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, excluding the blocks 'Approval coordinator/consortium' and 'Planning and progress' . Please ensure that no confidential matters are left in the remaining blocks.

General information	
PPP number	**TKI-AF-15235**
Title	PPS Tasty Sustainable Frozen Foods
Theme	Topsector Agri & Food, Roadmap High quality products and processing, Theme Healthy and Safe
Executive knowledge institution(s)	Wageningen Food & Biobased Research
Research project leader (name + e-mail address)	Theo Verkleij theo.verkleij@wur.nl
Coordinator (on behalf of private parties)	Bjorn van den Oudenhoven, LambWeston / Meijer
Government contact person	Cor Wever
Total project size (k€)	832 K€
Address project website	https://www.wur.nl/nl/Onderzoek-Resultaten/Onderzoeksprojecten-LNV/Expertisegebieden/kennisonline/Duurzaam-ingevroren-smaakvol-sustainable-frozen-and-tasty.htm
Start date	1 January 2016
End date	31 December 2019

Approval coordinator/consortium	
The coordinator has assessed the annual report on behalf of the consortium:	approved
Possible feedback on the annual report:	

Short content description/aim PPS
Freezing is a frequently used method to extend shelf life, to avoid spoilage of food, and loss of value in the chain. It contributes greatly to the reduction of food waste. Energy consumption, quality, weight and aggregation during frozen storage have led to a worse image compared with food directly prepared from fresh products. The objective of the project is to improve the final quality of frozen products after processing by consumers and reduce energy consumption during storage and processing of frozen products. To freeze and realize improvements in frozen storage, it is essential to understand both the performance of the process and the changes in the product. To understand the physical causes of loss in product quality of frozen products, in this project companies and knowledge institute work towards the scientific understanding of moisture migration and crystal formation, understanding of impact of variations in storage conditions and create the bridge to apply this knowledge in practice.

This insight will help businesses to deliver better quality frozen products as finished and semi-finished product. The industrial partners of the consortium will be the first to apply these insights to show the added value. By neutralizing the negative aspects of frozen food, the opportunity arises to emphasize the positive aspects of frozen foods, such as better retention of nutrients such as vitamins and short preparation time (after thawing). More use of frozen products, increases the food industry flexibility in sourcing and prevents spoilage. Improved freezing and storage processes provide for reduction of energy consumption in this sector.

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
Are there any deviations from the projected budget?	No

Results in 2018

Frosting and clumping in frozen vegetables, fruits and par-fried potatoes

During storage of vegetables, fruits and par-fried potatoes, crystallisation of a small layer of ice crystals or fat crystals occurs on the surface of the products and individual products can connect to each other in the formation of large blocks of frozen products (clumping). These processes negatively affect the quality of the products and the use of the product.

Based on the knowledge generated in the project, a scientific paper was written and published. In this paper, the problem of clumping due to frost formation on frozen vegetables, like par-fried potato products is reviewed. This problem has been very scarcely investigated in the scientific literature. Yet in the industry it is a significant problem, as evident by the various patents on this topic. Thanks to the enormous, recent growth of scientific literature on frost formation on engineered, structured surfaces, we have drawn a multitude of hypotheses of factors governing the clumping and frost formation of frozen foods, which can also be viewed as a structured surface.

The hypotheses resulting from this were used as guidance of the experiments that are performed in the project.

Role of oil properties in quality of frozen par-fried potatoes

The properties of frozen par-fried potatoes are also influenced by the oil blends used and the conditions of the frying process prior to freezing. The developed method to characterize the behaviour of oil blends as a function of temperature and time was used to gain more insight in the formation of fat crystals over time during storage of the par-fried potatoes. Industrial relevant temperature – time conditions for freezing and storage were used to determine the amount of crystallised fat in different oil blends.

Relation between temperature conditions and product quality

Detailed measurements were done on an industrial freezing line to determine temperature profiles of individual products in different stages of the production process. These temperature profiles were used to develop a predictive model, in which the effect of freezing on temperature behaviour and therefore on product quality can be determined. Also a lab scale pilot system for pre-treatment and freezing of vegetables was set up, to determine the impact on quality after freezing and during frozen storage. With the lab scale system, extreme conditions were evaluated to research the hypotheses on effect of processing conditions on product quality. By performing research both on industrial scale and lab scale, the project makes sure that relevant conditions are researched and results can be applied on industrial scale.

Analytical method to characterize ice crystals
The developed method to characterise ice and ice crystals in frozen vegetable products with X-ray Tomography was further optimised. With this method it is possible to visualise the size and distribution of ice domains in frozen vegetable which can give insight in the effect of e.g. different processing and storage conditions on quality of frozen vegetables. The analytical method was adapted to visualize the ice distribution in products and between products. This XRT tested needed adaptations to perform good results as experiments have to be performed at sub-zero temperatures to ensure that the product is still frozen. This method is disseminated to a wider public via a publication in Voedingsmiddelentechnologie

Dissemination of project results
In February 2018, a public workshop was organised to present project results to a wider public. This workshop was attended by 30 people from 17 companies, including fruit- and vegetable processers, equipment manufacturers and consultants. In this workshops, the following presentations were given:

- What happens during freezing and frozen storage of fruits and vegetables with the quality?
- X-Ray Tomografie (XRT) as method to characterise ice crystals and structure of frozen vegetables
- Impact of way of purchase of vegetables – frozen, fresh or ambient stable – on food waste by the consumer.

The workshop was well appreciated by the attendees.

Number of delivered products in 2018 / so far *(in an appendix, please provide the titles and/or description of the products or a link to the products on public websites)*			
Academic articles	Reports	Articles in journals	Introductions/workshops
1	0	1 (VMT)	2

Appendix: Names of the products or a link to the products on a public website

Scientific publications

	Title	**Year**
1	R.G.M. van der Sman. Clumping of frozen par-fried foods: Lessons from frosting on structured surfaces. Food Structure 17 (2018) 9-20	2018

Other dissemination activities

	Title	**Year**
1	R.G.M. van der Sman. A deep drive into the deep freeze. New Food, Vol. 19, issue 2, 2016, p.13-15	2016
2	R.G.M. van der Sman. Phase field simulation of directional freezing of sugar solutions. Presentation at DSFD2017, 26th International conference on discrete simulation of fluid dynamics. 10-14 July 2017. Erlangen, Germany	2017
3	R.G.M. van der Sman. Phase field simulation of ice formation in sugar solutions.Presentation at Symposium Thermodynamics and Phase Transitions in Food Processing. 29-30 January 2018 Wageningen University	2018
4	Public workshop at Wageningen University & Research: Diepvriesgroente en fruit: wat is de impact van invriezen op de kwaliteit. 2 February 2018	2018
5	A. Barbier (interview Erik Esveld, Ariette Matser). Diepvriesproducten bekijken in 3D , VMT . 1 JUNI 2018 . NR 7	2018