draw many conclusions on the relationship between these datasets but it will be interesting to observe whether the increase in academic output is correlated with a boost in patent filings and publications in future years.

One common theme across these datasets is that R&I activity on topics related to fermentation-made and cultivated proteins lags significantly behind plant-based in both datasets, indicating that increased public funding will be required to jumpstart more high- and low-technology readiness level (TRL) R&I in these areas. It is also noted that plant-based patent publications appear to have plateaued somewhat over the last two years. This may be due in part to a degree of maturation observed in this sector in recent years and an associated shift away from a reliance on patents with more emphasis placed on incremental improvements that can be better protected by the maintenance of trade secrets. However, it also demonstrates that continued growth cannot be taken for granted and that this pillar should continue to receive public and private funding support to capitalise on the progress made to date.

Figure 7. Comparison of trends in alternative protein academic research and patent publishing by European innovators in the years 2015-2023.



03 Assignees

Countries

A total of 398 assignees from 25 of the 30 countries analysed have contributed to the total volume of patents published in the timeframe analysed in this report. Switzerland is the clear leader in patent families (265, 23% of total) and total patents published (1,232), while Germany has the highest number of assignees (82). Innovators from five countries (Switzerland, the Netherlands, Germany, France, and the UK) are assignees or co-assignees on 72% of all patent families.

Some trends identified in our recent publications analysis can also be observed in patent publications. For example, the Nordics region again performs strongly on a per capita basis, with Denmark, Finland and Sweden all ranked in top 10 overall on the basis of unique patent families and ranked third, fourth and sixth, respectively, on the basis of patent families per million inhabitants.

On a per capita basis, Switzerland and the Netherlands are still in first and second position, but larger countries like France (ninth), Germany (10th), the UK (12th), Spain (14th), and Italy (16th) have considerable room to improve their relative performance – also mirroring trends that we observed in our publication analysis. It is, however, interesting to note a considerable difference in how Switzerland ranks on the basis of patents (first) when compared to its ranking on the basis of academic publications (14th), which is a somewhat unique situation amongst European countries. This points to a disparity between the relative strength of the Swiss public and private R&I ecosystems in alternative proteins and suggests that investing public funds in foundational research could enable the country to maintain and strengthen its competitive advantage in this space.

Figure 8. Heat map of total patents published per European country in the years 2015-2024 inclusive.

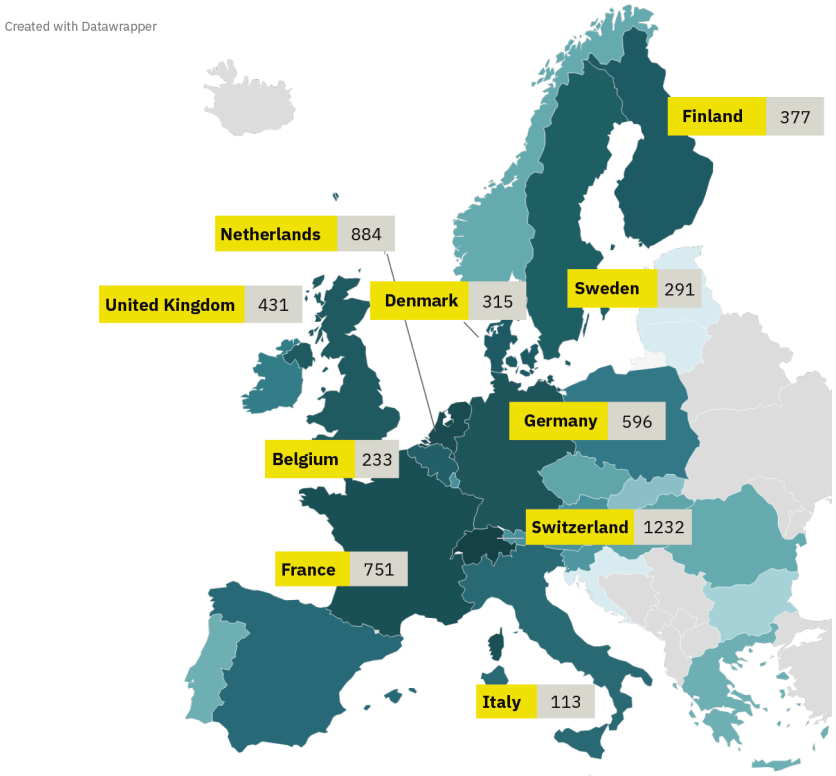


Figure 9. Heat map of patent families per capita in the years 2015-2024 inclusive.

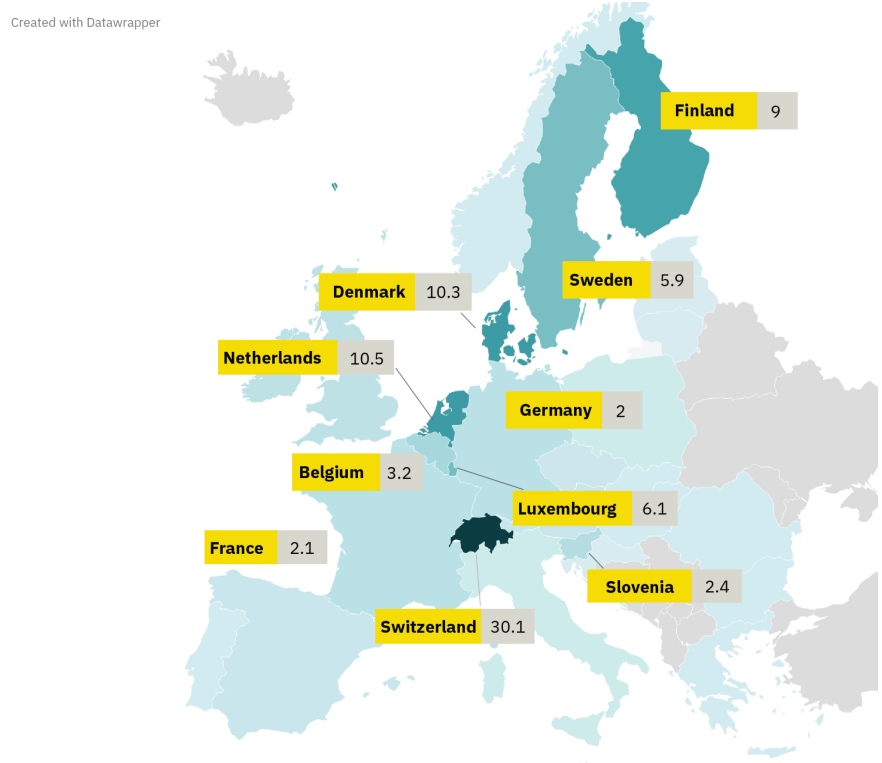


Table 1. Ranking of countries in Europe on the basis of patents published and patent families in the years 2015-2024 inclusive.

Country	Patent families	Patents	Assignees	Patent families per million inhabitants	Plant-based patent families	Fermentation patent families	Cultivated patent families
Switzerland	265	1232	32	30.1	215	13	6
Netherlands	185	884	42	10.5	127	23	18
Germany	167	596	82	2.0	117	24	14
France	136	751	34	2.1	103	15	12
United Kingdom	99	431	39	1.5	42	22	27
Sweden	63	291	19	5.9	49	12	1
Denmark	61	315	24	10.3	52	7	0
Finland	50	377	20	9.0	38	9	1
Belgium	37	233	17	3.2	34	2	0
Spain	31	95	25	0.7	19	5	4
Italy	31	113	24	0.5	30	0	1
Poland	20	43	12	0.5	19	1	0
Ireland	8	37	6	1.6	7	0	1
Austria	7	17	6	0.8	4	2	0
Czechia	6	6	3	0.6	4	0	2
Slovenia	5	13	1	2.4	2	0	0
Luxembourg	4	16	3	6.1	3	0	0
Romania	3	4	2	0.2	3	0	0
Greece	2	3	1	0.2	2	0	0
Cyprus	1	3	1	1.1	1	0	0
Norway	1	4	1	0.2	0	1	0
Slovakia	1	2	1	0.2	1	0	0
Bulgaria	1	1	1	0.2	1	0	0
Hungary	1	7	1	0.1	1	0	0
Portugal	1	3	1	0.1	1	0	0
Lithuania	0	0	0	0.0	0	0	0
Croatia	0	0	0	0.0	0	0	0
Latvia	0	0	0	0.0	0	0	0
Estonia	0	0	0	0.0	0	0	0
Malta	0	0	0	0.0	0	0	0

Private sector organisations

Just 10 companies account for 33% of all patent families published from 2015-2024. This data likely underrepresents the true volume of IP being generated by European innovators due to the food industry's reliance on trade secrets. However, it does support the perception that much of the innovation in alternative proteins is still happening in industry. This can be expected given the relative nascency of the field, but such a disproportionate reliance on the private sector to provide technological solutions further strengthens the argument for greater public investment in open-access R&I.

Even among the private companies listed here, there is obvious centralisation. Nestlé is the clear frontrunner with more than double the number of families and patents than the next most productive company. Interestingly, however, Nestlé is also ranked 39th overall in our 2019-2023 publications report – a clear example of how private industry can advance their R&I objectives while simultaneously making important contributions to the academic literature. The same is also true for Quorn, which ranks sixth on the basis of published patents in this analysis, and 32nd overall in our publication analysis.

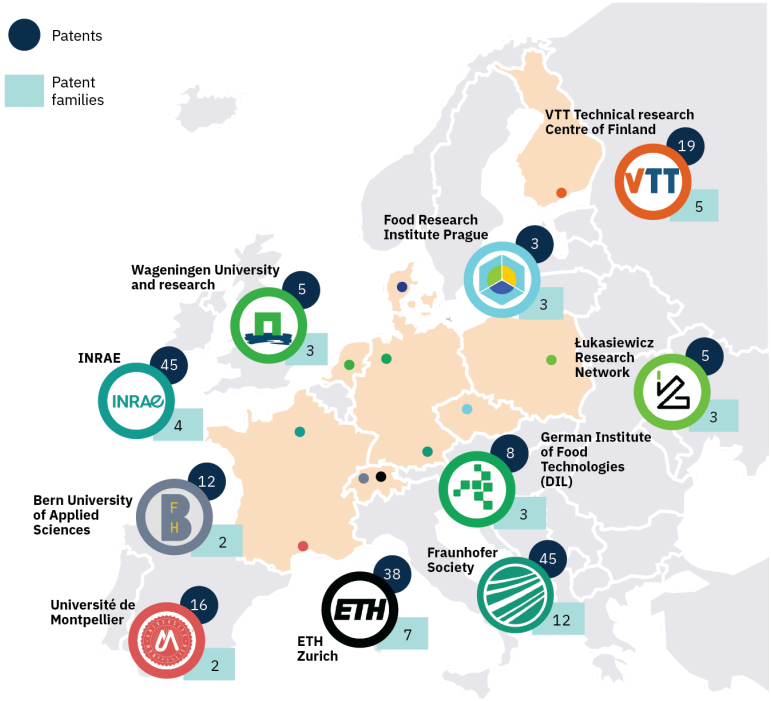
It is also worth noting that the secrecy and siloed approach that has traditionally been a feature of industrial R&I is slowly giving way to new, flexible means of generating and managing new knowledge. Concepts such as Open Innovation in Science and IP pooling are gaining popularity as useful and effective ways for companies to collaborate, share resources, and de-risk innovation while moving the space forward. The industry should increase its adoption of these approaches to accelerate innovation in alternative proteins.

Table 2. Ranking of private sector assignees in Europe on the basis of patents published in the years 2015-2024 inclusive.

Assignee	Country	Patent families	Total patents	Plant-based patent families	Fermentation patent families	Cultivated patent families	Cross-cutting patent families
Nestlé	Switzerland	131	744	129	0	0	2
Roquette Frères	France	51	324	48	3	0	0
DSM-Firmenich	Netherlands, Switzerland	50	221	35	6	1	8
Unilever	Netherlands, United Kingdom	39	210	30	1	0	8
Givaudan	Switzerland	26	142	18	0	1	7
Quorn	United Kingdom	19	122	1	14	0	4
Oatly	Sweden	18	94	18	0	0	0
Bühler	Switzerland	18	81	6	0	1	11
Philips	Netherlands	18	54	18	0	0	0
Chr. Hansen	Denmark	14	152	14	0	0	0

Public and nonprofit research organisations

In total, only 40 public or nonprofit research organisations have published patents on alternative proteins, representing 19 countries. As a proportion of the total, 7% of patent families have a public or nonprofit research organisation listed as a sole or co-assignee. Similar to trends in the overall data set, plant-based is the dominant pillar with 75% of all patents, followed by cultivated (9%), fermentation (8%) and cross-cutting (8%).



While patent publications have risen modestly in recent years, these data suggest that the recent increase in both academic output and public funding has not yet resulted in a significant increase in patent filings from public research organisations. This may in part be due to the more fundamental nature of this research, which is not as readily patentable and which can deliver a greater benefit to the wider ecosystem when published in an open-access format and without IP restrictions. However, it also suggests that alternative protein researchers require greater support to understand the commercial relevance of their research and, where appropriate, bring about a return on investment from public funding for R&I.

Another observation is that only 1% of patent families list both a public and private entity as co-assignees. While there are many reasons why public and private organisations may not be listed as co-assignees on a patent that describes jointly developed technology, this statistic does act as a barometer for a significant lack of public-private collaboration in the alternative protein field, and R&I funders and governments should prioritise the implementation of funding mechanisms that facilitate such interactions.

Figure 10. Number of alternative protein patents published by public and nonprofit research organisations during the years 2015-2024 inclusive.

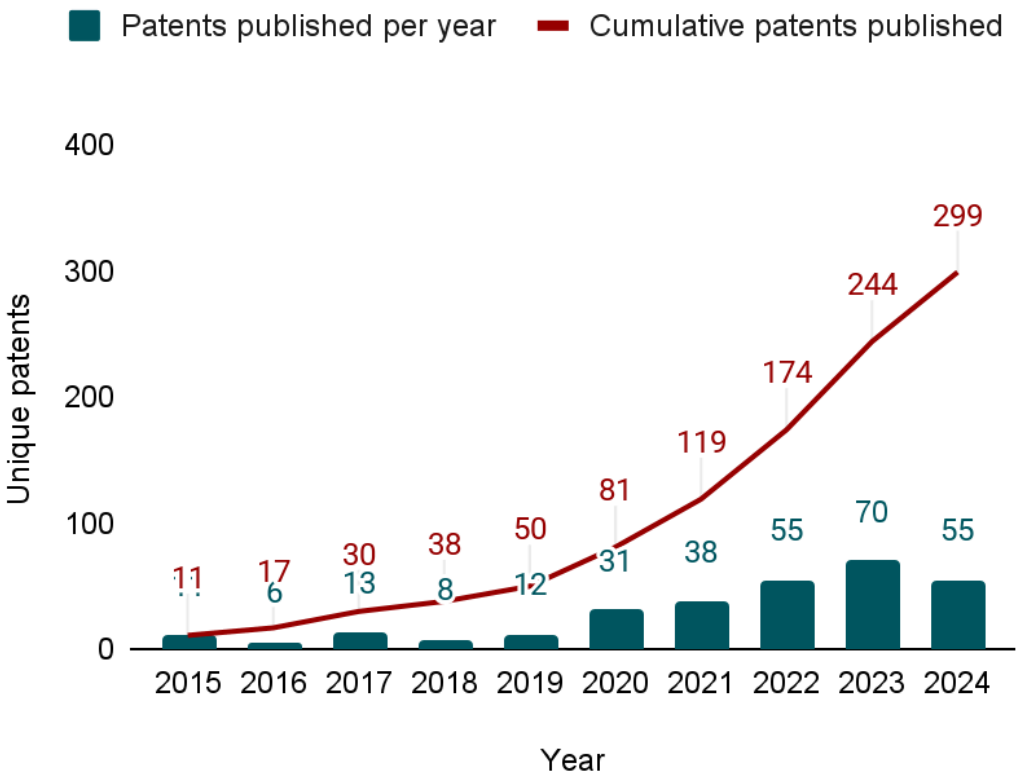


Table 3. Ranking of public and nonprofit research organisations in Europe on the basis of patents published in the years 2015-2024 inclusive.

Assignee	Country	Patent families	Total patents	Plant-based families	Fermentation families	Cultivated families	Cross-cutting families
Fraunhofer Society	Germany	12	45	11	0	0	1
ETH Zürich	Switzerland	7	38	6	0	0	1
VTT Technical Research Centre of Finland	Finland	5	19	2	1	0	2
National Research Institute for Agriculture, Food and Environment (INRAE)	France	4	45	4	0	0	0
German Institute of Food Technologies (DIL)	Germany	3	8	3	0	0	0
Łukasiewicz Research Network	Poland	3	5	3	0	0	
Wageningen University & Research	Netherlands	3	5	3	0	0	0
Food Research Institute Prague	Czechia	3	3	3	0	0	0
Université de Montpellier	France	2	16	2	0	0	0
Bern University of Applied Sciences	Switzerland	2	12	1	1	0	0

04 End product and ingredient types

End product type

To give an overview of the types of technological solutions being developed by European innovators and identify knowledge gaps, patents have been stratified on the basis of the intended end product type(s) listed in the patent claims. A diverse range of product types and technical innovations are represented in the data, suggesting that the alternative protein R&I ecosystem is proliferating to meet the numerous challenges in bringing alternative proteins to taste and price parity and bringing new solutions to market.

Meat is by far the most common end product, with 41% of patent families, while dairy products (combining the 'milk & milk proteins', 'cheese', 'yoghurt & fermented dairy', and 'cream & ice cream' categories) account for 30%. While not a like-for-like comparison, this is consistent with findings from our recent analysis of research funding for alternative proteins, which shows that where funded projects had a clear target end product in mind, meat was most common (65% by total investment value) and dairy was the second most represented (16%).

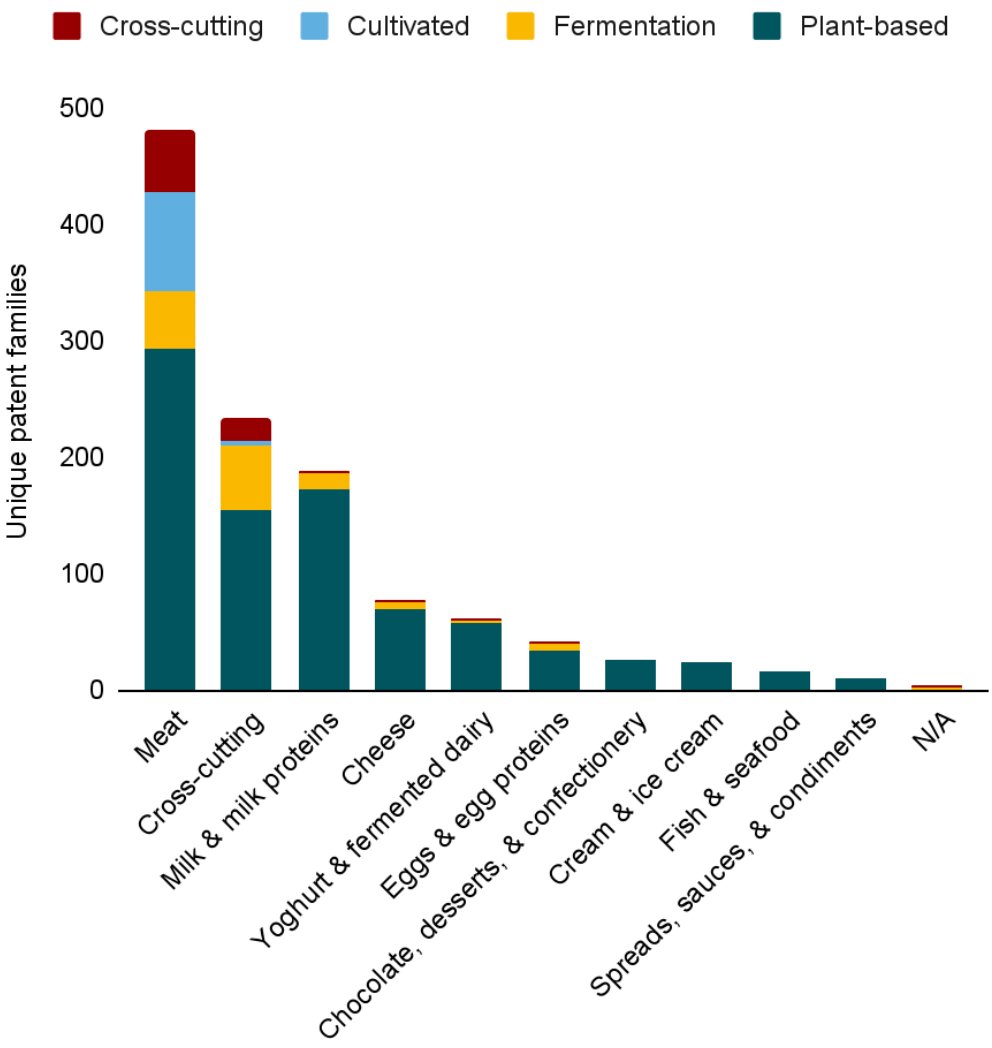
Most end product categories are largely dominated by plant-based patents, but it is interesting to observe a more diverse mix of patents from all three alternative protein pillars within the meat category, suggesting that meat analogues have been the primary focus of European innovators, irrespective of their technical discipline.

In contrast, only 17 dedicated families (1%) describe innovations specific to fish and seafood analogues. While this figure can be considered an underestimate, given a reasonable number of the cross-cutting patents cover fish and seafood analogues as one of numerous different use cases, when taken in the context of seafood alternatives receiving only 8% of dedicated European funding in the 2020-2024 period, this clearly indicates a neglected field of R&I.

More innovation is also needed in cheese and egg analogues, in particular. In general, dairy and egg analogue products remain dominated by plant-based innovations. Given the role that precision fermentation can play as an enabling technology in improving the sensory and functional attributes of these products, it would be encouraging to see more innovations harnessing the power of hybrid products, which combine the beneficial traits of plant-based and fermentation-made ingredients.

However, with seafood analogues receiving only 8% of dedicated public and nonprofit funding in the period 2020-2024, and egg analogues receiving only 2%, these discrepancies in the relative maturity of different end product types are likely to continue into the future unless specifically addressed by funders.

Figure 11. Patent families by intended end product type published in the years 2015-2024.



Ingredient type

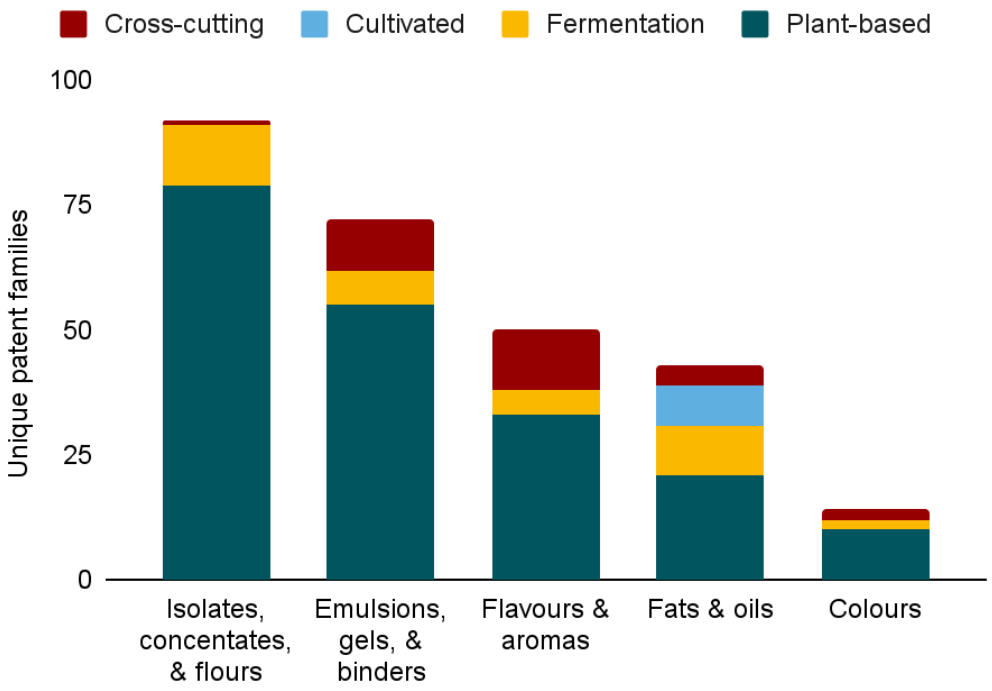
It can also be helpful to examine the specific ingredient types that European innovators are developing for the market. Protein preparations such as isolates, concentrates, and flours are the most common ingredients, followed by emulsions, gels, and binders.

Like with the end product type analysis, plant-based technologies dominate the ingredient type breakdown, although a more diverse mix of fermentation-made solutions are found in the 'emulsions, gels and binders', and 'flavours and aromas' categories.

Fermentation-made products are also being used to develop colour solutions for alternative proteins, particularly red pigments which can provide a red-to-brown transition during cooking, but this category remains one of the least developed ingredient types

Cultivated ingredients can also be found in the fats and oils category, with cultivated fats being developed by several European companies as an ingredient for meat analogues with the specific goal of enhancing the sensory properties of these products.

Figure 12. Patent families by intended ingredient type published in the years 2015-2024.



05 Alternative protein pillar deep-dives

Overview

This section of the report examines the patent landscape across the three alternative protein pillars in Europe to assess their relative stage of maturity and identify areas where greater research efforts are needed.

Table 4. Summary data describing key metrics in alternative protein patent publications by European innovators in the years 2015-2024 inclusive, categorised by alternative protein pillar.

Metric	Plant-based	Fermentation	Cultivated
Patent families	858	134	88
Patents	3,977	681	317
2015 patent publications	95	28	0[1]
2024 patent publications	792	154	112
Year-on-year % change in publications	19%	28%	150%
Assignee organisations	289	69	41
Assignee countries	24	13	11

Plant-based is the dominant pillar with 74% of all patents, reflecting the greater maturity of the technology and market. The first plant-based patent in this dataset was filed in 1999, whereas for fermentation the first patents were filed in 2011 and the first cultivated patents were filed in 2018. Plant-based filings showed very significant increases between 2016 and 2021, peaking at 842 in 2021. This trend broadly mirrors those seen in global annual investments in plant-based companies, which rose significantly during the same period and peaked at approximately €2.4 billion in 2021.

Fermentation and cultivation patent filings underwent larger relative increases in the late 2010s, albeit from a significantly lower base, with fermentation peaking at 141 in 2021 and cultivated peaking at 106 in 2022. These data reflect the relative nascency of these pillars and are concurrent with trends seen in academic publishing. While public and nonprofit funding for fermentation has increased significantly in recent years, historical investment in these pillars has lagged behind that of plant-based across Europe. It will take time for the increased funding for fermentation to be reflected in more academic publications and patent filings, and there is a clear need to increase dedicated R&I funding in underlying cultivated technologies to realise their full potential.

[1] The first cultivated patents from European innovators were not published until 2018.

Figure 13. Cumulative number of alternative protein patents published by European innovators during the years 2015-2024 inclusive, categorised by alternative protein pillar.

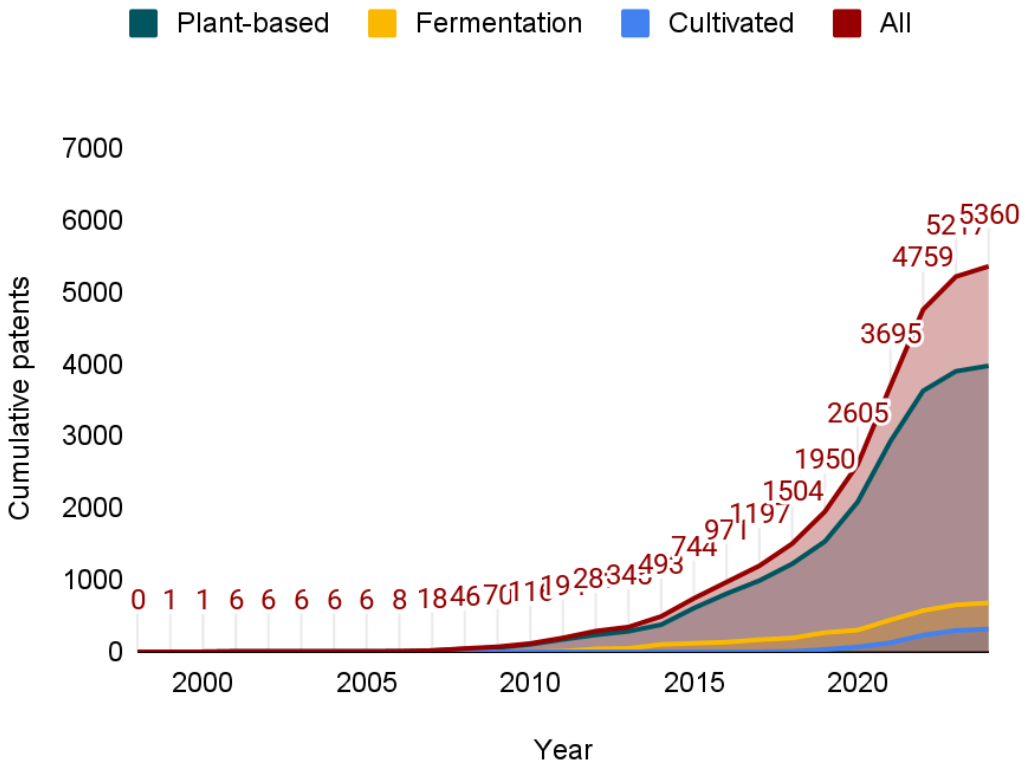
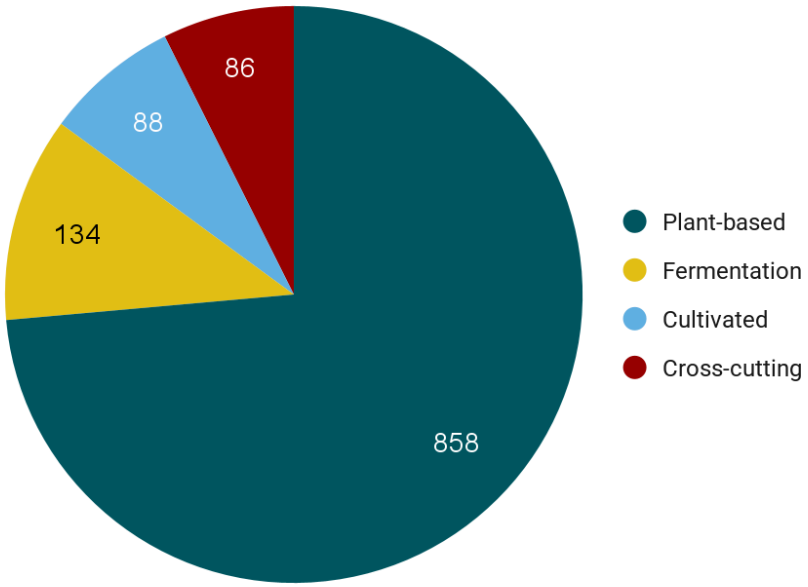


Figure 14. Breakdown of patents published during the years 2015-2024 by alternative protein pillar.



As part of this analysis, it is helpful to assess the technological advancements that can move alternative proteins closer to taste and price parity with conventional protein sources. This report uses nine 'technology sectors' to classify these R&I areas (summarised in Table 5). Using this information, we can then assess the relative maturity of each alternative protein pillar and identify priority areas where R&I activity is most urgently needed.

Table 5. Alternative protein technology sectors.

Technology sector	Description	Relevant AP pillar(s)
Bioprocess design	Innovations in bioreactor design and media or feedstock utilisation strategies (including the use of alternative feedstocks) to achieve higher efficiency, greater scale, and bring down costs.	Fermentation Cultivated Plant-based[2]
Cell culture media	Reducing costs and increasing availability of the nutrients needed for meat cultivation by characterising and validating novel sources of growth factors, amino acids, and other media components.	Cultivated
Cell line development	Optimising new and existing cell lines to achieve faster cell growth, greater stability and stress tolerance, and higher cell density in terrestrial and aquatic cell lines.	Cultivated
Crop development	Breeding of crops and increased use of underutilised protein crops for higher protein yields and functionality.	Plant-based
End product formulation & manufacturing	Process and formulation innovations, including (but not limited to) novel texturization methods such as extrusion, electrospinning, 3D printing, and enzymatic processing to match the texture of animal protein.	Plant-based Fermentation Cultivated
Strain development	Screening and optimisation of novel strains to identify the most efficient pathways for producing targets or modifying substrates.	Fermentation Plant-based[2]
Ingredient optimisation	Improved protein fractionation and functionalisation to achieve higher-quality ingredients with less processing. Also covers the development of novel ingredients to augment nutritional profiles and enhance the sensory experience of alternative protein products.	Plant-based Fermentation
Scaffolding	Improved scaffolding biomaterials that support cell adherence and differentiation to allow the replication of complex animal meat structures.	Cultivated
Target molecule selection	Target identification and validation to broaden the scope of food ingredients produced by precision fermentation.	Fermentation

[2] Refers to the use of traditional fermentation techniques to modulate or enhance the characteristics of plant proteins.

Plant-based meat, seafood, eggs and dairy

Key countries and organisations

Plant-based innovations account for a total of 858 patent families and 3,977 total patents from 289 assignees in 24 of the 30 countries analysed. Patent publications grew by 834% from 2015 to 2024, with the first plant-based filings from this dataset as far back as 1999. Switzerland leads the plant-based space, with 26% of all patents, while the Netherlands, Germany, France and Denmark round out the top five most productive countries in this pillar. Nestlé has published the highest number of patents, accounting for 15% of all patent families.

Table 6. Ranking of countries in Europe on the basis of plant-based patents published in the years 2015-2024 inclusive.

Country	Patent families	Total patents
Switzerland	215	1,021
Netherlands	127	583
Germany	117	376
France	103	569
Denmark	52	275
Sweden	49	239
United Kingdom	42	200
Finland	38	270
Belgium	34	219
Italy	30	109

Table 7. Ranking of private sector assignees in Europe on the basis of plant-based patents published in the years 2015-2024 inclusive.

Assignee	Country	Patent families	Total patents
Nestlé	Switzerland	129	728
Roquette Frères	France	48	273
DSM-Firmenich	Netherlands, Switzerland	35	134
Unilever	Netherlands, United Kingdom	30	166
AAK	Sweden	19	66
Givaudan	Switzerland	18	97
Oatly	Sweden	18	94
Philips	Netherlands	18	54
Chr. Hansen	Denmark	14	152
Royal Avebe	Netherlands	13	88

Technology sectors

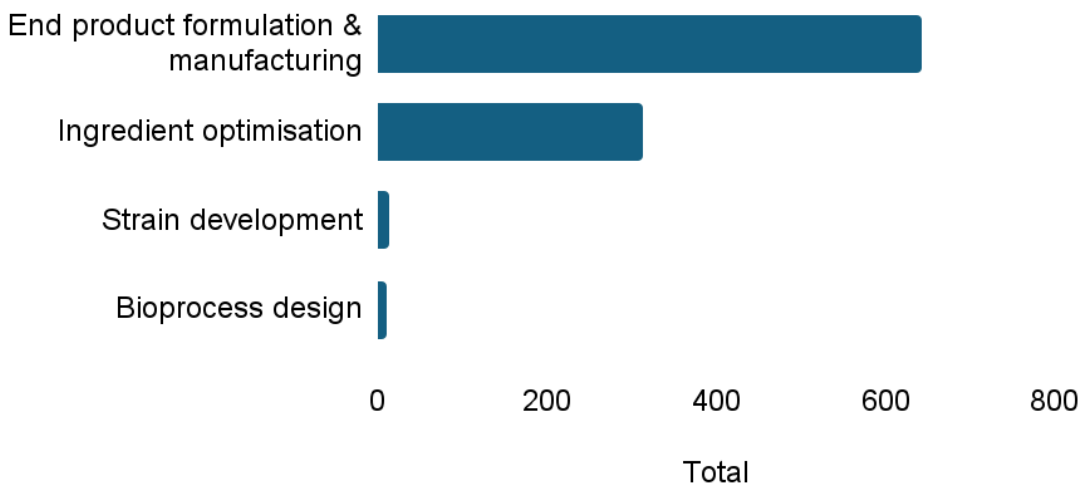
Plant-based patents mostly focus on ingredient optimisation and end-product formulation, with no patents found on crop breeding. Many patents cover areas such as plant protein texturization and the manufacturing of, in particular, plant-based meat. There are also numerous patents on the techno-functional properties of plant proteins such as their gelling and emulsification characteristics and improvements in these attributes – technical areas critical to delivering next-generation plant-based foods.

While there are a growing number of patents on plant-based cheese and egg, this area is still ripe for innovation to deliver products with exceptional techno-functional and sensory attributes. This analysis also highlights a clear need for more crop breeding with a focus on protein quality and yield, an area that would benefit from significant investment in the public sphere to increase knowledge sharing and reduce the barrier to entry for private companies.

The concept network map (see Figure S1 in appendix) of plant-based patents suggests an R&I domain that is developing rapidly, with a diverse mix of highly interconnected topics. This mirrors trends we have observed in the academic sphere, indicating that while plant-based R&I still has a way to go to tackle the key challenges in this space, it is becoming an increasingly cohesive ecosystem.

However, achieving taste and price parity remain the primary challenges for plant-based manufacturers and are the main barriers preventing European consumers from trying and continuing to purchase these products. It is therefore critically important that governments and R&I funders keep up the momentum by continuing to support plant-based research.

Figure 15. Technology sectors covered within plant-based patents published in the years 2015-2024 inclusive.



R&I priorities in plant-based

While the plant-based pillar has seen strong growth in a diverse range of R&I areas in recent years, there are still numerous technical challenges that need to be overcome to capitalise on this progress. Core R&I priorities include:

Better raw materials through breeding of crops and increased use of underutilised protein crops for higher protein yields and functionality.

Learn more >>

Improved protein fractionation and functionalisation to achieve higher quality ingredients, better energy-efficiency, and a lower degree of processing.

Learn more >>

Novel ingredients to mimic animal fat properties, augment nutritional profiles, and enhance the sensory experience of plant-based meat.

Learn more >>

Novel texturization methods in addition to extrusion, electrospinning, 3D printing, enzymatic processing to match the texture of animal protein.

Learn more >>

Fermentation-made proteins and ingredients

Key countries and organisations

Fermentation accounts for 134 patent families and 681 total patents from 69 assignees, indicating a significantly smaller R&I ecosystem than that of plant-based. Publications grew by 550% from 2015 to 2024, with the first filings coming in 2011. Germany ranks highest by number of patent families, followed by the Netherlands, and the UK. Only 13 of the 30 countries analysed have had a fermentation patent filed. Quorn is the clear leader in patent families, while Solar Foods have the highest number of patents. Roquette Frères is the only company to feature in the top 10 for both plant-based and fermentation.

Table 8. Ranking of countries in Europe on the basis of fermentation patents published in the years 2015-2024 inclusive.

Country	Patent families	Total patents
Germany	24	112
Netherlands	23	168
United Kingdom	22	123
France	15	99
Switzerland	13	36
Sweden	12	50
Finland	9	91
Denmark	7	26
Spain	5	9
Belgium	2	12

Table 9. Ranking of private sector assignees in Europe on the basis of fermentation patents published in the years 2015-2024 inclusive.

Assignee	Country	Patent families	Total patents
Quorn	United Kingdom	14	76
Promyc	Sweden	8	21
The Protein Brewery	Netherlands	7	30
Solar Foods	Finland	6	85
DSM-Firmenich	Netherlands, Switzerland	6	66
Infinite Roots	Germany	6	33
Standing Ovation	France	4	20
Roquette Frères	France	3	51
Algenuity	United Kingdom	3	15
FUMI Ingredients	Netherlands	3	14

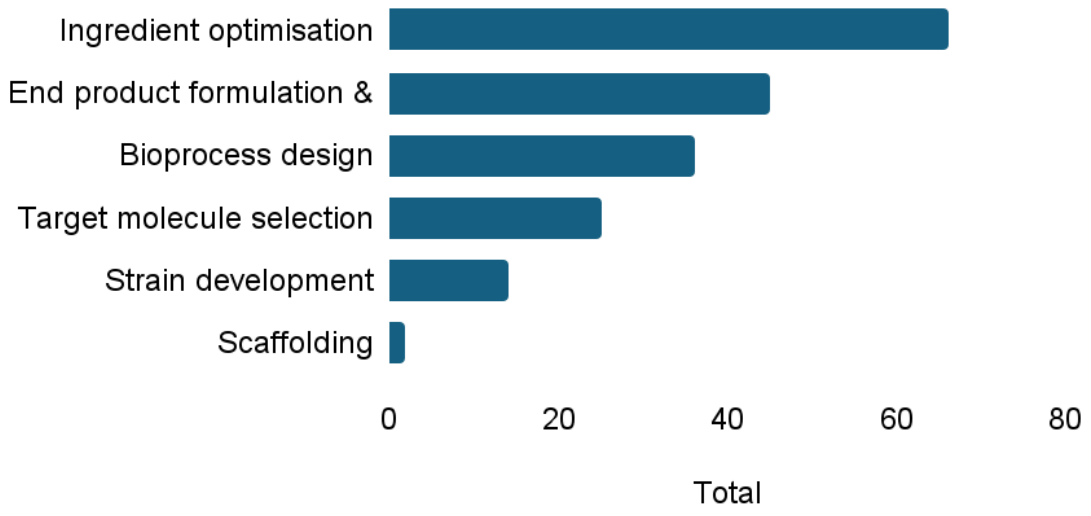
Technology sectors

A diverse range of topics are covered within the fermentation pillar, reflecting the broad uses of the technology. Numerous patents focus on the optimisation of fermentation-made ingredients, particularly the processing of microbial biomass from filamentous fungi, single cell protein, and microalgae. Accordingly, the number of patents describing innovations in biomass fermentation outnumber those describing precision fermentation innovations more than threefold.

It is notable that only a small number of patents are related specifically to strain development and target molecule selection. These technology sectors also remain largely underdeveloped in the scientific literature and, taken together, indicate that there are still significant knowledge gaps in this research area, particularly in relation to the use of precision fermentation technology as a means of producing animal protein analogues and functional ingredients.

Also consistent with academic research, the concept network (Figure S2 in appendix) shows a high level of clustering within topics but a low level of interconnectedness between clusters. In part, this reflects the breadth of this pillar and the wide range of topics it encompasses, but it also points to a relatively immature R&I ecosystem that is still working in silos and has not yet developed a high degree of cohesion and or a focused approach to addressing the key innovation challenges.

Figure 16. Technology sectors covered within fermentation patents published in the years 2015-2024 inclusive.

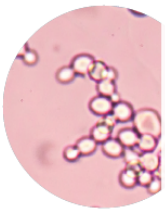


R&I priorities in fermentation

Although fermentation is a relatively mature platform, using it in the context of alternative proteins presents new challenges and this report highlights several important areas where fermentation R&I is lagging behind. The main R&I priorities in fermentation are:

Target identification and validation to broaden the scope of food ingredients produced by precision fermentation and unlock new experiences for consumers.

Learn more >>



Screening and optimisation of novel strains to identify the most efficient pathways for producing targets and introduce greater robustness to manufacturing processes.

Learn more >>

Unlocking alternative feedstocks by leveraging existing agricultural and food processing waste streams to cut costs, reduce waste, and improve sustainability.

Learn more >>

Improved bioprocess design to increase titers and yields, achieve more efficient scale-up, and drive down operating costs across the sector.

Learn more >>

Cultivated meat and seafood

Key countries and organisations

Cultivated accounts for 88 patent families and 317 total patents from 41 assignees, making it the smallest of the three pillars. The first patent was filed in 2018 and publications grew by 11,200% to 2024. Filings are dominated by the United Kingdom, Netherlands, Germany, and France and assignees from only 11 countries in Europe have filed patents on cultivated meat and seafood. In contrast to plant-based and fermentation, most of the companies in the top 10 rankings would be considered startups with a specific focus on cultivated products. It is interesting to note that the two companies with the most patents have also been the first to submit regulatory dossiers to the European Food Safety Authority.

Table 10. Ranking of countries in Europe on the basis of cultivated patents published in the years 2015-2024 inclusive.

Country	Patent families	Total patents
United Kingdom	27	75
Netherlands	18	71
Germany	14	58
France	12	52
Switzerland	6	20
Spain	4	20
Czechia	2	2
Finland	1	10
Italy	1	4
Ireland	1	3

Table 11. Ranking of private sector assignees in Europe on the basis of cultivated patents published in the years 2015-2024 inclusive.

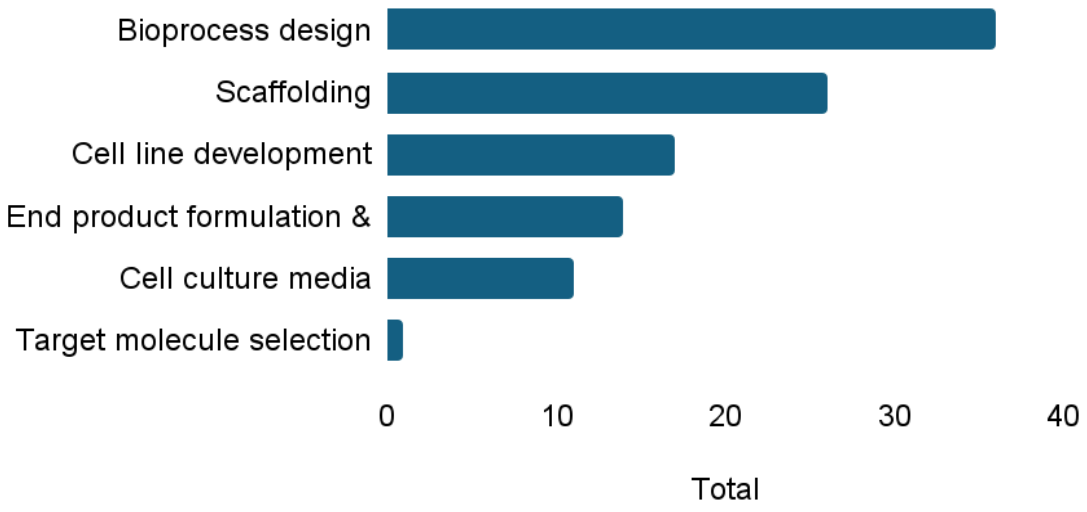
Assignee	Country	Patent families	Total patents
Mosa Meat	Netherlands	12	61
Gourmey	France	8	21
Ivy Farm Technologies	United Kingdom	5	10
Meatable	Netherlands	5	8
BioTech Foods	Spain	4	20
Cellular Agriculture Ltd	United Kingdom	4	12
Merck	Germany	3	32
Uncommon	United Kingdom	3	16
Multus Biotechnology	United Kingdom	3	8
Mirai Foods	Switzerland	3	7

Technology sectors

It is encouraging to see a range of innovations arising from European innovators in the field of cultivated meat and seafood, covering a diversity of technology sectors across cell line development, scaffolding, and culture media. The largest number of patents in the cultivated pillar focus on bioprocess design, including bioreactor designs and methods for their use. However, the number of patent families in cultivated is dwarfed by that of plant-based by nearly a factor of 10, highlighting the distance this pillar still needs to go to catch up. As with cultivated meat and seafood academic research, the concept map (figure S3 in appendix) shows a low diversity of topics and low interconnectedness between clusters, thus reinforcing the impression that this field of R&I is still in its infancy in Europe.

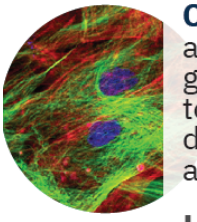
While the literature suggests that fundamental technological breakthroughs are not necessary to eventually achieve economically viable production, significant chemical and biological engineering challenges remain to further reduce costs and increase yields. Many of these technical challenges are of a sufficiently universal nature that they would be much better addressed through publicly funded, open-access R&I. In this context, it is encouraging to see more funding being dedicated to cultivated research, including dedicated centres of excellence such as the Cellular Agriculture Manufacturing Hub (CARMA) hosted by the University of Bath (UK) and the CellFood Hub hosted by Aarhus University (Denmark), Horizon Europe projects such as FEASTS, and national initiatives such as the €60 million Cellular Agriculture Netherlands consortium. However, it is clear that significant further public investment will be required to bring these foods to mass production.

Figure 17. Technology sectors covered within cultivated patents published in the years 2015-2024 inclusive.



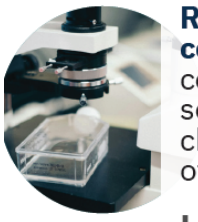
R&I priorities in cultivated

This analysis reveals that R&I activity must be significantly ramped up to reduce costs and increase yields for cultivated meat and seafood. The main R&I priorities here are:



Cell line development to achieve faster cell growth, greater stability and stress tolerance, and higher cell density in terrestrial and aquatic cell lines.

Learn more >>

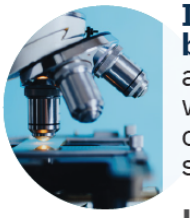


Reduced cell culture media costs by bringing down the cost of growth factors and sourcing amino acids from cheap plant hydrolysates and other sources.

Learn more >>

Increased bioprocessing efficiency via innovations in bioreactor design and media utilisation strategies to achieve greater scale and bring down costs.

Learn more >>



Improved scaffolding biomaterials that support cell adherence and differentiation which allows the replication of complex animal meat structures.

Learn more >>

06 Conclusions and recommendations

Alternative protein R&I shows rapid growth in Europe

Innovation in alternative proteins as measured by published patents has undergone rapid growth in Europe with a total of 5,360 patents from 1,191 patent families published by European innovators during the period 2015 to 2024 inclusive. 398 assignees from 25 countries contributed to this output. The average year-on-year growth in publications during this time period was 32%, and the overall growth was 960% when comparing 2024 publication figures with those from 2015.

Viewed within the wider context of increases in public funding and academic publications, we can point to a rapid growth of the overall R&I ecosystem in Europe, with innovators from across all sectors of society exploring a diverse range of technological areas and achieving exciting breakthroughs in the process.

However, the alternative protein field is still in its infancy and has a way to go to achieve widespread market penetration. As the majority of public funding for alternative protein R&I in Europe has come in the last two years, we can expect this growth in R&I output (as measured by both academic publications and patents) to continue in the near future as this increased funding starts to bear fruit.

Public organisations need support to promote open innovation

The data presented here indicate that the recent increase in both academic output and public funding for alternative protein R&I is not yet materialising in significant increases in patent filings from public research organisations. To bridge this gap, public and nonprofit organisations need greater support to collaborate with private industry via pre-competitive and open innovation mechanisms to stimulate the generation of new IP while delivering a benefit to the overall sector. As discussed in other sections of this report, open-access research and patents are not mutually exclusive and, given the relative immaturity of the alternative protein field and the low TRL nature of many of the technical hurdles to overcome, it would be more cost-effective to fund much of this R&I in public institutions.

With this in mind, the concept of Open Innovation in Science (OIS) has gained popularity in recent years as a means of purposely enabling more efficient knowledge flow and stimulating increased inter- and transdisciplinary collaboration between public and private entities. This type of approach runs counter to the traditional secrecy and silo mentality that has until recently characterised industrial R&I. It has emerged in response to the widespread recognition that no private company, irrespective of its size and resources, can expect to

effectively innovate on its own. In the field of alternative protein research, we can look to the Plant2Food project hosted by Aarhus University as an example of what can be achieved. Under the OIS framework used to govern this project, results are open for all to use but can be brought into IP-protected follow-on projects for exploitation by private industry.

Facilitating efficient technology transfer as a means of accelerating innovation has become a focus of public funders worldwide and countries such as Australia and Japan have developed strategies to stimulate more efficient use of R&I results and to offer guidance on effective collaboration between industry and academia. European public funders should strive to adopt similar mechanisms that effectively combine open-access R&I with OIS principles as a means of shortening the innovation cycle, reaping the economic benefits of innovation, and positively impacting the food system.

Regional disparity is a challenge in alternative protein R&I

The growth in alternative protein R&I activity observed in recent years is encouraging to see. However, as is also the case with academic research in alternative proteins, considerable differences in output can be observed between countries, with five European countries contributing to 72% of the total patents published since 2015. Large discrepancies can also be observed when considering innovation output on a per capita basis, with some smaller countries such as those in the Nordics region performing strongly, while their larger neighbours have the capacity to expand their activity in this field.

This disparity is broadly in line with wider trends in European R&I activity, whereby countries with a high degree of innovation are typically those located in northern and western Europe, whereas areas of moderate and emerging innovation are primarily clustered in southern and eastern Europe. The European Commission has highlighted the need to develop regional and local strategies that can continue to support the development of existing pockets of excellence into flourishing ecosystems while also utilising unused potential in less well-developed regions.

While the Horizon Europe mechanism is a significant vehicle for international collaboration between both academic and industry stakeholders, its emphasis on scientific excellence makes it challenging for institutions from less well-developed regions or those with fewer institutional resources to be competitive in these funding calls. Strategic investments via mechanisms such as the European Regional Development Fund could help to boost the R&I capabilities of less developed regions and allow them to establish a foothold in the alternative protein sector. It is well documented that national funding for R&I activity varies significantly between European countries, and governments of underrepresented countries should explore mechanisms to stimulate greater R&I activity in alternative proteins to capitalise on the follow-on economic benefits of innovation.

R&I activity differs significantly across end-product types

When stratifying by end-product type, we see noticeable differences in maturity from one category to the next, with meat analogues the most common end product type, followed by a range of different types of dairy alternative end products. While not a like-for-like comparison, these findings are consistent with our recent analysis of research funding for alternative proteins. This showed that, where funded projects had a clear target end product in mind, meat was most common (65% by total investment value) and dairy was the second-most represented (16%). Most end-product categories are largely dominated by plant-based patents – but it is interesting to see a more diverse mix of patents from all three alternative protein pillars within the meat category, suggesting that meat analogues have been the primary focus of European innovators, irrespective of their technical discipline.

Innovation in products such as cheese and egg analogues has seen some exciting developments but will require further development. The full potential for precision fermentation to act as an enabling technology to deliver mainstream success in these categories should be further explored. There are, however, key fundamental bottlenecks which must be overcome to allow innovators to fully exploit precision fermentation, such as the identification of new protein production candidate strains and biosynthetic pathway discovery for fermentation-produced molecules, alongside challenges with reducing the cost of downstream processing. Given their complexity and broad relevance in the industry, these are challenges that would be best addressed in the public research sphere.

With only 17 dedicated patent families (1% of the total), fish and seafood analogues are an area that has been largely neglected by European innovators and should be a priority for R&I funders. While this figure can be considered an underestimate given fish and seafood are covered as part of a reasonable number of cross-cutting patents, this clearly indicates a neglected field of R&I. However, with seafood analogues receiving only 8% of dedicated public and nonprofit funding in the period 2020-2024, and egg analogues receiving only 2%, these discrepancies in the relative maturity of different end-product types are likely to continue into the future unless specifically addressed by funders.

Key technology areas remain significantly underdeveloped

This analysis, in combination with previous trends observed relating to academic publications, reveals large discrepancies in some technology areas that will be key to moving alternative proteins towards taste and price parity with conventional animal products.

The plant-based field is developing rapidly, with numerous new avenues of innovation being explored. However, certain areas in the plant-based space such as dedicated crop breeding for alternative protein applications remain highly neglected. Other priorities include the

development of improved methods for protein fractionation and functionalisation to achieve higher-quality ingredients and optimise protein ingredient characteristics for specific end-product types. This could be enabled through a better understanding of protein sequence, structure, and functionality and the development of a centralised, open-access space to compile this data for the benefit of the entire R&I ecosystem.

Conversely, fermentation and cultivated meat and seafood are at a much earlier stage of development and the lack of fundamental research in these areas is a clear hindrance to innovation and product development. One example is in the area of microbial fermentation, which provides an efficient method for generating lipids and functional proteins that are chemically identical to those produced by animals. Research efforts are needed to expand current knowledge about the process of engineering the appropriate metabolic pathways for the synthesis of animal-derived molecules into microbial organisms well-suited for large-scale fermentation. As touched upon in the previous section, this analysis also shows that cultivated seafood is a particularly underexplored area of R&I and solutions are required in aquatic cell line development, especially the development of methods to promote efficient fish cell proliferation. These technology areas should be urgently prioritised for increased funding and governance mechanisms through which all sectors of society can collaborate more effectively on solving the major R&I challenges in these areas should be adopted as standard practice.

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07 Methodology

Search criteria

Data was sourced from Dimensions, an interlinked research information system provided by Digital Science (https://www.dimensions.ai). Given the interdisciplinary nature of alternative protein R&I and the wide range of potentially relevant patents that could fall under that definition, complex search terms were devised that allowed us to trigger numerous patents that may be relevant to our analysis. These search teams were:

1. ("meat substitute" OR "meat analogue" OR "meat analog" OR "vegan meat" OR "meat alternative")
2. ("plant based milk" OR "non dairy milk" OR "oat milk" OR "soy milk" OR "rice milk" OR "plant based cheese" OR "plant based dairy" OR "vegan dairy" OR "vegan cheese" OR "vegan milk" OR "dairy substitute" OR "milk substitute" OR "dairy alternative" OR "milk alternative" OR "dairy replacement" OR "milk replacement" OR "cashew cheese" OR "plant based egg" OR "egg substitute" OR "egg replacement" OR "egg alternative" OR "vegan egg")
3. ("precision fermentation" OR "fermentation derived" OR "fermentation made" OR "biomass fermentation" OR "fermentation" OR "mycoprotein" OR "single cell" OR "microbial" OR "fusarium" OR "fusarium venenatum" OR "fungus" OR "fungi" OR “fungal” OR "mycelium" OR "mycelial" OR “recombinant protein” OR “microbial cell factories” OR “recombinant expression” OR "microalgae" OR "microalgal" OR "yeast" OR "edible filamentous fungi" OR "fungal hyphae" OR "bacteria" OR "bacterial" OR "engineering biology" OR "hydrogen oxidizing bacteria" OR "microbial biomass" OR "saccharomyces cerevisiae") AND ("meat substitute" OR "meat analogue" OR "meat analog" OR "megan meat" OR "meat alternative" OR "plant based milk" OR "non dairy milk" OR "oat milk" OR "soy milk" OR "rice milk" OR "plant based cheese" OR "plant based dairy" OR "vegan dairy" OR "vegan cheese" OR "vegan milk" OR "dairy substitute" OR "milk substitute" OR "dairy alternative" OR "milk alternative" OR "dairy replacement" OR "milk replacement" OR "cashew cheese" OR "plant based egg" OR "egg substitute" OR "egg replacement" OR "egg alternative" OR "vegan egg")
4. ("cultivated meat" OR "cultured meat" OR "cell cultured meat" OR "lab grown meat" OR "cell-based meat" OR "cellular agriculture" OR "synthetic meat" OR "cell grown meat" OR "cellular meat" OR "stem cell meat" OR "cultivated seafood" OR "cultured seafood" OR "lab grown seafood" OR "cell based seafood" OR "lab grown fish" OR "cell-based fish" OR "cell cultured fish" OR "cell cultured seafood" OR "cellular aquaculture" OR "cell grown seafood" OR "cell-grown fish" OR "cellular seafood" OR "in vitro meat" OR "cultivated fat" OR "cultured fat")

The publishing date period was limited to 2015-2024. Countries selected for analysis were Austria, Belgium, Bulgaria, Croatia, Republic of Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, and the United Kingdom.

The 'Full data' search setting was used to ensure all patents relevant to the scope of the keywords were captured by including mentions of alternative protein use cases in the invention description and claims. All data was downloaded from Dimensions.ai on 14 January 2025 in a spreadsheet format.

Data screening

Results of the patent searches were screened against a set of inclusion/exclusion criteria to determine whether they were in scope for this study. Patents relevant to plant-based, fermentation-made, or cultivated proteins and ingredients that satisfied the following **inclusion criteria** were considered to be within the scope of this analysis:

Patents describing the development or optimisation of a plant, algal or microbial species or cultivated animal cells as a source of protein or other ingredients (including, but not limited to, lipids, enzymes, or fibres) that can contribute to improving the sensory and techno-functional properties of an alternative protein ingredient or product with a stated use case for human food.

Patents describing the development or optimisation of a processing method of plant, algal, microbial, or cultivated animal tissues to improve protein functionality or quality for use as a food.

Patents describing crop or strain optimisation or agronomic or bioprocessing innovations that improve protein quality or yield or improve ease of processing.

Patents describing the development or optimisation of alternative feedstocks or cell culture media or bioprocessing methods or strategies for their utilisation with the aim of improving the sustainability, efficiency, and/or economic viability of the process.

Patents describing the development or optimisation of hybrid products where the stated aim is the reduction or substitution of animal products and/or the improvement of the functionality of plant, microbial, or cultivated proteins.

Patents describing the optimisation of the biochemical properties (flavour, aroma, nutritional properties, allergenicity) of plant, algal, microbial or cultivated proteins or the development of novel ingredients therefrom.

Publications that met one or more of the following **exclusion criteria** were judged to be outside the scope of this analysis:

Patents describing the development or optimisation of a plant, algal or microbial species or cultivated animal cells, where the outcomes were not relevant for the development of alternative protein products.
Patents describing the development or optimisation of a plant, algal, microbial species, or cultivated animal proteins, with a stated use case for pet food or animal feed only.
Patents describing the development or optimisation of blended products where the aim is the improvement of the functionality of animal products or ingredients.
Patents describing the development or optimisation of a plant, algal, or microbial protein ingredient functionality where the stated aim is the development of nutraceuticals, bioactive peptides, or some other health-promoting ingredient.
Patents describing the development or optimisation of plant, algal, or microbial proteins, or associated processing techniques, where the stated aim was the development of a food that does not substitute animal proteins (eg, bread, pasta, snacks).
Patents describing the development or optimisation of the biochemical properties (flavour, aroma, nutritional properties, allergenicity) of plant, algal, or microbial proteins where the stated use case is not substituting animal products (meat, egg, dairy analogues).
Patents describing the development or optimisation of plant-, algal-, or microbial-based foods as medical nutrition solutions or publications on the development of alternative protein products where the stated end user is a vulnerable person (eg, children, end users with a diagnosed medical condition).
Patents describing any other technological advancements not listed in the inclusion criteria.

Data processing

To facilitate more efficient screening, duplicates were removed on the basis of Family ID with the assumption that if one member of a patent family was judged to be in scope then all other patents in the same family would also be included in later analysis. This resulted in 3,580 patent families being screened against the inclusion/exclusion criteria listed above.

Following screening, the results were sorted into four groups based on their corresponding alternative protein technology pillar:

- Plant-based meat, seafood, egg, and dairy.
- Fermentation-made proteins and ingredients.

- Cultivated meat and seafood.
- Cross-cutting patents, which incorporated results that covered more than one alternative protein pillar or which did not fit squarely into one of the previous groups.

Patent families were assigned to a technology sector (described in detail in Table 5 on page 29). Additionally, all patent families were assigned to an end-product type and where relevant were also assigned to an ingredient type.

It was found that the name given to a significant number of assignees was not consistent across all patent families in their portfolios, particularly in the case of startups that have changed their name over time, but also due to inconsistent assignee naming in the data . As a result, this issue needed to be manually fixed to ensure consistency. During this step, assignee names were also updated to reflect the most up-to-date trade name of each assignee.

Additionally, while the Dimensions platform assigns a GRID ID to most of the large public and private organisations, therefore ensuring important information relating to these organisations is captured and can be easily accessed, it was found that more than half of assignees in this data set did not have a GRID ID in Dimensions. As a result, they were not included by default in country breakdown analyses in the Dimensions Landscape & Discovery application so this data needed to be manually inputted and analysed in spreadsheet format.

Following screening and sorting of patent families, Family IDs were used to download the full dataset of all relevant patents published from 2015-2024 inclusive and blank cells were auto-filled with the relevant information on alternative protein pillar, technology sector, product and ingredient type, trade name, and country to complete the dataset for subsequent analysis.

For the respective search terms described above, 1,166 patent families were found to be in scope from a total of 3,580 screened (33%). The high number of patents judged to be outside the scope of this analysis indicated the broad depth of search returns that were triggered by the search terms used and can give us a high degree of confidence that the results presented here are relatively exhaustive, notwithstanding the caveats and limitations outlined below.

Data were then analysed using the Dimensions Landscape & Discovery application by inputting the relevant publication IDs to this platform and extracting the results. Data is correct as of January 2025.

When ranking countries on a per capita basis, figures for country populations were sourced from Statista.

Where figures are presented as a percentage, they are rounded to the nearest whole number. Figures and tables were generated in Google Sheets while network map visualisations were generated using the embedded VOSviewer application in Dimensions Landscape & Discovery.

Caveats and limitations to this analysis

Limitation	Rationale and possible implications
Patents are only one metric for measuring innovation	Patents are not the only way to protect IP and the food industry relies heavily on trade secrets, so this likely only represents a small fraction of innovation going on across the sector.
Recently filed patents are not captured	This analysis is based on published patents as they are the most reliable source of information. However, patents under examination are not captured (due to the 18-month publication delay), so this does not capture the full breadth of patents filed and is therefore an underestimate of the total.
Ongoing R&I activities are not captured	The majority of public funding for alternative proteins has only come in recent years, so this analysis likely underrepresents the volume of R&I activity currently ongoing in the public and private realm.
Data limitations	This report aims to give the reader the best understanding of the characteristics and dynamics of the European alternative protein patent landscape that is currently available. While this analysis was developed using a rigorous protocol (described in detail above), due to inevitable limitations around the use of appropriate search terms and the total number of patents available in the Dimensions.ai platform, it is likely an underestimate of the true size of the alternative protein patent landscape in Europe.
Analysis is not global in scope	This analysis aims to present a thorough overview of the European alternative protein patent landscape, including overall growth, key organisations and countries, and specific fields of innovation. This was done on the basis of patents published on topics related to alternative proteins by European organisations (defined here as those within the 27 EU member states, along with Norway, Switzerland, and the United Kingdom) during the years 2015-2024 inclusive. However, it does not capture information on patents filed in European jurisdictions by non-European assignees.

08 Appendix

Figure S1. Concept network map of the plant-based protein patent output in the years 2015-2024 inclusive. Colour coding indicates the median year when the concept appeared most in published patents, while bubble sizes indicate the number of published patents on each concept.

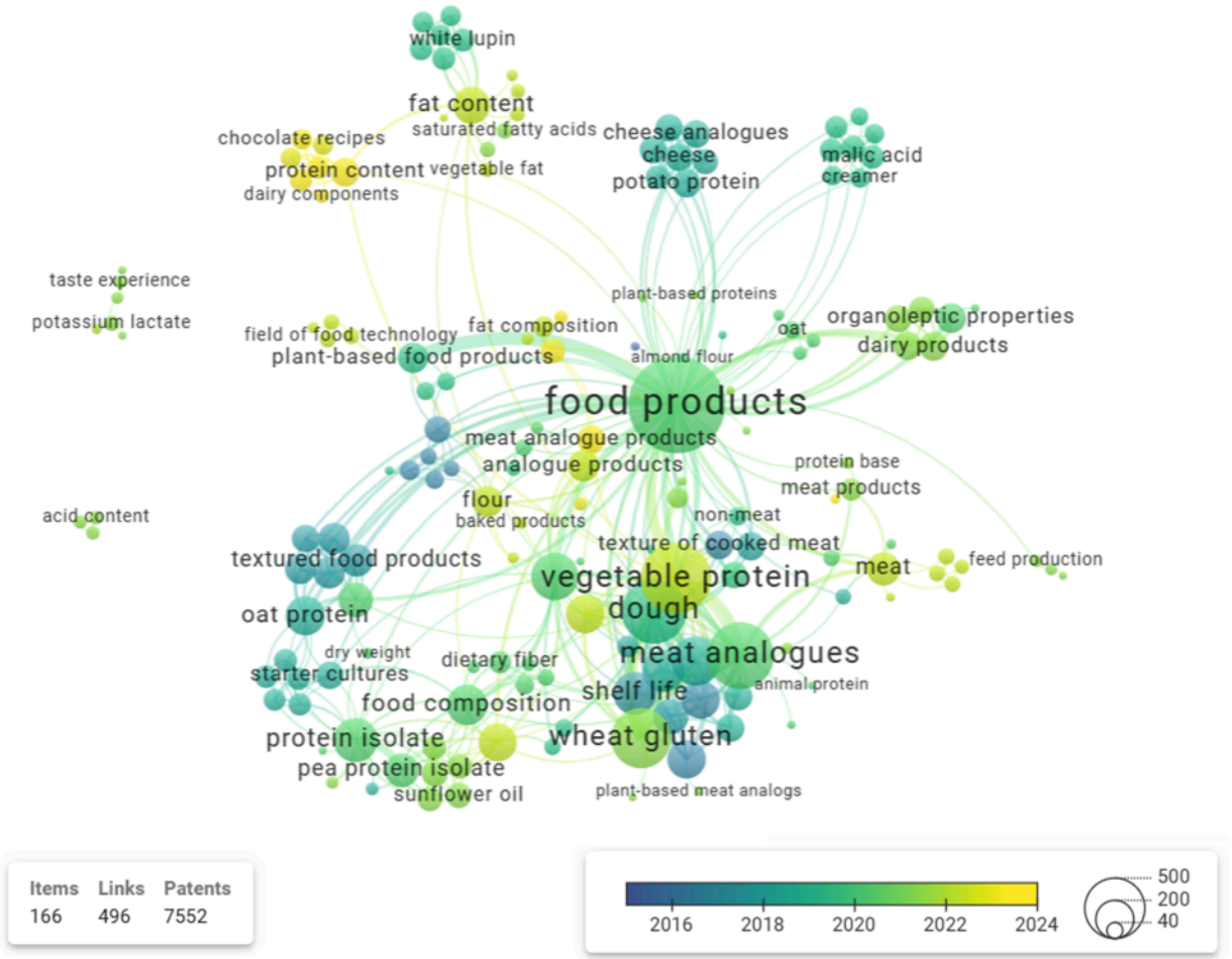

Figure S2. Concept network map of the fermentation patent output in the years 2015-2024 inclusive. Colour coding indicates the median year when the concept appeared most in published patents, while bubble sizes indicate the number of published patents on each concept.

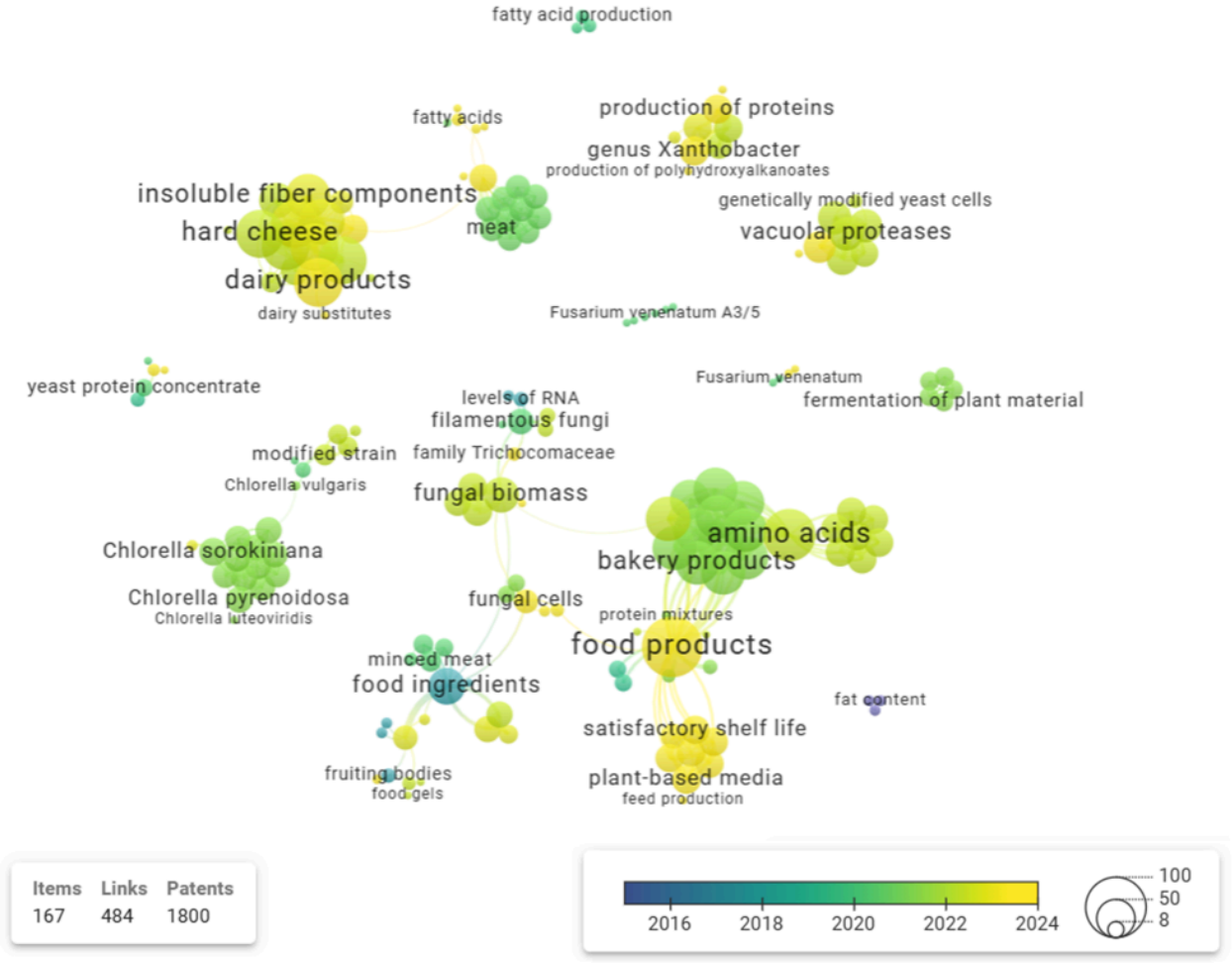

Figure S3. Concept network map of the cultivated patent output in the years 2015-2024 inclusive. Colour coding indicates the median year when the concept appeared most in published patents, while bubble sizes indicate the number of published patents on each concept.