



### PPP-final report

PPP projects which are under supervision of the “Topsectoren” must file a final report concerning the total project period. This form is used to report the content of the project. There is a separate form for the financial reporting.

**The final report will be published on the TKI / topsector website. Therefore, please ensure that there is no confidential information in the final report.**

*The report must be submitted before 15 February 2020 to **Hans van der Kolk.***

General information	
PPP-number	<b>TKI-AF-17102c</b>
Title	<b>Manufacturing of water-resistant starch containers</b>
Theme	
Implementing institute	<b>Wageningen Food &amp; Biobased Research</b>
Project leader research (name + e-mail address)	<a href="mailto:Frans.kappen@wur.nl">Frans.kappen@wur.nl</a>
Coordinator (on behalf of private partners)	<b>Wageningen Food &amp; Biobased Research</b>
Project-website address	
Start date	<b>1-9-2017</b>
Final date	<b>31-12-2019</b>

### Approval by the coordinator of the consortium

The final report must be discussed with the coordinator of the consortium. The “TKI’s” appreciate additional comments concerning the final report.

Assessment of the report by the coordinator on behalf of the consortium:	<input type="checkbox"/> Approved <input type="checkbox"/> Not approved
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Additional comments concerning the final report:	
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### Consortium

Mention any changes in the composition of the project partners:	No change
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### Summary of the project

Problem definition	There is a need in the market for new, sustainable manufacturing solutions for the packaging industry. Furthermore there is a need of increasing the value of rest streams in various applications. Starch rest streams are an interesting raw material source for packaging applications, however, current starch packaging concepts do not often have the right water resistant properties to be used in a wide range of applications.
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Project goals	The aim of this project is to develop thermoplastic water-resistant containers from starch and a process to manufacture them. The desired final process consists of a combination of mechanical and / or chemical modification together with thermal plasticization in one step. The process will lead to thermoplastic starch that can be further or in situ processed into a tray. The resulting product should be water resistant, biodegradable or recyclable, made mainly of starch and suitable for food contact applications. These requirements make this project highly challenging but open the possibilities for innovation.
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<b>Results</b>	
Planned results in the original project plan	<p>The intended results of this project are:</p> <p>I. Chemically modified thermoplastic hydrophobic starch Main deliverable: Most effective chemical modification of pre-gelatinized starch.</p> <p>II. Process to obtain chemically modified thermoplastic hydrophobic starch Deliverable: Suitable manufacturing process for the most effective modification and a prototype of a water resistant starch tray.</p>
Achieved results	<p>Several chemical modifications were tested in an extruder. It was shown that, at the right conditions, the reaction was complete without by-products. The degree of substitution was higher compared to values given in literature and the material was less soluble in water. Although an increased hydrophobicity was shown, the materials were not completely water resistant. Increasing the amount of reactant lead to less miscibility in the extruder and incomplete reaction.</p> <p>The extrusion products could be processed in a compression or injection moulding machine. Demonstration products (tensile bars and flat sheets) were produced.</p> <p>Based on the reactants being used, their amount and reaction efficiency, it is expected that the developed material is still biodegradable.</p> <p>Similar modified starch products are being used in food applications, but since this is a novel process with slightly different product properties, food contact is not approved yet, although all used components are used in food contact safe products.</p>
Explanation of changes relative to the project plan	<p>During the course of the project, it was decided that firstly the process needed to be developed with native potato starch. Residual starch waste streams would have to much variables in their properties and might influence the material properties in an unknown way.</p> <p>In the first phase of the project is was shown that the extrusion product has hydrophobic properties, it was less soluble in water than unmodified starch. It could also be processed in an injection moulding machine. Therefore it was decided to go to the second phase for optimisation. At that point it appeared that a product of the material was not completely water resistant and possibly would not meet the requirements. More effort than anticipated has been done to increase the water resistance.</p>

<b>What was the added value created by the project for:</b>	
Participating "Knowledge Institutes" (scientific, new technologies, collaboration)	Wageningen Food & Biobased Research has increased its knowledge on reactive extrusion on starch. Processability has improved (a.o. handling/feeding and blending of hydrophilic with hydrophobic materials in an extruder). Also the interaction between 'chemistry' and 'extrusion' has improved possibly leading to more reactive extrusion projects in the future.
Participating private partners (practical application of the results, within which period of time?)	Ozephius Development B.V. has gained more knowledge on starch and starch extrusion. Also their network in the packaging industry is increased. Possibly new technologies can be developed.  Duynie Holding B.V. has increased its knowledge on reactive starch extrusion and analytical characterisation techniques. Possibly new processing technologies can be developed.
Society (social, environment, economy)	Although the goal of a water resistant starch container was not achieved, possibly other starch based packaging could benefit from the results. This would improve the environmental impact by increasing the biodegradable content.
Possibly other stakeholders (spin-offs)	The 3 partners in the project are currently studying the project results to be used for other applications, possibly with other partners.

<b>Follow-up</b>	
Did the PPP result in one or more patents (first filings)?	No
Are there any follow-up projects planned? If yes, explain. (Contract research resulting from this project, additional funding, or new PPP projects)	No, although the project results are currently being studied to be used for other applications

<b>Deliverables/products during the entire course of the PPP</b> (provide the titles and/or a brief description of the products/deliverables or a link to a website.)
<u>Scientific articles:</u>  no
<u>External reports:</u>  no
<u>Articles in professional journals/magazines:</u>  no
<u>(Poster) presentations at workshops, seminars or symposia.</u>  Planned: Stärke Tagung 2020, Maurice Essers
<u>TV/ radio / social media / newspaper:</u>  no

Remaining deliverables (techniques, devices, methods, etc.):

no