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.

The PPP Project Annual Reports must be submitted by 15 February 2019 to Ineke Ammerlaan

General information	
PPP number	**TKI-AF-AF16508**
Title	Design and sensory perception of multi-scale food structures fabricated by 3D printing
Theme	
Executive knowledge institution(s)	Wageningen University & Research
Research project leader (name + e-mail address)	Maarten Schutyser (Maarten.schutyser@wur.nl)
Coordinator (on behalf of private parties)	Daniel Florea, FrieslandCampina
Government contact person	
Total project size (k€)	467
Address project website	
Start date	1/9/2017
End date	31/8/2021

Approval coordinator/consortium The annual report should be discussed with the coordinator/the consortium. The TKIs appreciate being informed of possible feedback on the annual report.	
The coordinator has assessed the annual report on behalf of the consortium:	X approved ☐ rejected
Possible feedback on the annual report:	No Remarks; Fine progress report

Short content description/aim PPS

What is going on and how is this project involved?
What will be delivered by the project and what is the effect of this?

3D Food printing is a rapidly emerging research area with much attention in the media and from consumers. Current technologies however only allow its use as small-scale 'gimmick': the use of ingredients is limited, one cannot yet create a multiscale food structure as is present in natural foods, and its use of energy and other resources per kg product is still prohibitive for larger-scale use. This is why it holds great potential as method for point-of-sale assembly, which can strongly reduce the amount of waste in the chain, which ranges from around 30% in Europe, to 50% in the United States. The overall objective of this PhD project is to develop a scientific base to prepare printed food structures that have excellent sensorial properties with focus on structure formation at multiple length scales.

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?	Yes, the start has been delayed due to the search for a suitable candidate for the PhD-position. In September 2017 Sicong Zhu has been appointed which also indicates the actual start of the project.
Are there any substantive bottlenecks?	No
Are there any deviations from the projected budget?	In-kind contributions of partners in 2018 have been lower than agreed upon. This will be addressed in the next user meeting early 2019 to ensure that actions are taken.

Results in 2018/ so far
Give a short description of the highlights and (most important) project deliverable in 2018 / so far and their target group

Two 3D printers from ByFlow and Natural Machines have been acquired and a centrifugal mixer has been purchased which allows de-aeration of concentrated viscous mixtures. This helps prepare paste that can be 3D printed with fine nozzles. A dispenser set up is connected to the texture analyser to measure force during extrusion of different formulations.

A frame work is developed for assessing suitability of materials for 3D printing it is suggested to define categories of materials with 'similar 3D printing properties' and select one material to represent this category. (WP1)

We investigated the relationship between rheology and on the one hand extrusion behaviour and on the other hand stability during printing. The combination of extrusion behaviour and stability can be used to predict printability. Subproject 1 is aiming at characterizing and understanding printability for tomato puree as a model product. Additionally, 7 commercial products were chosen for comparison (vege pate, Speculoos, Nutella, kip pate, tomato puree, mayonnaise, chili paste) and 15%NaCas. Rheological behaviour was assessed via oscilatory rheology and stability was measured by printing till the collapse point (see figure 1).

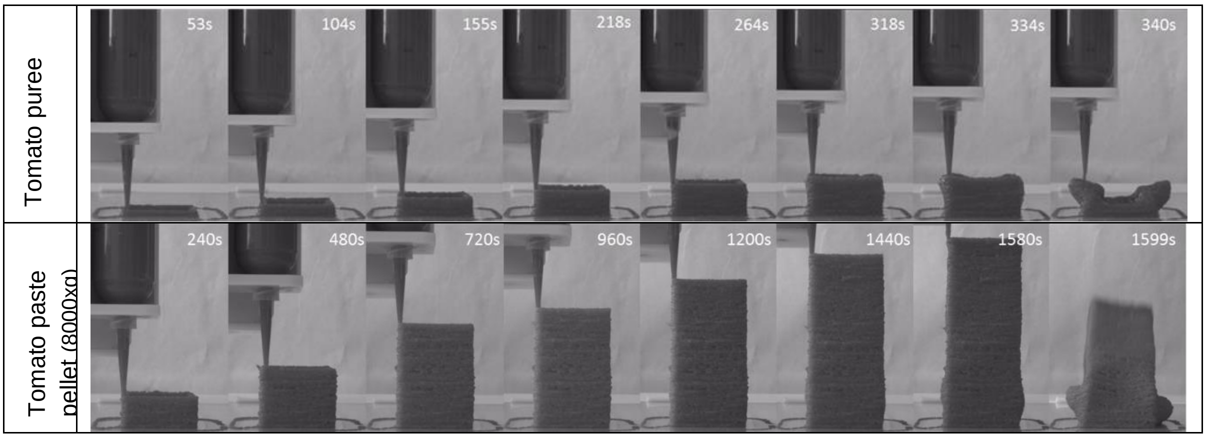

Figure 1: 3D printing of hollow square column using tomato puree and centrifuged paste printed with grey nozzle. a) commercial tomato puree. b) tomato paste centrifuged at 8000g.

Interesting a linear relation was observed between the flow stress derived from rheological measurements and the normal stress at the collapse point of the object from the visual printing observations (Figure 2).

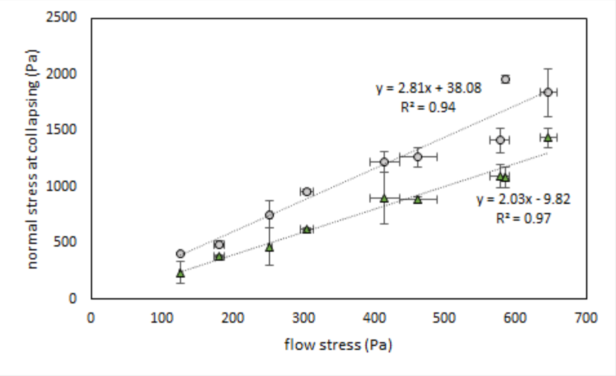

Figure 2: Correlating rheological properties with printing stability. Grey dots represent printed object with grey nozzle. Green triangle represent printed object with bright green nozzle. plot of normal stress at collapse versus flow stress.

Separately also measured extrusion behaviour could be linked to parameters obtained rheological data. The explanation of these relationships are more complex, but that is something which is currently being investigated.

In subproject 2 we study the influence of 'pure' components (fibre, starch and oil) on printability of PPI paste. 20% PPI was chosen as the printing base. An experimental design was made to study the influence of individual component. Below we provide a more detailed description of the work carried out in the framework of a Bsc thesis:

To evaluate the extrusion behaviour, the force needed to extrude the material out of the nozzle during printing was examined. Regarding the rheological properties, the flow point and storage modulus in rest were measured by performing a stress sweep test. Also the effect of oven baking regarding the stability and texture of printed products was examined for different mixtures containing PPI. The stability was again defined as the height of the object. To determine the texture after baking, a compression test was performed. Finally, the effect of having low or high concentrations of sunflower oil (3 or 8%), pea fibre (1 or 3%) and pea starch (3 or 6%) added to a mixture of 20% pea protein isolate (PPI) regarding the different characteristics tested was studied. Based on this Bsc thesis research, creating a framework to indicate the printability of a material is not yet possible. But, it is likely that there is a linear trend between the flow point and extrusion force, however further tests are required to prove this.

No relation was observed between any of the other printability characteristics. The effects of having a low or high concentration of oil, fibre and starch added to a 20% PPI solution on different printability characteristics were observed. The results obtained are valid for the amount of oil being between 3 and 8%, the amount of fibre being between 1 and 3% and the amount of starch being between 3 and 6%. Within these ranges, printed stability and stability after baking were hardly affected. The flow point will increase by an increase in oil, fibre or starch content. Interactive effects between fibre and starch will even further increase the flow point. An increase in extrusion force will be caused by a high level of oil, fibre, starch, the interactive effect between oil and fibre and the interactive effect between fibre and starch. The force required to compress a baked sample will increase with an increasing level of starch. The interaction between fibre and starch has a negative effect on the force required to compress a baked sample.

Results from Subproject 1 will be drafted soon as a first publication. Subproject 2 will take another few months to finish. Next steps to be taken in year 2 (WP2, etc.) will be more directed to making actual products that are structured or consist of multiple ingredients.

An additional Bsc thesis was supervised that was concerned with the creation of macroscopically anistropic structured products with pea protein, starch and $CaCl_2$. Below an impression is given of the design with alternating lines of printed materials. Interesting results were obtained, which showed the potential of this approach for making new products. However, there is still room for improvement.

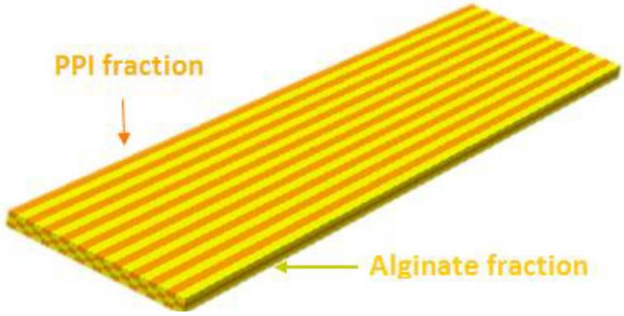

Fig. 3 Design of 3D printed anisotropic structure

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
Not applicable	**Bsc Thesis** Nienke Eijkelboom - Screening methodology development and identification of potential materials used for 3D food printing **Bsc Thesis** Luuk Rook The creation of an edible 3D printed macroscale anisotropic fibrous structure.	Not applicable	Not applicable

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