



PPP Project Annual Report 2018

The PPP-projects that have been established under the direction of the top sectors must submit an annual report on their technical and financial progress. This format is to be used for reporting the technical progress. A separate format ('PPP final report') is available for PPP-projects that have been completed in 2018.

The annual reports will be published in full on the websites of the TKIs/top sector. Please ensure that no confidential matters are left in the remaining blocks.

General information	
PPP number	TKI-AF-16011
Title	Plant Meat Matters. Towards a next generation meat analogues.
Theme Topsector	Topsector Agri & Food, Healthy and Safe
Executive knowledge institution(s)	Wageningen University & Research
Research project leader (name + e-mail address)	Ariette Matser Ariette.matser@wur.nl
Coordinator (on behalf of private parties)	Louis van Steijn, Meyn
Government contact person	Marjan van Creij
Total project budget (k€)	5880 k€
Address project website	https://www.wur.nl/en/Research-Results/kennisonline/AF16011-Plant-Meat-Matters.htm
Start date	1 January 2017
End date	31 December 2021

Approval coordinator/consortium	
The coordinator has assessed the annual report on behalf of the consortium:	<input checked="" type="checkbox"/> approved <input type="checkbox"/> rejected
Possible feedback on the annual report:	-

Short content description/aim PPS
<p>Plant Meat Matters will build the required scientific basis to understand the structuring process of meat analogues while including flavour components, fat and other ingredients. Together with partners that span the entire vegetable protein chain, this basis will be used to further develop technologies for making the next generation of consumer-accepted meat analogues with improved characteristics that can be produced more cost-effectively and will have reduced environmental impact compared to meat analogues currently available on the market.</p> <p>The high and increasing consumption of products from animal origin is one of the key factors making current food production routes insufficiently efficient to feed the growing, and more affluent world population. Meat production is inefficient with respect to the use of land, water and raw materials. In addition, there is an increasing resistance against the meat industry in the Western World on for example animal welfare grounds.</p>

Nutritionally, peas or soy would be excellent protein sources, but most consumers prefer meat. The fact that meat is a product that is fibrous on various length scales including the nanometer scale, is for a major part responsible for this: the flavour components are gradually released upon chewing, giving a good taste experience during the complete duration of mastication.

A route to reduce the consumption of those products is the development of plant-based analogues for meat or meat-like products. Consumer sciences indicated that products that resemble the original will have the highest chance of success to be picked up by the broadest range of consumer groups. In recent years, Wageningen University and the Technical University of Delft jointly developed a novel technology for the production of fibrous, plant-based materials on nano to mesoscale, resembling the structure and bite of meat better than commercial products that are currently available to consumers. This fibrous material could, therefore, form the basis of the next generation of meat analogues.

Plant Meat Matters has the following vision and ambition towards a next generation of meat analogues:

- Reduced consumption of products from animal origin is a key step towards a sustainable diet and can be achieved by direct replacement by textured plant-based products
- Ingredients necessary for meat analogues can be produced with higher efficiency, and reduced use of energy, water and chemicals when focusing on the right ingredients for meat analogues rather than on pure ingredients
- Producing less waste by the production of meat analogues is possible by keeping food fresh for longer and on-demand production of meat analogues

Project objectives:

- Improve scientific basis for next generation meat analogues
 - Product quality: water binding, fat, flavours, etc.
 - Ingredient flexibility & possibilities for processing
- Further development of technologies and ingredients for meat analogues
 - Consumer accepted and improved characteristics
 - Cost-effective process with reduced environmental impact
- Enable partners to develop and produce better meat analogues, ingredients, flavouring and equipment.

The Plant Meat Matters consortium consists of Meyn Food Processing Technology, Avril, Ingredient, Givaudan, saturn petcare, Nutrition & Santé SAS, De Vegetarische Slager, Unilever R&D Vlaardingen. Wageningen University Food Process Engineering and Wageningen Food & Biobased Research.

Planning and progress (if there are changes to the project plan, please explain)	
Is the PPP going according to plan?	Yes
Have there been changes in the consortium/project partners?	No
Is there a delay and/or deferred delivery date?	No
Are there any substantive bottlenecks?	No In 2018, a new PhD student started in WP7 and took over the responsibilities of the previous PhD student. It means that this WP will end a bit later than expected but will not result in substantive bottlenecks for the project
Are there any deviations from the projected budget?	No

Highlights 2018:
In January 2017, Plant Meat Matters started with eight industrial partners, Wageningen Food & Biobased Research and Wageningen University. The project is divided into 8 work packages. WP 1 and 2 focus on bridging the technology gap and build on background knowledge and results from the 6 other work packages. WP 3-6 focus on understanding the structuring process by in depth research involving PhD students. Knowledge transfer is addressed in WP 8 focussing on communication and dissemination.

The highlights for 2018 are described below for the different work packages.

WP 1 Upscaling and maturing shear cell technology

The aim of WP1 is to develop shear cell technology for high-quality meat analogues and to deliver full-scale solutions for meat analogue production. In 2018, the first version of an R&D test model for shear cell technology that can be scaled up towards industrial application was developed and tested. The research focussed on reproducibility and protocol development, including pre- and post-processing. For scaling up, heat transfer towards the dough is important as this influences the texture of the product and performance of the shear cell process. A heat transfer model was made and used for the calculation of the heat transfer to the product. The data from the model were confirmed by temperature measurements in the dough in the shear cell.

The results will serve as input for upscaling and maturing shear cell technology.

WP 2 Developing meat analogue products with excellent taste and texture and investigating consumer acceptance of those products

The goal of WP2 is to develop meat analogue proof of principle prototypes with excellent taste and texture for launching further development by the partners. The development of these prototypes is based on the understanding of consumer wishes, available equipment and understanding of the effects of different ingredients. In 2018, we exploited the fundamental knowledge on soy/gluten recipes to develop robust product prototypes with a desired fibrous texture. Together with WP3, 4, and 5, the obtained knowledge of soy proteins is being applied to other types of plant-based protein-rich materials.

WP 3 Understanding the structuring potential of oilseeds, which includes the effect of fractionation

The aim of this WP is the understanding of structuring of oilseeds, including the effect of oil extraction and fractionation. In this WP, three PhD students are active. In 2018, Birgit Dekkers successfully defended her PhD thesis entitled 'Creation of fibrous plant protein foods'. Her PhD defence was honoured with *Cum Laude*. The fundamental knowledge described in this thesis is being used for understanding the effect of fractionation conditions on the composition and structuring potential of soy protein rich fractions and on investigating the potential use of rapeseed meals as an ingredient for meat analogues. Mild fractionation processes were used to obtain soy protein fractions with different compositions. The structuring properties of these fractions were studied in the shear cell and linked with water holding capacity and viscosity.

WP 4 Investigating the structuring potential of protein concentrates and isolates from pulses and beans, including the effect of mild fractionation

This WP focusses on the development of dedicated functional ingredients for meat analogue applications based on pulses and beans. The aim is to integrate ingredient production and product assembly to make further savings in energy-, water- and raw material use. The PhD student active in this WP started on 1 December 2017. In 2018 the focus of the activities was on quantifying function and structuring behaviour of pulse and/or corn-based ingredients with shear cell technology to better observe, learn, quantify and predict the functional behaviour of the ingredients under relevant conditions. Water holding capacity, denaturation temperature and enthalpy, conformation of proteins by Fourier-transform Infrared Spectroscopy and rheology in a Closed Cavity Rheometer were measured to understand the mechanisms behind the protein integration during the shear cell process.

WP 5 Understanding mechanical properties, juiciness and flavour release of structured protein systems

The aim of WP5 is to improve the juiciness of meat analogues produced with the shear cell by generating a better understanding of the underlying mechanisms that control juiciness. A PhD student is active in this WP. In 2018, significant progress has been made in analysing the water holding capacity of mixed soy-gluten gels. Water holding capacity is an important aspect of juiciness and it is therefore important to understand how it is affected by the used recipe. A method was developed to measure juice release kinetics of gels during compression. This method was applied to soy gels and gluten gels. A model was developed based on Flory-Rehner theory and Darcy flow to quantitatively describe the kinetics of fluid release as measured experimentally. The model provides insights into the underlying mechanisms governing juice release kinetics.

WP 6 Towards the development of plant-based alternatives for meat-derived ingredients in pet food

The aim of this WP is to research the possibilities for vegan pet food, using shear cell technology. Making vegan pet food gives rise to challenges that are similar to making products for human consumption, but has some additional requirements for texture, taste and nutrients. A PhD student is active in this work package. In 2018, we investigated the effect of different combinations of raw materials to create a balanced diet for pets taking in account the nutritional value and the sustainability of vegan pet food. It was found that diets with sufficient nutritional value could be created with plant-based ingredients. Moreover, experiments were performed to evaluate the effect of post-processing steps on the texture of shear cell products during shelf life.

WP 7 A sustainability analysis of various alternatives for meat

The aim of this WP is to make a sound sustainability analysis on the production of meat analogues. To create a structured protein product from plants, processing is necessary to obtain ingredients with a right nutritional profile and to assemble it into final products. This requires many processing steps, of which a number are energy intensive and can lead to biomass losses. In 2018, a new PhD student started in this WP and took over the responsibilities of the previous PhD student. It means that this WP will end a bit later than expected. In addition to the activities focussing on exergy analysis of meat and meat analogue production chains, also Life Cycle Assessment was included as this is one of the main standards in sustainability analysis. We will also investigate the role of nutritional value in the sustainability of meat analogues (coupling nutrition to sustainability).

WP 8 Communication and dissemination

This WP focusses on the internal and external communication and dissemination of Plant Meat Matters. In 2018, two general meetings and multiple WP meetings were organised where all partners were present. Plant Meat Matters already resulted in various dissemination activities. In the appendix, you will find an overview of scientific publications, contributions to conferences and other dissemination activities (e.g. publications in professional journals, newspapers). On 1 and 2 November, the conference 'Science and Technology for Meat Analogues' was organised in Wageningen. This was the first scientific conference dedicated to meat analogues and attracted 135 participants, of which many from industry. During this conference, interesting scientific presentations were given, not only related to meat analogues but also from other scientific fields that can help us understand meat analogues and improve the quality and use of new processes and ingredients. The conference was concluded by professor Louise Fresco, who stressed the importance of the protein transition.

Number of delivered products in 2018

Scientific publication	Reports	Contributions to professional journals and general news	Introductions/workshops
7	1 PhD thesis	15	8

Titels/descriptions of main delivered products in 2018 (max. 5) and target audience

Conference 'Science and Technology for Meat Analogues', 1-2 November 2018, Wageningen. Organised by Plant Meat Matters and attended by 135 participants (industry, scientists, NGOs).

PhD thesis of Birgit Dekkers: Creation of fibrous plant protein foods, 14 September 2018.

Lecture of Atze Jan van der Goot at UC Berkeley 'Design and technology for next generation meat analogues', as part of the A. Richard Newton Distinguished Innovator Lecture Series, 16 Jan 2018.

Review publication: Structuring processes for meat analogues, B.L. Dekkers, R.M. Boom, A.J. van der Goot, Trends in Food Science and Technology, 81: 25-36, 2018.

Various interviews for national and international news, e.g.:

- Eenvandaag Radio, 1 March 2018
- Frankfurter Allgemeiner Zeitung, 18 July 2018
- Financial Times, Future of Foods, 15 October 2018.

Appendix: Names of the products and publications from the start of the project

Scientific publications

	What	Title	Date
1	Scientific publication	Aqueous fractionation processes of soy protein for fibrous structure formation. Marlies Geerts, Birgit Dekkers, Albert van der Padt, Atze Jan van der Goot. Submitted for publication. <i>Innovative Food Science and Emerging Technologies</i> , 45: 313–319	2018
2	Scientific publication	Understanding fiber formation in a concentrated soy protein isolate - pectin blend. Birgit L. Dekkers, Remco Hamoen, Remko M. Boom, Atze Jan van der Goot. <i>Journal of Food Engineering</i> , 222: 84-92	2018
3	Scientific publication	Viscoelastic properties of SPI-pectin blends: richer than a simple composite material. Birgit L. Dekkers, Remko M. Boom, Atze Jan van der Goot. <i>Food Research International</i> , 107: 281-288	2018
4	Scientific publication	Structuring processes for meat analogues, B.L. Dekkers, R.M. Boom, A.J. van der Goot, <i>Trends in Food Science and Technology</i> , 81: 25–36	2018
5	Scientific publication	The phase properties of soy protein and wheat gluten in a blend for fibrous structure formation, B.L. Dekkers, M.A. Emin, R.M. Boom, A.J. van der Goot, 2018, <i>Food Hydrocolloids</i> , 79: 273-281	2018
6	Book chapter	Chapter 6: Plant-based meat analogues, K. Kyriakopoulou, B.L. Dekkers, A.J. van der Goot, 2018, in <i>Sustainable Meat Production & Processing</i> (Elsevier-Academic Press) edited by Dr. C Galanakis	2018
7	Book chapter	Novel Processing Concepts for Making Fibrous Food Products, B.L. Dekkers, A.J. van der Goot, 2018, in <i>RSC book - Process intensification in bioprocessing</i> , edited by Dr. A. Gorak and Prof. A.I. Stankiewicz	2018

Contributions to scientific conferences

	What	Title	Date
1	Presentation	Presentation Plant Meat Matters. Atze Jan van der Goot. 10th Protein Summit 2017. Creating New Protein Strategies. 26-28 September 2017, Reims, France	September 2017
2	Poster and presentation	Understanding fiber formation in a concentrated soy protein-pectin blend. Birgit Dekkers, Remko Boom, Atze Jan van der Goot. Conference Delivery of functionality in complex food systems', 5 to 8 November 2017 in Auckland, New Zealand	November 2017
3	Presentation	Lecture UC Berkeley 'Design and technology for next generation meat analogs', Atze Jan van der Goot, as part of the A. Richard Newton Distinguished Innovator Lecture Series, 16 Jan 2018	January 2018
4	Presentation	Invited Presentation 'Novel proteins for plant-based meat', Atze Jan van der Goot, Pulse Protein Summit Oakland, USA, 18 Jan 2018	January 2018
5	Presentation	Plant Meat Matters. Towards a next generation meat analogues, Ariette Matser, <i>New Protein Technologies</i> , Rotterdam, 17 April 2018	April 2018
6	Poster and flash presentation	Poster and flash presentation. Flory-Rehner theory as a tool for juicier meat analogues. Steven Cornet, 3rd Food Structure and Functionality Forum Symposium in Montreal, Canada, 3-6 June 2018	June 2018
7	Conference	Conference on Science and Technology for Meat Analogues, 1-2 November 2018, Wageningen	November 2018

8	Presentation	Opening Lecture `Science and technology for The next generation meat analogues`, Atze Jan van der Goot, Conference on Science and Technology of Meat Analogues, Wageningen, 1-2 November, 2018	November 2018
9	Presentation	Effect of structure on water holding capacity of meat analogues, Steven Cornet, Conference on Science and Technology of Meat Analogues, Wageningen, 1-2 November, 2018	November 2018
10	Presentation	Creation of fibrous plant protein foods, Birgit Dekkers, Conference on Science and Technology of Meat Analogues, Wageningen, 1-2 November, 2018	November 2018

Other dissemination activities

	What	Title	Date
1	Publications based on press release	<p>Publications in newspapers based on press release of PMM:</p> <p>http://nos.nl/artikel/2161713-unilever-stapt-in-plantaardige-biefstuk-dit-is-een-doorbraak.html http://www.telegraaf.nl/binnenland/27746781/_Plantaardige_biefstuk_Unilever_.html http://www.volkskrant.nl/economie/unilever-en-andere-multinationals-stappen-samen-in-plantaardige-biefstuk~a4471105/ http://www.ad.nl/economie/universiteit-wageningen-en-unilever-werken-aan-doorbraak-vegetarische-biefstuk~a4f6ae9f/ https://www.trouw.nl/religie-en-filosofie/unilever-gaat-voor-vegabiefstuk-nu-de-aandeelhouders-nog~a8aadb0e/ http://www.nu.nl/eten-en-drinken/4150164/onderzoekers-maken-biefstuk-van-plantaardige-ingredienten.html http://www.marketingtribune.nl/food-en-retail/nieuws/2017/03/unilever-stapt-in-vleesvervangers/index.xml http://www.maxvandaag.nl/sessies/themas/eten-drinken/plantaardige-biefstuk-stapje-dichterbij/ http://nieuws.nl/eten/20170308/eerste-vegetarische-biefstuk-straks-geserveerd-worden/ http://www.boerderij.nl/Home/Nieuws/2017/3/Onderzoek-naar-industriële-plantaardige-biefstuk-103190E/ http://www.voedingnu.nl/Nieuws/WUR_planteneiwitten_met_de_textuur_van_biefstuk-170308080000 http://hoogenlaag.nl/lokaal/wur-werkt-aan-plantaardige-biefstuk-218862 http://radar.avrotros.nl/nieuws/detail/universiteit-werkt-aan-plantaardige-biefstuk-met-steun-van-multinationals/ http://gfcnieuws.org/wageningen-universiteit-werkt-aan-plantaardige-biefstuk/ https://mmv.nl/nieuws/gezonde-biefstuk-binnen-handbereik http://www.melkvee.nl/economie/nieuws/10386/wagening-en-ur-zet-stap-in-ontwikkeling-vegetarische-biefstuk https://www.nieuweoogst.nu/nieuws/2017/03/07/unilever-stapt-met-wageningen-ur-in-vleesvervangers http://www.food-nutrition.nl/nieuws/onderzoek-maakt-industriële-productie-plantaardige-biefstuk-mogelijk/ http://theoptimist.nl/wageningen-werkt-aan-plantaardig-biefstuk/ https://www.foodholland.nl/nieuws/artikel.html?id=189686</p>	March 2017

		http://www.cirrus.nl/rssfeed/5515522/unilever-stapt-in-plantaardige-biefstuk-dit-is-een-doorbraak http://www.duurzaambedrijfsleven.nl/voeding/21511/unilever-werkt-mee-aan-ontwikkeling-vegetarische-biefstuk http://www.omroepgelderland.nl/nieuws/2129487/Doorbraak-universiteit-werkt-met-Unilever-aan-vleesvervanger http://www.waarmaarraar.nl/pages/re/101255/De_eerste_vegetarische_biefstuk_kan_straks_geserveerd_worden.html http://www.dutchnews.nl/news/archives/2017/03/unilever-joins-wageningen-vegetable-steak-project/	
2	Publication in professional journal	Vlees is passé. Vijf alternatieven voor de kotelet. Zo komt de mens straks aan zijn eiwitten. Karbonaadje 2.0. Marc Seijlhouwer. De Ingenieur. April 2017, p11-19	April 2017
3	Publication in newspaper	Lab vlees. Waarom het ineens wel heel hard gaat met het niet-van-echt-te-onderscheiden vegetarische vlees. Mac van Dinther. Volkskrant 12 July 2017. pV5-V9	July 2017
4	Interview	Interview Food Navigator Niamh Michail 2017, http://www.foodnavigator.com/Market-Trends/Plant-Meat-Matters-Unilever-Givaudan-and-Ingredion-invest-in-vegetarian-steak?utm_source=newsletter_daily&utm_medium=email&utm_campaign=13-Mar-2017&c=xEcK4N6UA4cDExlAIPj2z2K2OXW%2FcCPQ&p2=	March 2017
5	Interview	Interview Samantha Boh, 2017, The Straight Times, Singapore, http://www.straitstimes.com/singapore/mock-meat-made-to-feel-like-the-real-deal	March 2017
6	Interview	Interview Albert Sikkema, Resource Wageningen 2017 https://resource.wur.nl/nl/show/Vleesvervangers-uit-de-snelkookpan.htm	March 2017
7	Interview	Interview by Michelle Knott, Meat Alternatives in boom, Food Manufacture, 25 febr. 2018 https://www.foodmanufacture.co.uk/Article/2018/01/27/Meat-alternatives-in-boom-the-opportunity-for-food-manufacturers	February 2018
8	Radio interview	Interview, Eenvandaag Radio, by Suzanne Bosman, 1 maart 2018, https://www.nporadio1.nl/homepage/8445-de-nep-biefstuk-komt-eraan	March 2018
9	Interview	Interview Roel Verrycken, Redacteur De Tijd, Belgium, 26 April 2018 https://www.tijd.be/tablet/newspaper/beleggen/de-betekenis-van-het-woord-vlees-zal-veranderen/10006175 , ook gepubliceerd in Vilt http://www.vilt.be/toenemende-interesse-in-plantaardig-vlees	April 2018
10	Radio interview	Interview Elsbeth Gugger, Swiss radio, Landwirtschaft auf Irrwegen, 21 April 2018 https://www.srf.ch/sendungen/international/landwirtschaft-auf-irrwegen	April 2018
11	Interview	Interview by Douglas Heingartner, 2018, The Race to Make a Great Fake Steak, IEEE Spectrum, https://spectrum.ieee.org/green-tech/conservation/the-race-to-make-a-great-fake-steak	June 2018
12	Interview	Interview Il Manifesto, La nostra ricetta? Proteine di soia, glutine di grano e aromi naturali, 6 juni 2018	June 2018
13	Interview	Interview by Annemique de Kroon, Biefstuk-zonder-dier, ONVZ bijlage, NRC, 9 juni 2018, https://www.nrc.nl/advertentie/onvz/biefstuk-zonder-dier	June 2018
14	Interview	Interview Frankfurter Allgemeiner Zeitung, 18 July, 2018, Wie die Speisen der Zukunft reifen	July 2018

		http://www.faz.net/aktuell/race-to-feed-the-world/so-sieht-die-welternaehrung-der-zukunft-aus-15693859.html	
15	Interview	Interview Johannes Böhme, Brand Eins, Augsut, 2018, p. 70-71, Im Treibhause, https://digitaal.360magazine.nl/magazine/145/artikel/8 , https://international.brandeins.de/cultivating-change	August 2018
16	Publication	Contribution to article Bloomberg https://www.bloomberg.com/news/articles/2018-09-14/vegetarian-butcher-s-secret-to-making-fake-meat-you-want-to-eat	September 2018
17	Publication	Contribution to article Financial Times Future of Foods by Enrike Terazono 15 Oct, 2018, https://www.ft.com/content/199cae4c-cbc6-11e8-b276-b9069bde0956 , http://www.expansion.com/economia-digital/innovacion/2018/10/25/5bce05e6268e3e81738b462b.html , https://www.straitstimes.com/opinion/agritechs-silicon-valley-and-the-future-of-food , http://up-magazine.info/index.php/securite-alimentaire/securite-alimentaire/8121-frenesie-high-tech-sur-la-production-agroalimentaire	October 2018
18	Publication	Contribution to article NRC by Martine Kamsma C, Wat als we stoppen met vlees eten, https://www.nrc.nl/nieuws/2018/10/25/wat-als-we-stoppen-met-vlees-eten-a2752737 , 27 October 2018	October 2018
19	Exposition booth	Booth at the Innovation Expo. Birgit Dekkers, Nynke Draijer, 4 October Rotterdam	October 2018
20	TV interview	Interview, BNN Bloomberg TV Canada about meat analogues, 5 November 2018 https://www.bnnbloomberg.ca/commodities/video/power-shift-plant-based-meat-tasting-more-like-the-real-thing-1532208	November 2018
21	Publication in professional journal	Black box shear cell technologie ontrafeld. Voedingsmiddelentechnologie, 2 November 2018, p 017-018	November 2018

<https://www.wur.nl/en/Research-Results/kennisonline/AF16011-Plant-Meat-Matters.htm>

<https://topsectoragrifood.nl/project/towards-a-next-generation-meat-analogues/>