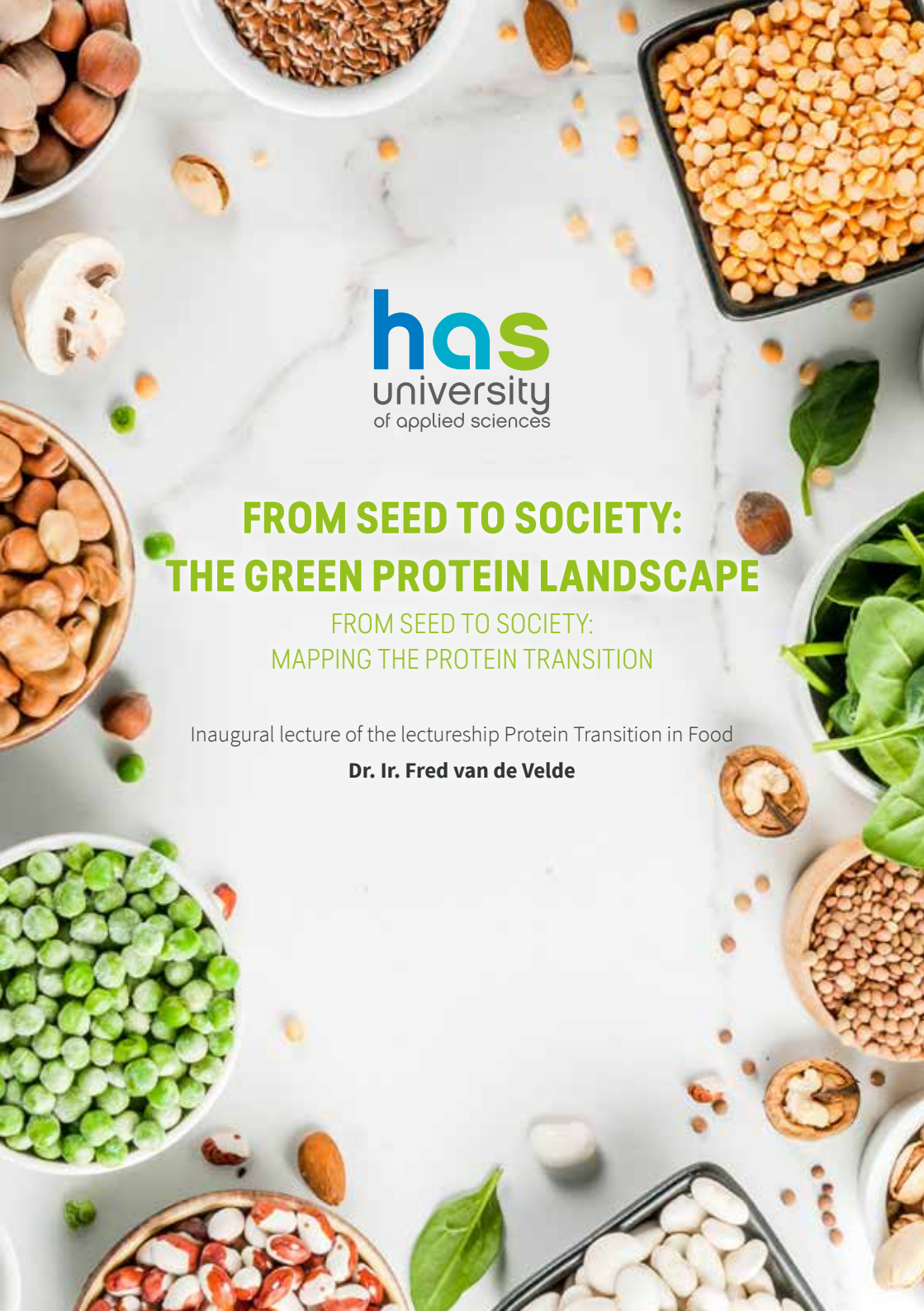

has university of applied sciences

FROM SEED TO SOCIETY: THE GREEN PROTEIN LANDSCAPE

FROM SEED TO SOCIETY: MAPPING THE PROTEIN TRANSITION

Inaugural lecture of the lectureship Protein Transition in Food

Dr. Ir. Fred van de Velde

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CONTENT

INTRODUCTION

According to current predictions, the world's population will grow to almost 10 billion by 2050.[1] What you may not know is that there is nothing new about this prediction. In 1798, Thomas Robert Malthus (1766 - 1834) published the pamphlet 'An Essay on the Principle of Population'.[2] He predicted that the population would grow exponentially, while increases in food production would be linear.

Parallel to global population growth, the average standard of living is also increasing. Together this results in a major increase in the demand for proteins and protein-rich products. If we want to carry on feeding the global population, we will need to produce around 60 to 70 % more food by 2050 (Figure 1). Producing this food using the current balance between plant-based and animal-based proteins is not a realistic option. Hence, not only more food needs to be produced, but there will also have to be a shift from the consumption of animal-based proteins towards plant-based proteins.

Figure 1. Influence of global population growth on food production (Infographic source: FAO)

LECTURESHIP PROTEIN TRANSITION IN FOOD

The protein transition is the transition from the use of animal proteins to plant proteins. In addition to the increasing global population and prosperity, sustainability and animal welfare are important drivers for this transition. This definition of protein transition also defines the boundaries of the lectureship. We are working on the protein transition from animal proteins towards plant proteins. Research into the use of insects as an alternative source of protein is therefore out of scope. Insects do admittedly have a high food conversion efficiency, but they are part of the animal kingdom, so insect consumption does not contribute to the protein transition away from animal proteins.

The protein transition is the transition from the use of animal proteins to plant proteins.

The second boundary is implied by the addition of 'in food', indicating the focus of my lectureship. Within my lectureship we are focussing on the application of plant proteins in food for humans and not on the application of alternative or plant proteins in food for animals. Finally, we are focussing on the full range of protein transition in food, i.e. on replacing animal proteins, such as those from milk, eggs and meat.

THE HISTORICAL PERSPECTIVE

In the Netherlands, the Green Protein Alliance is working to shift the balance between plant-based and animal-based proteins. The objective is to have achieved a balance between plant-based and animal-based proteins by 2025, i.e. 50 % plant-based and 50% animal-based proteins in the average diet in the Netherlands.[3] To put the GPA's objective into perspective, the current balance between plant and animal proteins is 35:65 (Figure 2). This is based on data from the RIVM's Food Consumption Survey (in Dutch, the National Institute for Public Health & Environment, Voedsel Consumptie Peiling, VCP) conducted on those aged 7-69 in 2007-2010 and on older people in 2010-2012.[4-6]

Currently the RIVM are analysing the data from a new Food Consumption Survey (2012-2016). A report on these data was published at the end of 2018.[7]

However, the balance between plant and animal protein has not always been so uneven. Around 1965 the balance was still equal.[8] Within the period of 25 years, this balance has shifted from 50:50 to 35:65. This is why the Green Protein Alliance's objective is so ambitious because there are only 13 years to restore this balance (calculated from the last consumer survey in 2012). The next step towards achieving the recommended balance of 60 % plant-based proteins and 40 % animal proteins will undoubtedly be equally ambitious.

Fortunately the market trends are positive. For instance, since 2011 there has been a sevenfold increase in the number of new products claiming to be plant-based, such as meat substitutes and alternatives for milk.[9] Another example are the sales figures: in 2017, Dutch supermarkets sold 1.6 % less meat and 1.3 % less dairy compared to 2016.[10] In spite of these positive results, the protein transition remains an extremely ambitious goal.

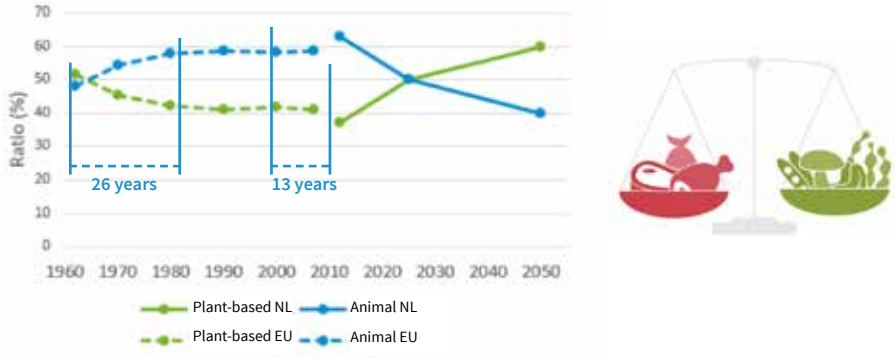
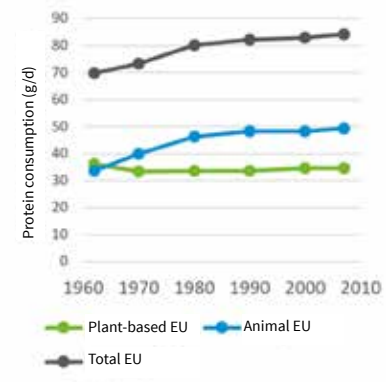


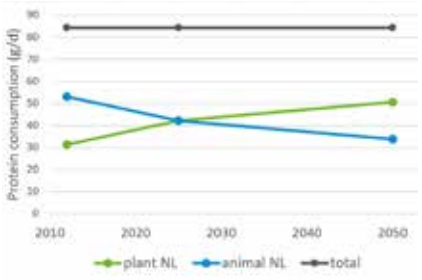
Figure 2. Historical trends in the balance between plant-based and animal proteins.

AMBITION AND REALITY

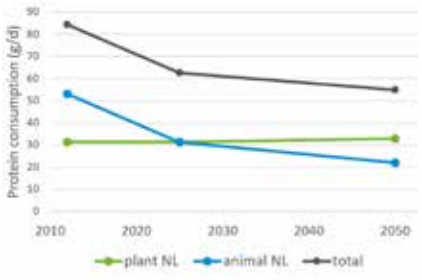
Until now I have talked about the protein transition in terms of ratios and balance, but as a scientist, I prefer to work with absolute numbers. On average, people in the Netherlands eat 31 g of plant protein and 53 g animal protein per day.[4] Although absolute protein consumption is different for men and women, the ratio between plant and animal proteins is equal: 35:65. To turn this balance around to 60 % plant and 40 % animal protein, we will have to eat an extra 20 g of plant protein and 20 g less animal proteins per day. To give you an idea, 20 g of plant protein is the equivalent of 1 kg of lettuce; rather a lot of lettuce to eat every day. Taking into account the historical trends in the consumption of animal and plant proteins (Figure 3), today I would like to set the figure for a realistic objective for the protein transition at **10g plant protein per day.**



If we plot a graph of absolute protein consumption in the past 50 years, rather than looking at the shifting balance between plant and animal protein consumption, it is obvious that the balance has shifted due to increased consumption of animal proteins.



The shift of 20 g per day from animal to plant protein I mentioned earlier is applicable if protein consumption remains at the current level of 84 g/day.



However, the amount of protein recommended by the Dutch Health Council amounts to around 55 grams of protein per day (for an average person weighing 62 - 75 kg). The recommended quantity of protein per kg of body weight differs for specific segments of the population.[11] The recommended average protein intake of 55 g/day is considerably lower than the current consumption of 84 g/day. If protein transition is not only focussed on shifting the balance, but also on overall reduction of protein consumption, then a reduction in animal protein consumption is enough to achieve both objectives.

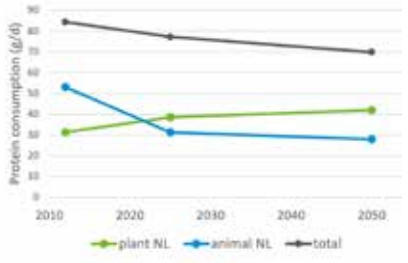


Figure 3. Trends in protein consumption over time for A. Historical perspective; B. Forecast if protein consumption remains the same; C. Forecast if total protein consumption is reduced to the level advised by the Dutch Health Council; D. Forecast if total protein consumption is reduced to 1960's level.

However, I do not expect protein consumption to reduce so drastically in the near future. That is why it is more realistic to focus on a gradual reduction of protein consumption to the 1965 level. In that case, an increase of 10 g of plant protein per day would be sufficient to achieve the objective. And that is why today I would like to set the figure for a realistic objective for the protein transition at **10g plant protein per day**. If we keep protein consumption at the current level, we will have to have achieved this by 2025 or we can do so by reducing total protein consumption in 2050. The choice is yours.

LECTTUCE, BEANS OR OTHER PRODUCTS

One way of achieving this extra 10g of plant-based protein per day is to eat half a kilo of lettuce per day, but that is certainly not the only method. Many products rich in plant-based proteins can play a role in restoring the balance. Roughly, we can divide these into three groups:

- Protein-rich plant-based products,
- Minimally-processed protein-rich plant-based products,
- Products based on plant protein ingredients,

The first option is to eat plant-based products that are rich in proteins, such as beans, rice and nuts. This is the most sustainable solution because these products have undergone almost no processing.

Another option is to consume minimally processed products, such as vegetable-based burgers (bean burgers, lentil burgers), plant-based drinks or products, such as tofu. These products are minimally- processed plant-based products, but they do open up new possibilities for increasing the amount of plant protein in the diet.

The third category is to use plant protein ingredients (e.g. protein isolates or protein concentrates) to produce a whole range of plant-based products, such as substitutes for meat and dairy. Another advantage of using plant protein ingredients is the fact that these ingredients can be obtained from sources or side streams that cannot be eaten by humans. These three groups of plant-based products require different levels of processing. Moreover, these groups appeal to different consumers.

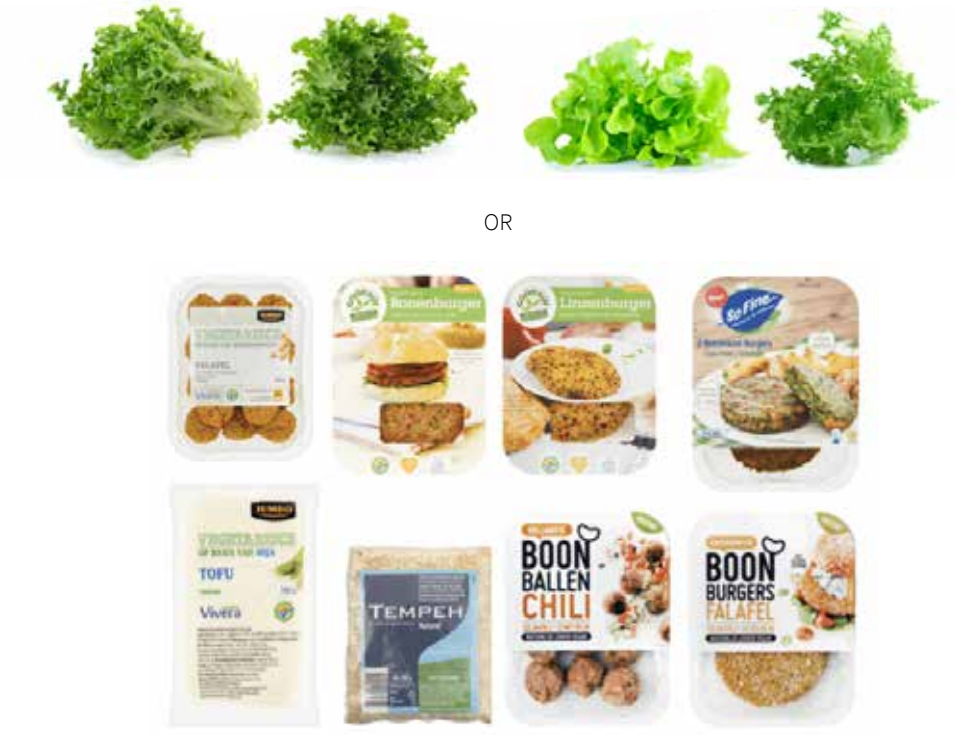


Figure 4. Different products to help add an extra 10 g/day of plant-based protein.

THE BALANCE BETWEEN TECHNOLOGY AND THE CONSUMER

As I have already mentioned, products with different degrees of processing appeal to different groups of consumers. This is the balance between technology on one side and the consumer on the other. In my lectureship I would also like to keep a balance between technology and the consumer by conducting research into both aspects of the protein transition. Both elements are essential for a successful transition. On the one hand we need appealing plant-based products which in turn need new and/or improved ingredients. On the other hand, the consumer has to be prepared to make that move.

On the technology side, we want to focus on developing new sources of plant protein. This requires a deep understanding of the functionality of these proteins, based on the molecular properties of the various forms of protein. Here the focus is on understanding the functionality of proteins to allow the replacement of dairy, egg and meat proteins. On the consumer side of the equation we want to focus on identifying the most important motivations for eating plant-based products. The methods we intend to use for this include how plant-based products are positioned in shops, developing new categories of plant-based products and using absolute methods for measuring consumer preference. The latter is necessary because if consumers respond with socially desirable answers, it will have a major impact on research into the consumption of plant-based products.

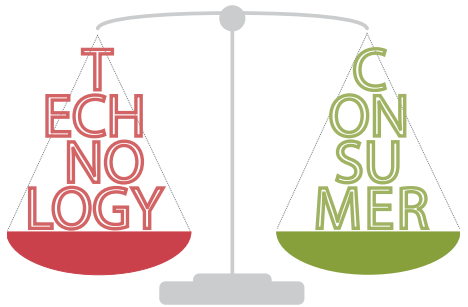


Figure 5. The Protein Transition in Food Expertise & Research Centre: balancing Technology and the Consumer.

SELECTING NEW SOURCES

I have been talking for some time about plant proteins, but which plant proteins are we talking about? Figure 6 shows an overview of various sources that can be used for producing plant protein ingredients.[12] Purified plant protein ingredients have been used in foods for several decades. Plant protein ingredients, such as concentrates and isolates (with a protein content varying from 50 to 90 %) from wheat, soya, rice, maize, potato and peas are well-known and used in foods. These are the sources of protein from the first category, the so-called established sources. The second generation of plant protein ingredients is currently emerging with the development and introduction of protein concentrates and isolates of canola (rapeseed), duckweed and legumes, such as chickpeas, faba beans (fava or broad beans) and lentils. The last category are the upcoming sources of protein ingredients that are still in their infancy, thus there are few ingredients commercially available. Examples of the latter category are proteins from green leaves or seaweed, from pressed cakes from sources such as flax and sunflower seeds, but also from algae and nuts.

With such a wide range of sources available, choosing the correct crop to focus on is a complex process.

With such a wide range of sources available, choosing the correct crop to focus on is a complex process. Currently, many plant proteins are still produced as a by-product of the production of starches, such as pea, potato and wheat. Due to the increasing demand for plant proteins there will be a growing interest in protein yields and the functionality of the protein ingredient produced. Choosing the correct crop as the protein source of the future depends on several different parameters, such as land use, water use, use of pesticides, fertilisers, transport and its impact on biodiversity.

One relatively simple parameter is land use. This can also be expressed as the protein yield per hectare. In the Dutch and European climate, legumes such as the faba bean, pea and lupin show favourable results.[13] Yields from the faba bean are particularly high with almost 2 tons of protein per hectare. In the longer term, aquatic plants such as duckweed (or water lentils) have also been mentioned. They have great potential because they can produce yields of up to 7 tons per hectare. There is one condition for this, namely that these crops have to be capable of being cultivated all year round, which is not yet possible in the Netherlands in the open field. Another advantage of aquatic plants is that they can be cultivated in basins that do not require arable land. However, as far as the near future is concerned, our focus is on land-based agricultural crops.

Figure 6. Various sources from which plant-based protein can be extracted. Photos taken by Sanjay Acharya, Shimei Barger, Kristina D.C. Hoeppner, Luis Molinero, Mirjam van de Velde and others.

PULSE PROJECT

One of the signature parts of the 'Technology' side of my lectureship is the PULSE project. PULSE is funded for four years under the Netherlands Taskforce for Applied Research's RAAK-PRO award programme. PULSE is the acronym for Protein Utilisation from Legumes for a Sustainable European crop, focussing on the development of high quality protein from legumes. Within the legume family, the project focusses particularly on peas and faba beans, because these grow perfectly well in the climate of the Netherlands and North-west Europe. The consortium is a collaboration between HAS University of Applied Sciences and NIZO together with six companies: Limagrain, GEA, Cosucra, MFH Pulses, Ruitenberg Ingredients and Sofine Foods. The consortium partners represent the entire supply chain from seed to consumer products.

The acronym PULSE is an exact description of the project's focus: to achieve an improvement in all links in the protein production supply chain. All the companies involved have their own position within the chain. The following subjects are being studied in four working areas:

- Sustainability throughout the supply chain, with the aid of lifecycle analysis
- Seed selection and plant breeding
- Protein extraction
- Application and functionality in various foods

Customer requirements for vegetarian products are being collected and processed by food producers and will eventually result in the information needed for seed selection. Improvements therefore spread across the entire supply chain, from what is required from the actual product that the consumer will buy, via extraction to the selection of seeds, i.e. selecting those seeds that produce the proteins needed to achieve the correct texture or functionality in the final product. We are going to improve on this functionality and focus on sources of protein for applications in high value-added products. Not only do the companies involved in this project cover the entire supply chain, but the whole range of study programmes at HAS are also involved. Five study programmes are taking part in this project, across the whole supply chain: Applied Biology, Horticulture & Agriculture, Environmental Studies, Food Technology and Food Innovation.

We are going to improve on this functionality and focus on sources of protein for applications in high value-added products.

Students play an important role in carrying out this project. One example of this is the development of a cream liqueur based on a pea protein, described in the 'Applied or fundamental research' box. However, studying the stability of emulsions in the presence of alcohol is not the only thing being studied about the functionality of these proteins. To improve our insight into the molecular properties determining the functionality of proteins in foods, we determined the protein composition of peas and faba beans with HPLC and SDS-PAGE. HPLC (High Performance Liquid Chromatography) is an analytic technique separating the different proteins present in a protein isolate according to the proteins' hydrophobic properties. SDS-PAGE (Sodium Dodecyl Sulfate PolyAcrylamide Gel Electrophoresis) separates these proteins according to their molecular mass or size. By combining the results of these techniques with data on the composition of proteins from databases of genetic information, we were able to identify the different classes of proteins in faba beans. The following step is to link this to the functionality of these classes of protein in different foods.

Applied Biology

Horticulture & Business Management

Environmental Studies

Food Technology

Food Innovation

Breeding → SEED → Agriculture → CROP → Harvest → SEEDS → Extraction → PROTEIN → Process → FOOD

Limagrain from earth to life

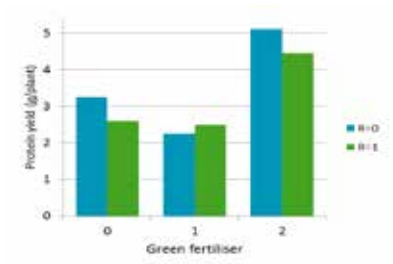
mfh pulses

GEA

cosucra From seed to food. Naturally

RUITENBERG INNOVATION AS MAIN INGREDIENT

SoFine Foods



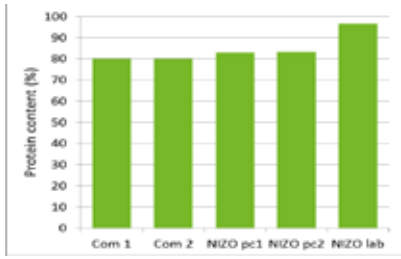


Figure 7. The PULSE project with businesses and training throughout the entire supply chain, from seed to consumer.

APPLIED OR FUNDAMENTAL RESEARCH

Within the PULSE project, we perform research throughout the entire supply chain from seed to food product. At the end of this supply chain, the functionality of plant proteins in the food product is of key importance. Together with the nutritional value (determined by the quantity of essential amino acids in the protein and its absorption) and the flavour and taste, the applicability of a protein ingredient is determined by its technical functionality, i.e. those properties that make it possible to use the protein in a food product. Examples of technical functionalities include solubility, gel formation, foam formation and emulsification properties. A less well-known and less frequently studied property is the stability of proteins and/or protein products in the presence of alcohol.

Measuring functional properties is a good example for explaining the difference between applied and fundamental research. Fundamental research into the stability of proteins in alcohol is usually carried out using milk proteins, producing an average of 10 scientific publications per year in recent years. To name a few: 'Characterisation of alcohol-containing dairy emulsions: pseudo-ternary phase diagrams of sodium caseinate solution-oil-ethanol systems'; 'Some aspects of the ethanol stability of red deer milk (Cervus elaphus hispanicus): a comparison with other dairy species'; 'Fortification of milk protein content with different dairy protein powders alters its compositional, rennet gelation, heat stability and ethanol stability characteristics'.[14-16]

Applied research focusses not on writing scientific publications, but on developing expertise that can be applied in practice.

Applied research focusses not on writing scientific publications, but on developing expertise that can be applied in practice. An example of this is the Specialisation Assignment (part of the fourth year of the Food Technology study programme) carried out by Elise van der Laan, Saskia Horde, Sjanien Groenenboom and Lynn Martens within the PULSE project. The assignment's objective was: to develop one or more products based on pea protein isolate in which one or more of its technical functionalities are essential for the texture of the final product. Firstly they carried out market research, looking for specific vegetarian or vegan products that met consumer demands. Thereafter, the list of desired products was compared with the various technical functionalities of pea protein isolate. Based on this information, they developed the concept 'Products of Nature', with two products: 'Nature's Kisses' and 'Nature's Liqueur'. The foaming properties of pea protein were central to Nature's Kisses. They studied factors, including the effects of pH, sugar content and stabilisers on foam formation and foam stability. For Nature's Liqueur, multiple pea protein properties play a role: emulsifying properties are needed to homogenise the fat in the cream liqueur; alcohol stability is important, because both the protein and the protein-stabilised fat globules have to be stable in the presence of the alcohol in the liqueur; heat stability because the final product need to pasteurised to guarantee shelf life stability. All these properties of pea protein were investigated and although no scientific paper was published, the student developed good tasting products. With their pea protein-based concept Nature's Products, Elise, Saskia, Sjanien and Lynn won first prize in the Circular Challenge during the HAS Food Experience 2018 and third prize in the national Ecotrophelia 2018.

Figure 8. Elise van der Laan, Saskia Horde, Sjanien Groenenboom and Lynn Martens developed 'Nature's Products Liqueur', a pea protein-based vegan 'cream' liqueur.

WHAT DO CONSUMERS EAT?

On the 'Consumer' side of the lectureship, we focus on the consumer and consumer behaviour in relationship to the protein transition. In order to understand this behaviour we go back to the daily consumption of proteins. In the 'Ambition and reality' section, I set a realistic target of **10 g of plant protein per day**. Looking carefully at the relevant graph, you will see that this also means at least 10 g less animal protein per day. If we want to make this shift possible, it makea sense to know which animal proteins make the greatest contribution to the current 63 g of animal protein per day.

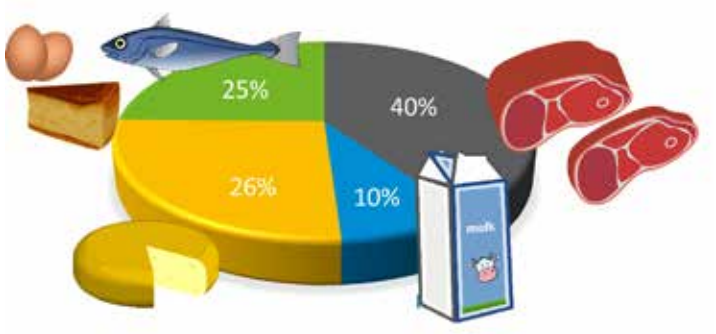


Figure 9. Contribution of meat, milk, cheese and other animal proteins to the daily consumption of 63 g of animal protein per day.

With an annual consumption of 77 kg of meat (carcase weight[17]), meat, meat products and meat proteins contribute most (40 %) to the consumption of animal proteins (Figure 9). Even though the Dutch population drinks a lot of milk, with a consumption of almost 50 L of milk per year,[18] its contribution to animal protein consumption is less than 10 %. Because cheese has a higher protein content than milk, consumption of cheese (21 kg/year18) makes up over 25 % of our daily animal protein consumption. The remaining 25 % is made up of fish, eggs and animal proteins in other products, such as cakes.

Now that we know that meat is the greatest contributor to the consumption of animal proteins, the next question is whether replacing meat is the best or easiest route. In a thought experiment, I investigated what the contribution of various replacements would have on the daily intake (Table 1). For meat, I have assumed that one portion of meat per person per week should be feasible. This contributes 3 g of animal protein per day. For milk, I think that adding plant protein, such as that from peas or oats is a relatively simple method to make a change. I expect the a replacement of 50 % of the proteins in milk by plant proteins is possible without any great impact on the flavour. However, due to the low protein content in milk, this makes a difference of 2.3 g protein per day. A similar hybrid product can be developed for cheese. However, this is a much greater technical challenge and the top limit for replacing milk protein with plant protein will be a maximum of 30 %. Nevertheless, eating a hybrid cheese with 30 % plant-based protein would already make a greater contribution to the protein transition than replacing one portion of meat per week. Please, note that these three replacements taken together are not yet enough to achieve the target of 10 g of protein per day.

With an annual consumption of 77 kg of meat, meat, meat products and meat proteins contribute most (40 %) to the consumption of animal proteins

The thought experiment clearly shows that the goal of 10 g of protein per day cannot be achieved by one product and that we need a wide range of new products to tempt the consumer to contribute to the protein transition.

Table 1. The contribution of various products to the consumption of animal protein.

PRODUCT	CONSUMPTION	ANIMAL PROTEIN	REPLACEMENT	REPLACEMENT
Meat	77 kg/year	21.0 g/day	1 portion/week	3.0 g/day
Milk	49 L/year	13.8 g/day	50 % protein	2.3 g/day
Cheese	21 kg/year	4.6 g/day	30 % protein	4.1 g/day

WHICH PRODUCT FOR THE CONSUMER?

If we look at the table in the previous paragraph, hybrid cheese products have a great potential for contributing to the protein transition. Hybrid meat products also provide the same possibilities as hybrid dairy products. Does that mean hybrid products are the answer to the protein transition? From a technological standpoint, they are, but from the point of view of the consumer, the answer is far more complicated. Examples from the past demonstrate that consumer acceptance of such hybrid products is a thorny issue. Product introductions in the past have often been unsuccessful. If hybrid products are not acceptable to the consumer, should the industry go in search of the best vegetarian/vegan burger? And is the solution cultured meat or 'clean meat' grown in a petri dish or reactor? Or will the industry carry on searching for meat substitutes with the texture of beef? This could be achieved, for example, by using shear cell technology.[19] It is already possible to produce pieces of meat weighing a few kilos using this technology. Hybrid products, cultured meat and shear cell meat substitutes can all be perceived by consumers as products that are too highly processed.

Is the solution cultured meat or 'clean meat' grown in a petri dish or reactor?

Figure 10. Cultured meat.

Looking from this angle, burgers or other products made from beans, chickpeas or faba beans are far closer to their raw materials. Does that make these products more attractive in the eyes of the consumer? Following this thought process, eating crops with high protein contents makes the greatest direct contribution to the protein transition. Think, for example, about eating pulses, cereals, nuts and also mushrooms. Or could plant-based beverages made from these raw materials be a solution? Whereas soya-based beverages (also known as soya milk) were for a long time the only alternative to dairy, nowadays the range on supermarket shelves has expanded to include beverages based on almonds, rice, oats, cashews and combinations thereof. To gain more insight into these products, at NIZO food research, we have studied the sensory profile of several of these products.[20] Apparently major differences in the taste and mouthfeel of these products can be observed.[20] In particular, there are large variations in the mouthfeel astringency. Astringency is the dry, tightening, puckering sensation known from black tea and red wine. If the composition of these plant-based beverages is taken into account, it becomes clear that astringency is strongly related to the protein content of the drinks (Figure 11). Drinks with a low astringency score usually have a high score for creaminess, a property that is strongly related to a high sugar and fat content. If we look closely at the composition of these drinks, some appear more suitable as alternatives to soft drinks than as a nutritionally complete alternative to milk.

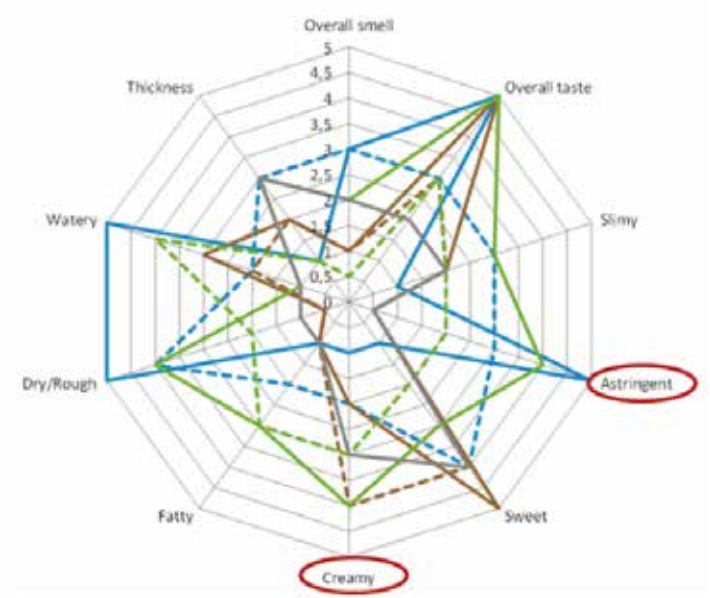
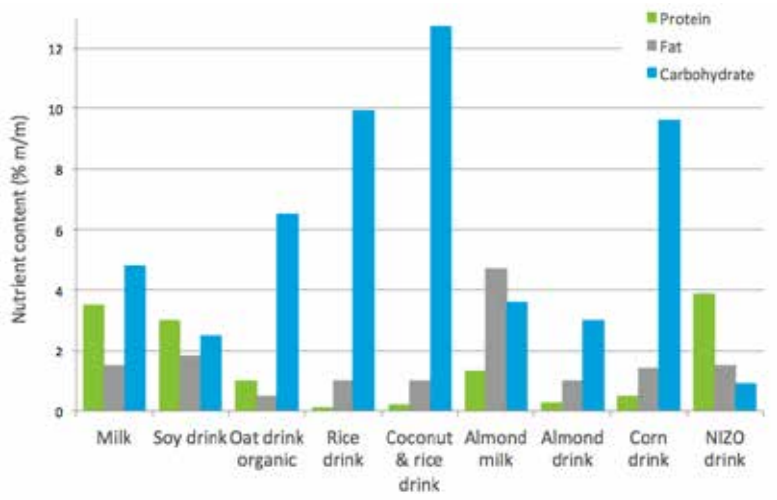


Figure 11. Sensory profile and composition of various plant-based drinks.



THE CONSUMER AND THE PROTEIN TRANSITION: A NEW PROJECT

The discussion in the previous paragraph reflects points that have been raised during a number of discussion sessions. In various sessions it has become obvious that there is no clear understanding of the consumer. Consumers can be divided into different groups, each with their own desires and motivations. For example, there are vegans, vegetarians, flexitarians, uninformed consumers and die-hard meat-eaters. In addition, let us not forget that the protein transition is not only about meat, but about the complete range of animal proteins, hence also proteins from milk and eggs. The important thing to ask is, what is needed to tempt or convince the customer to adopt more plant-based proteins in their day-to-day dietary habits? How can we make great strides in the shift from animal-based to plant-based proteins? This is the base for developing a research project focussing on the role of the consumer in the protein transition from animal to plant proteins. This will be a major guiding principle within the Consumer side of the lecutreship. This research will contribute to a greater understanding of the consumer and their role in the protein transition. We intend to focus on aspects including the following topics:

- Dietary habits of various groups of consumers,
- Acceptance of hybrid products,
- Objective testing of consumer preferences,
- Effectiveness of influencing consumers,
- Positioning of plant-based products.

A NEW FIELD

I have now described two of the focus areas of my lecureship. With a project in each of these focus areas, this provides a certain degree of balance in the lectureship. That brings us to the next question: do these two focus areas describe the entire field? Recently, Becel launched a series of plant-based beverages with the slogan: 'Plants are the new cows'. With a landscape designer, my wife Mirjam, and a protein expert, myself, in the house, it didn't take long for the discussion to arise around the dinner table: if plants are the new cows, what are the new fields? What will the Dutch landscape look like if there are no more cows in the fields, replaced by protein-rich arable crops? This brings us back to the choice of the new sources of protein. We can base our decision on the protein yield per hectare, but also on the impact these crops have on the landscape. For instance, legumes are attractive in the spring and/or summer while they are in

flower, but as they ripen in the autumn, they present a completely different picture. Maize is an extremely tall crop that remains in the field, dominating the landscape. But if algae are the future of plant-based proteins, cows will be replaced by algal bioreactors in fields, giving them an industrial appearance.[21] In contrast, orchards of nut trees open up the view. An orchard also fits neatly within the principle of food forests and double cropping. During the minor 'Landscape occupation' and in collaboration with the Municipality of Oss, a first step has been taken in the past year to survey the impact of the protein transition on the occupation of space within the municipality.

If plants are the new cows, what are the new fields?

Figure 12. The new field: cultivation of protein-rich crops.

Figure 13. Impression of the different protein crops per province. Photos taken by Sanjay Acharya, Shimei Barger, Kristina D.C. Hoeppner, Luis Molinero, Mirjam van de Velde and others.

PROTEIN TRANSITION IN FOOD: THE AMBITION

shift from the consumption of animal protein to the consumption of plant protein. I am not going to do this by focussing on a 50:50 balance in 2025 or a 60:40 balance in 2050. No, I am making it concrete and saying: **"eat 10 grams more plant protein per person per day".** This ambition is not based upon the balance between technology and the consumer, but based on the tripod of Consumer – Technology – Landscape.

My ambition is to make a significant contribution towards the shift from the consumption of animal protein to the consumption of plant protein.

As we all know, a tripod is always stable. As well as this, a tripod is also a good reflection of the three-legged drying racks that used to be applied for drying legumes, such as peas and beans.
Translated in terms of the three sides of a tripod:

Consumer: For this side of the tripod, we want to focus our research on a better understanding of the consumer, hence optimising the introduction and acceptance of plant-based products.

Technology: For this side, I want to focus on understanding the functionality of plant proteins at a molecular level. This will help us to develop more solutions that can be applied or are applicable to the production and use of plant proteins and ingredients.

Landscape: For this, we want to focus on research into the impact that the protein transition is having and will have in the future on the Dutch landscape.

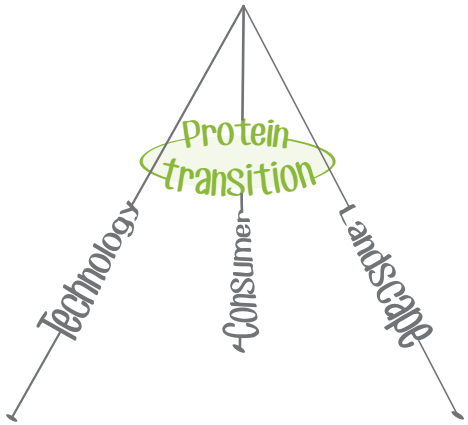


Figure 14. The tripod of Consumer, Technology and Landscape, forming the supporting pillars of the protein transition.

To make this even more concrete, I would like to translate these ambitions into the following objectives for the lectureship:

Consumer: To start a consortium project into the consumer's role in the protein transition, as described above. We want to involve several companies and interest groups in this project.

Technology: Up until now, this has been the most important aspect of the lectureship, so the focus remains on successful completion of the PULSE project. This project focusses on legumes, a real arable crop. By the end of the lectureship term, I intend to have moved in the direction of aquaculture since it is possible to achieve much higher protein yield per hectare with aquacultures, such as duckweed and algae than with arable crops.

Landscape: This topic is still in its infancy in comparison with the other two topics, both within the lectureship and in general. Our goal is to take exploratory steps with our initial projects using student groups.

Education: Protein transition will become an integral part of the curriculum in several study programmes. In addition, I intend to involve as many students as possible in our research, covering all three sides of the lectureship.

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