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Prospective Cultivation Area of Field Peas Used in Animal Meat Substitutes in the EU

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ABSTRACT

Meat alternatives from leguminous raw materials are expected to play an increasing role in human nutrition. Additional global cultivation areas and additional general cultivation potential for peas as raw material for meat substitutes are projected to increase. The aim of the present study is to estimate the prospective area of peas for pea-based meat alternatives in the EU within a simple model calculation. With a consumption share of 2 % for pea-based meat alternatives in the EU, the effects on the production volume and pea cultivation area would remain relatively small. With an increased consumption share of pea-based meat alternatives of 12.5 % the pea cultivation area would rise to almost 100 % compared to the current cultivated area. By the third scenario with a consumption of 40 % pea-based meat, the cultivated area would triple. However, the additional share of the pea cultivation area in the total arable area in the EU would be only a small additional increase. Thus, increased pea cultivation would only have minor effects on competition for agricultural land. If pea-meat replaced animal meat, land used for animal feed production would become available.

Keywords: increase of cultivation area; legumes; meat alternatives; pea protein isolate.

1 Introduction

Meat alternatives from leguminous raw materials are expected to play an increasing role in human nutrition (Aiking et al., 2018; Röös et al., 2018; van der Weele et al., 2019). A main lever is the raising trend of consumers who eat meatless diets and the emerging need to develop the respective legal framework (Sochirca, 2018). A market for plant-based meat alternatives is emerging (Thakur, 2019). Seitan, tofu and tempeh are traditional plant-based meat alternatives which are complemented by textured vegetable protein in innovative plant-based meat alternatives (You et al., 2020). Increasing the availability of proteins from legumes is pursued through increased legume production at the primary production level and in food processing within the EU. Especially in organic agriculture legumes play a major role as a N-fixing crop (Schmidt et al., 2012). In order to diversify crop rotations legumes are recommended in conventional agriculture (Magrini et al., 2018). To this end EU and national policies have provided the framework for several programs and strategies offering incentives for the establishment of more legume cultivation (Kuhlmann et al., 2014). The aim of the present study is to estimate the prospective area of peas as a major European grain legume for pea meat in the EU within a simple model calculation. Thereby the study aims to answer the question if land availability could be an obstacle to the expansion of field pea cultivation. The results should give a first indication of field pea cultivation area if the consumption of pea-based meat alternatives were to increase.

2 Background and framework

2.1 Legumes as innovative food ingredient

Different private and public initiatives have started to develop innovative foods from European legumes like for example faba bean, pea, lupines, lentils and chickpeas. At the consumption level divers diets that include legumes make important contributions to healthiness (Foyer et al., 2016). The health benefits of legumes include positive effects on cholesterol levels, decrease diabetes, heart diseases, hypertension and have preventive effects on cancer (Dahl et al., 2012; Madar et al., 2002; Trinidad et al., 2010). Although there are possible challenges related to less absorption of some vitamins and low content of some essential minerals and amino acids, diet specialists recommend legume consumption (Baldwin et al., 2017). Food innovations that highlight positive health aspect and more explicit dietary guidelines are relevant steps for increasing consumption of legumes (Figuiera et al., 2019; Magrini et al., 2019). More than 3,500 new legume-based products were introduced in the European food market, particularly in the UK, France, Germany Spain and Italy in the period 2010-2014, products mainly based on chickpea (31%), pea (30%), beans (25%), lentils (14 %), of which only 13% organic (Hamann et al., 2019). In 2016, the consumption of pulses per person per year in Europe was on average 3 kg, but with large variations between countries. From 2017 to 2018, the Spanish market experienced a growth of nearly 300 % in demand for dried legume-based pasta, including organic legume-based pasta. Also, demand for lentil-pate, hummus and chips (snacks) increased by 128 % (Hamann et al., 2019). Protein flours, concentrates and isolates from legumes are used in an increasing number of innovative food products having the potential to partly replace meat and dairy products (Singhal et al. 2016). Protein meals and isolates from legumes have the potential to improve the protein content of traditional flours in the backing industry to sustain the functional properties of traditional flours with low protein contents (Turfani et al., 2017). Innovative food products also include a whole range of products based on legume protein such as vegan ice cream or vegan yoghurts (e.g. Lim et al. 2019) and beverages (Qamar et al., 2019). Also a high diversity of spreads has been and is being developed. In addition, low-carb diets depend on protein rich ingredients for which legume-based protein meals and isolates can be used. Additionally, ingredients in food supplements for sportspeople have been introduced. Direct meat and sausage imitates depend on plant based protein alternatives for which legumes function as important alternatives (Dreher et al., 2020). Some of the innovations are already in the market but constitute only small market shares. Other legume-based food products are still in the R&D pipeline with possible market potential (Murphy-Bokern et al., 2019).

2.2 EU pea market

Peas play an important role in human and animal nutrition in the EU, whereby the use for feed still dominates. Within the EU countries, the share for food and feed can be totally different. While 36 % of the national consumption of peas are used for food in Germany, it is more than 80 % in the UK (Kezeya Sepngang, 2019). According to Eurostat, pea is the second most produced grain legume in the EU with a production of 2 Mio.t, after soybeans, 2,9 Mio.t in 2018. The trend of pea production in the EU is increasing. This increased production during the last five years is partly due to the Common Agricultural Policy (CAP) implemented in 2015 that consider legumes' growing areas as ecological focus areas (Wobser, 2018). The leading producers of pea in the EU are France, Germany, Lithuania, Spain, Romania and UK. These countries represent more than 75 % of the EU production.

The EU pea market is also characterized by important foreign trade with EU-Extra and EU-Intra countries, whereby the trade balance is in surplus in the EU, with a self-sufficiency of 1.07 on average between 2014 and 2018 (Kezeya Sepngang et al., 2020). The trade within EU-intra countries dominates (see Fig 1). Spain, Germany, Belgium, Italy and the Netherlands are the main importers in the EU. The main exporters in the EU are France, Lithuania and Romania. Until 2017, India was an important market of the peas produced in the EU. The implementation of import taxes on legumes in India in 2017 is the reason of the closing of this lucrative market for food. The use of peas and other legumes for food is better valuated than for feed. Therefore, the impact of innovative companies that use protein isolate based on legumes could be seen as a lever for the market development of legumes in the EU.

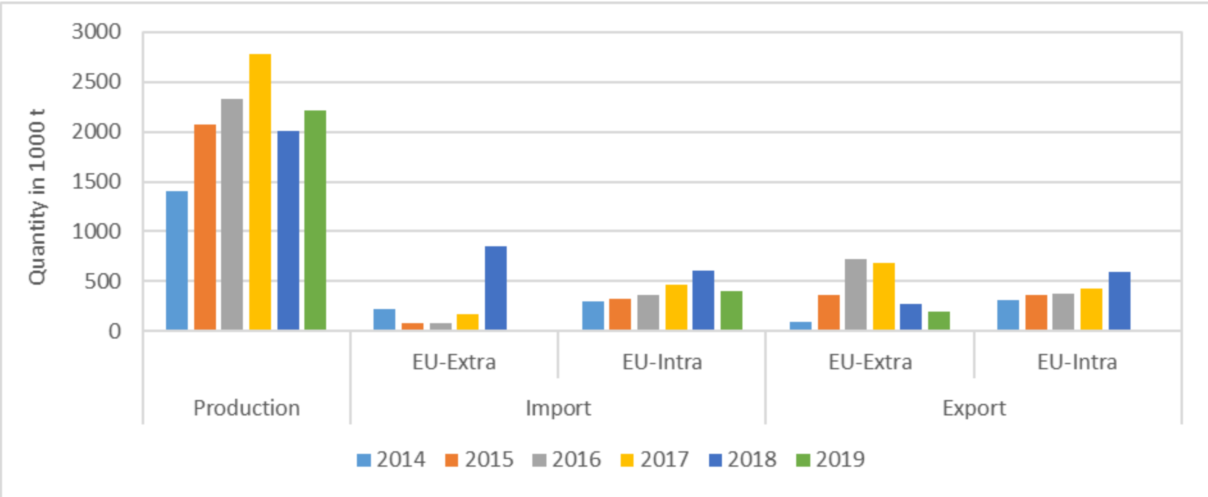

Figure 1. Production and foreign trade of field peas in the EU. Primary source: Eurostat.

2.3 Beyond Meat case study

The US based company Beyond Meat is a major innovator in pea-based meat alternatives. It has been founded as a start-up in 2009 by Ethan Brown. Brown follows the vision to reduce the negative impact on the environment that is connected to animal-based protein production by livestock. He attracted major capital investments by a number of private equity firms including Cascade Investments of Bill Gates. In May 2019 Beyond Meat sold shares at the Nasdaq, which resulted in an initial market evaluation of 1,5 billion US$, only a few days later it rose to 3,5 billion US$. Producing financial net losses until 2018, the company reported profits of 4,1 million US$ for the 3rd quarter of 2019. The turnover was expected to reach 275 million US$ in 2019 and in 2020, Beyond expects revenue in a range of $490 million to $510 million. A higher number of points of sale, more delivery channels and international customers and well as lower prices foster higher sales. The fast food industry, namely McDonald's and Kentucky Fried Chicken (KFC), partnered in September 2019 with the company (Beyond Meat, 2019c).

Beyond Meat entered the EU retail market in the UK, the Netherlands and Germany with a pea-based vegan burger patty in 2019 which is seen as accelerating the trend towards plant-based meat alternatives in the EU (Bloomberg, 2019; Reuters, 2019). Comprehensive advantages of the Beyond Meat patties over patties from US beef production were found in a life-cycle assessment by Heller et al. (2018). In the US, the company offers other pea-based meat alternatives in addition to the burger patty (Beyond Meat, 2019b). Pea protein isolate is the protein basis of the Beyond Meat burger patty (Beyond Meat, 2019a). The raw material basis for the protein isolate is assumed to be peas from the northern states of the US and from Canada (Bloomberg, 2019; Heller et al., 2018). Additional cultivation areas and additional general cultivation potential for peas are forecasted for the short to medium term (Bloomberg, 2019; Reuters, 2019). European peas may become increasingly relevant as raw materials in the future if the expected market growth evolves with a regional origin of the raw materials. This would result in additional sales potential for EU legume producers with growing cultivation areas. The French company Roquette's partnership with Beyond Meat gives an indication of the strategic supply development (Beyond Meat, 2020).

3 Data and methods

Various data sources were used to estimate the cultivation potential of peas for the production of "pea meat". In our analysis here, pea meat is defined as a plant-based animal meat alternative based on field pea protein. We assume the same ingredients for pea meat as for the Beyond Meat burger patties. To estimate future consumption shares, an expert panel was interviewed as part of the European joint project LegValue. 30 of the 42 participants in the annual project meeting answered the following question in a smartphone-based online survey, with the software Mentimeter: "What is your estimate of the percentage share of EU "vegan meat" consumption from European legumes in 2030?"

Based on per capita consumption of animal meat, consumption volumes of pea meat can be estimated. The model calculation assumes the same proportion of peas utilized for the Beyond Meat patty also for pea meat in general. In this way the amount of peas for a certain amount of pea meat can be calculated. Based on average yields of peas the required cultivation area can be derived.

Factory processing capacities of 20.000 t/year in the basic calculation can be used to derive the number of factories required to process the required quantities of protein isolate from peas. We assume that with increasing pea meat consumption companies would invest in increasing capacities even further to 30.000, 50.000 and 100.000 t/year. The required growing area per factory can again be calculated by employing pea yields.

We assume constant pea yields and constant protein content in our model although this might change with increased breeding efforts. In the calculation, plausible assumptions were made in case of unavailable data. The model calculation does not take into consideration price effects – neither on the assumed consumption on the demand side, nor on the supply side with respect to additional pea cultivation.

Table 1.
Assumed parameter values for the model calculation and respective sources

Parameter	Value	Source
(I) Weight of one burger-patty	113,5 g	*Beyond 2019a*
(II) Share of pea protein isolate in pea meat	18,0 %	*Beyond 2019a*
(III) Protein content of pea protein isolate	85,0 %	*Emsland 2015*
(IV) Protein content of peas	24,0 %	*Emsland 2015*
(V) Yearly factory production capacity pea protein isolate	20.000 t	*Assumption*
(VI) Pea cultivation area in EU	1.025.790 ha	*Eurostat for 2017*
(VII) Pea production in EU	2.782.440 t	*Eurostat for 2017*
(VIII) Average pea yield	2,7 t/ha	*Own calculation*
(IX) Animal meat consumption	64,39 kg per capita	*Eurostat for 2017*
(X) Assumed share of pea meat in total meat	2 % | 12,5 % | 40 % | 100 %	*Survey and assumption*
(XI) Population EU	511,37 million	*Eurostat for 2017*

4 Results

To estimate the future consumption shares, results of the expert survey (Tab 2) were used. Minimum (2%), median (12,5%), maximum (40%) values from the survey and the additional extreme value of 100 % were used as the basis for four scenario calculations for the EU.

Table 2.
Estimated "vegan meat" consumption as share of animal meat in the EU in 2030

Estimated shares in %	2	5	7	10	15	20	25	30	40
Frequency (from 30 answers)	2	2	1	10	6	4	2	2	1

The pea protein isolate quantity and the pea equivalent quantity per patty can be calculated based on the weight of the pea meat burger patty, the proportion of pea protein isolate in the recipe and the pea protein content in peas as well as in the pea protein isolate (Table 3). If the pea equivalent quantity per patty is set in relation to the pea yield, the necessary pea cultivation area for one pea meat burger patty is obtained.

Table 3.
Calculated parameter values set in relation to one pea patty

Parameters	Value
(XII) Quantity of pea protein isolate = [(I)*(II)/100]	20,43 g/patty
(XIII) Exploitation rate of pea protein isolate from raw peas = [(IV)/(III)*100]	28,24 %
(XIV) Equivalence quantity of raw peas per patty = [(XII)/(XIII)*100]	72,36 g/patty
(XV) Quantity share of raw pea equivalents in pea meat = [(XIV)/(I)*100]	63,75 %
(XVI) Pea area per patty = [(XIV)/((VIII)*1000000)*10000]	0,27 m^2/patty

Four scenarios are assumed for the annual consumption of pea meat with consumption shares of 2 %, 12,5 %, 40 % and 100 % of the animal meat consumption of 64 kg per capita and year in the EU. This makes it possible to estimate corresponding consumption quantities for the total population in EU (Table 3). The pea protein isolate content in the recipe and the pea protein yield can be used to calculate the required pea quantity. If this is set in relation to the pea yield, the required pea cultivation area is obtained. This can be set in relation to the previous pea cultivation area or to the total arable land of approximately 103 million ha in the EU.

Table 4.
Calculated quantity and area parameters in different consumption scenarios for pea meat

	Consumption share scenarios			
(XVII) Assumed consumption share of pea meat in total meat	2 %	12,5 %	40 %	100 %
(XVIII) Consumption quantity of pea meat in EU (kg per capita and year) = [(IX)*(XVII)]	1,29	8,05	25,76	64,39
(XIX) Total consumption quantity of pea meat in EU (1000t/year) = [(XI)*1000000*(XVIII)/1000000]	659	4.116	13.171	32.927
(XX) Required pea quantity (1000t/year) = [(XIX)*(XV)/100]	420	2.624	8.396	20.991
(XXI) Required additional pea growing area (1000ha) = [(XX)/(VIII)]	155	967	3.095	7.739
(XXII) Required additional pea growing area as share of previous pea area (%) = [(XX)/(VII)*100]	15	94	302	754
(XXIII) Total arable land EU in 1000 ha (Eurostat, 2016)	103.081	103.081	103.081	103.081
(XXIV) Share of additional pea growing area in total arable land of EU (%) = [(XXI)/(XXIII)*100]	0,15	0,94	3,00	7,51

Assuming different production capacities of factories, additional factories would be required to process peas to pea protein isolate. Assuming constant agricultural yields of 2,7 t/ha different growing areas per factory would be required. Assuming an average growing area of 5 ha peas per farm between around 5.200 farms in the lowest and more than 25.000 farms in the 100 %-consumption scenario would benefit from increased pea meat consumption.

Table 5.
Calculated factory parameters in different consumption scenarios for pea meat

	Consumption share scenarios			
(XVII) Assumed consumption share of pea meat in total meat	2 %	12,5 %	40 %	100 %
(XXV) Assumed pea protein isolate capacity per factory (1000t/year)	20	30	50	100
(XXVI) Total protein isolate in EU (1000t/year) = [(XIX)*(II)/100]	119	741	2371	5927
(XXVII) Required number of factories for EU consumption with increased capacity (number of factories) = [(XXVI)/(XXV)]	6	25	47	59
(XXVIII) Pea growing area per factory with assumed constant yields (ha/factory) = [(XXI)*1000/(XXVII)]	26.114	39.171	65.285	130.569
(XXIX) Number of 5ha-pea-growing farms (farms/factory) = [(XXVIII)/5]	5.223	7.834	13.057	26.114

5 Discussion

Potential pea growing areas within the EU based on assumptions of increased pea meat consumption have been estimated based on a simple back-of-the-envelope calculation. The quantity estimates are in the magnitude of reports in the media (Financial Times, 2019). With a consumption share of 2 % for pea meat, the effects on the production volume and pea cultivation area remain relatively small. With an increased consumption share of pea meat of 12,5 % the pea cultivation area would rise to around 94 % more compared to the current cultivated area. By the third scenario with a consumption of 40 % pea meat, the cultivated area would triple and with a full replacement of animal meat by pea meat the additional pea area would be 7,5-times larger. This increase in cultivation area of pea as legumes would be an advantage for the ecosystem, since it is known that legumes provides an enormous range of ecosystem services and enable a sustainable agriculture (Stagnari et al., 2017). Furthermore, increase of pea will be also beneficial agronomically within crop rotations for the farmers (Zander et al., 2016). However, the additional share of the pea cultivation area in the total arable area in the EU would be only a small additional increase. A successful valorization of pea as food ingredient in this way may encourage processors to look at other legumes as well. In this perspective, the area under legumes in general could increase considerably, as well as the proportion of legumes in relation to arable land.

Area requirements for additional ingredients especially plant oil have not been included in our analysis. Future analyses should consider comprehensive area requirements. Still, increased pea cultivation would only have minor effects on competition for agricultural land. Land competition would be even reduced if less land is required to produce feed for animal meat production. This land could be used for other purposes like promotion of biodiversity or for natural greenhouse gas sequestration with afforestation. Considering increased consumption of pea meat, it will be important to show the environmental compatibility of pea cultivation. This offers the opportunity for EU legume cultivation to demonstrate the public welfare-oriented ecosystem services in pea cultivation for meat alternatives. Biodiversity impacts of legume cultivation are already well known even if it still requires more research to quantify these benefits. Also, climate impacts of pea meat replacing animal meat should be conducted for the European context highlighting the contribution of pea production to the EU Green Deal policy and the "farm-to-fork-strategy".

The origin of the peas remains open with an increase of the consumption shares. With the opening of a new Beyond Meat production site in the Netherlands (Reuters, 2019) and the use of pea protein isolate as ingredient in other foods, there is the prospect that more European peas will be processed. It is unclear how the raw materials would be sourced via agricultural collection trade and stages of processing, especially the production of pea protein isolate. This requires the establishment and analysis of corresponding value chains especially the institutional arrangements in how farmers are included in value-chains. Contractual arrangements of farmer supply relations are still heavily characterized by private information. More transparent supply chain arrangements are required to develop a broad supply basis and allow more farmers to participate in lucrative pea markets for food production. For this purpose better market information systems for legumes are required. Also, agricultural extension services should put a stronger focus on legume cultivation to support farmers endeavoring into these new crops. Breeders should offer new legume varieties optimized for utilization in protein isolate production.

The calculation of required factories for processing shows the potential for a decentralized development of the pea meat raw material market even if factory capacities continue to increase. It would be possible to establish factories in several regions favorable for pea cultivation. No systematic overview of pea processing factories is available. Basic internet searches and expert knowledge indicate that there is already a factory of Emsland Group located in Germany (Emsland, 2020), of Cosucra in Belgium (FoodBev Media, 2018) as well as in Denmark (RTBF, 2019) and of Roquette in France (Roquette, 2020). Also, in other parts of the world companies have invested in the production of pea protein like Nutri-Pea (Companylisting, 2020) and AGT (AGT, 2020) in Canada. Besides this, Chinese companies are investing in pea processing facilities (Orientalprotein, 2020). *In the past, China processed dry peas to extract the starch for noddle production and exported the pea protein isolate to the USA. It is unclear if this trade still taking place today as China has important demand for food and because of the trade conflict between China and USA started in 2018.* This dynamic in investment activities may indicate a private sector expectation of growing pea protein demand.

It is questionable if a focus on supply side legume policies will facilitate innovative food products from European legumes. Innovation is a key to support food systems transformation and private food system actors are key to innovations. Actors have to ensure that innovations operate within natural resource boundaries and diminish climate change impact. Pea meat has the potential to reduce animal based food consumption inflicted with sustainability issues. In this regard, system approaches based on agroecological principles are needed on a pathway to enable sustainable intensification of food production and consumption, not only for organic food production, but also making the conventional sector more sustainable. Legume expansion will need to integrate and cross-link activities in a multi-stakeholder approach with different initiatives and projects in order to develop synergies and increase joint impact on food systems. To operationalize the innovation potential of different research and innovation activities, research results have to be presented and discussed with different food system actors in a multi-stakeholder approach to validate the practical implications of legume related research. Research results should be used by food system actors to promote and to nudge more diverse, sustainable food choices thus diversifying food systems from field to plate.

Basic consumer studies have been conducted with regard to traditional grain legumes but these studies have not taken into account the recent development in innovative food products from legumes like those of pea meat. Owing to the novelty of legume-based food products there is a dearth of empirical studies looking at the socio-demographic and psychographic factors of consumers that influence food choices related to innovative food products from European legumes. Neither has it been analyzed in how far sustainability considerations of consumers impact on their food choices related to European legume food products and in how far organic labelling interacts with legume-based food products. There is also a lack of understanding how sensory aspects, visual stimuli, informational aspects and the shopping context impact on food choices related to food products from legumes. Therefore, a better understanding of consumer choices regarding the consumption of innovatively processed plant-based protein foods from legumes is required.

Currently still high prices and the limited willingness to pay of the consumers constitute a negative factor that affect the demand of such new products. According to Kezeya Sepngang et al. (2020) the increasing awareness of consumers to eat sustainably will increase the demand of plant based protein products and supply of plant protein isolate. This will lead to a lower costs of these products. Increasing price competition will also lead to lower prices as markets mature. Price effects on the supply side as well as on the demand side should be considered in future studies to extend our framework only considering basic potentials to an estimation of possible future scenarios. Our very basic calculation can only give a very loose space of possibilities, which only shows that major increases in plant-based meat substitutes would dramatically ease up the competition for land. More realistic estimations considering price effects – especially land prices – should qualify our first estimations here.

In order to engage consumers in the transition towards more sustainable food systems based on higher shares of plant proteins from legumes, new insights and an in-depth understanding are required with regard to factors actually driving consumers' purchasing practices, cultural and sensorial priorities, preparation methods, informational perception and their attitude towards alternative legume based foods. In a multi-stakeholder approach a better understanding of these factors will help food system actors to better target their marketing strategies towards the needs and preferences of consumers. Implementing appropriate nudges will help to align stated preferences of consumers with their actual food selection decisions. In this way increased diversity of legume based diets will lead to more diverse food systems.

6 Conclusion

The results of this study provide scientific support for policy actors in different areas of topics. By gaining a profound and in-depth understanding of potential pea growing areas robust policies at the European and national level can be designed by policy makers. The new insights can be used to develop informational strategies for the promotion of more diverse legume-based food products that will constitute an important element towards a transition to diverse food systems. Based on the results of this study, food system actors can develop strategies to further research, develop and promote plant-based proteins in different foods. This applies for all stages of the supply chains where at the farm level sustainability aspects can be addressed which are most relevant for consumers. Also, legume plant breeders can benefit by having a sound basis for investment in legume breeding, often neglected in recent years. Considering the main uses of peas for starch and protein, breeders have started to re-emphasis breeding efforts for protein content. The assumption regarding protein content in our calculation is rather optimistic and has not consistently been achieved in the last years. Food processors can benefit from having knowledge of supply planning by developing products that suit consumers. Different retailers can better target consumers to foster more sustainable diets by fostering collaboration with farmers and processors. Projects and initiatives involved in the promotion of legume cultivation and legume processing benefit from a better understanding of legume-based food products as they can direct their efforts towards meeting consumers' preference. Farm networks are highly interested in the results of the drivers and barriers of legume-based products.

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