TITLE: Strategic Innovation Program (SIP) "**Customized Processed Foods for Quality and Health**".

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Confidentiality This proposal is updated from the version that was agreed upon by the Grand Design Steering Committee. Further information regarding the potential synergy between TNO and DLO has been incorporated. This version is intended for the Theme Committee 7&9 of the TKI Agri&Food and to be kept confidential.

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1. Introduction

Food Quality, Processing and Consumption and the Grand Societal Challenges

Food production and food consumption play a key role in solving the Grand Societal Challenges defined in the European Union. To tackle these challenges more processed food has to be produced from less resources yet with a higher quality and a healthier composition targeting individual needs. The proposed SIP program "Customized Processed Food for Quality and Health" aims to ***provide breakthrough technologies that enable efficient and effective manufacturing of food products that fit personal healthy diets and sustainable choices***. This will be instrumental to secure a steady supply of processed food that is implicitly healthy and to empower consumers to take more control over the composition of their foods in relation to their needs, lifestyle and health. TNO and DLO have joined forces to demonstrate their ability to develop a portfolio of public-privately funded projects relevant to industry, based on an excellent science and technology base, scoped by the European societal challenges.

The Fact Sheet "Tackling Societal Challenges" outlines the Grand Societal Challenges that Europe faces and addresses in the Horizon2020 framework program for research and development[1]. Innovation for Food Quality, Processing and Consumption are of direct importance to two of the seven challenges: 1) Health, demographic change and wellbeing and 2) Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy. The SIP program "Customized Processed Food for Quality and Health" addresses the following goals that are part of the Horizon2020 framework program. For Health, Demographic Change and Wellbeing the major goals addressed "Promoting Healthy Ageing and Preventing Disease throughout the Lifespan" and "Shifting from Hospital Care to Prevention and Citizen Based Care". In the context of food processing, quality and consumption we translate this into the following needs:

- Citizens need to have access to meals that are healthy and convenient and fit in their personal context including personal health status and personal genomic background
- Elderly citizens living at home longer need access to meals that are easier to prepare and suited for their personal condition

For Food Security the major relevant goal is improving food management to reduce food waste by 50% by 2030. In the context of food processing, quality and consumption we translate this into the providing solutions that allow:

- Food processing technologies that allow efficient and effective manufacturing of food products
- More efficient agri&food value chains using ICT tools.

The Innovation Contract for the Topsector AgriFood has also set the societal challenges that the Food Industry wants to address in the coming years.

In general these issues require new flexible ingredients and technology to rapidly develop healthy processed food products that can be readily adapted to both the personal context of individual citizens. For this approach we coin the term "Customized Processed Food". The technological development is This Strategic Innovation Program (SIP) will be open to industries and knowledge parties that contribute financially or with expertise to strengthen the output of the SIP. The SIP "Biorefinery for food security" that is under joint development as well, focuses on new agrifood biomass production schemes to tackle sustainability issues related to raw materials security in the food & biobased sector. It is aligned with our proposal that focuses on the post-harvest part of the production chain, particularly food processing, quality and consumption.

[1] http://ec.europa.eu/information_society/newsroom/cf/horizon2020/document.cfm?doc_id=3778

2. State of the art

The main, long term innovation goals in the food industry are sustainability and consumer health. Progress in sustainability is driven by new biorefinery concepts that produce food ingredients more efficiently. The strategic Innovation Program "Biorefinery for Raw Material availability and flexibility" that is jointly developed by TNO and DLO will provide the platform for industry to create new value chains and technology to this end. Towards personal health and healthy food choices TNO and DLO are also jointly developing programmes to involve industry in developing new technology and assist consumers in making healthy diet choices of consumers.

The state of the art in the area of personalised product quality and ingredient functionality is given by practical examples of personalised products like cartridge coffee machines and birthday cakes with edible printed pictures. Within the EU KP7 project Performance we have demonstrated the possibility to use new printing technology to reshape mashed food products into attractive shaped products for people suffering from dysphagia. Not only does this technology provide personalized textures but can also be used to adapt meals to personalized food intake based on specific nutritional needs.

"Yesterday"
Mashed Carrots
One Size Fits All

"Tomorrow"
Reshaped Carrots Personalized amount, texture and composition

For new processing technologies there are a number of promising mild techniques that will reach the market within a few years enabling customized food products to become mainstream. Recent technological developments (e.g., in ICT and manufacturing) enable the next step in mass customization to be performed at a profitable scale: *individualized customization*, i.e., building a unique product for each individual customer.. This requires more insight into health effects such as nutritional value, digestibility and allergenic issues of raw materials as well as the influence of processing and storage.

The developments in the area of monitoring personal behaviour and physiological parameters are taking place at an extremely fast pace. Smartphones nowadays can measure their owner's heart rate and caloric expenditure during the day, without additional hardware. This will develop towards continuous monitoring of heart rate, blood oxygen levels, blood pressure and blood sugar levels. The development seems only to be hampered by the availability of low-cost, low energy consuming and easy to use sensors that can be directly incorporated into smartphones. Web tools already exist that can produce a target caloric intake based on with basic physiological parameters such as body weight and height and make suggestions for daily meals. No knowledge development in this area is proposed within the context of this program since this will be incorporated in a separate program.

In between these two developments is the core of food technology. Using material and processing knowledge to create high quality food products by processing a range of ingredients that are first blended in a complex mixture. The personalisation trends that are

the current state-of-the-art will put stronger demands on the quality and variety of the processed food products that are produced by the food industry. To meet with these demands industry will have to strengthen the tools to make food processing more flexible, use less additives and undesired ingredients and more personalised. This bears on the type of knowledge and technology that needs to be developed on the level of ingredient functionality, product quality and consumer interactions.

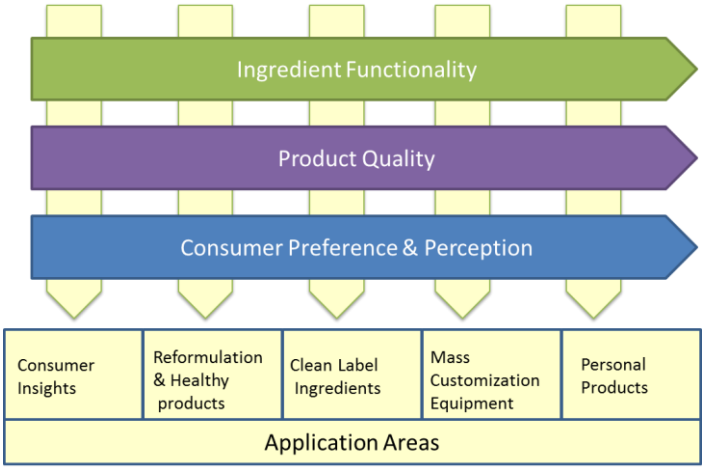

Figure 1: Relation between required levels of expertise and application area's for the proposed programme

The expertise required to achieve the desired innovations in processed food comprise ingredient functionality, Product Quality and Consumer Preference and Perception as outlined in figure 1. Industrial benefits typically draw on each of these area's to achieve innovation in the specific area's ranging from consumer insights to producing specific personalised products. The challenge for technology providers is to have the right expertise in place as soon as industry is ready to develop them. In this respect it is essential to develop new capabilities in the 6 specific expertise areas presented in figure 2. To create maximum benefits and focus of this programme for industry we propose to work on 4 of these area's in this programme. The other 2 work packages will be developed in other initiatives.

3. Objectives and Knowledge Questions

This programme is founded on the ambition to develop technology required for a long term innovation strategy to improve both healthy composition as well organoleptic quality of processed food in relation to changing consumer behaviour and demand. In general, the programme aims to create new expertise and capabilities to meet the future innovation demands for processed food products. The industrial application area's are the most prominent innovation demands from the food-industry: Consumer Insights, Clean label processed food products, Reformulation, Customisation and personalised Products.

For Consumer Insights the long term objectives are

- To better understand the food choice behaviour of specific consumer groups
- To better understand how food choice behaviour can be nudged towards healthy and sustainable choices
- To develop technology to measure and predict food preference and appreciation
- To develop technology to apply nudging to specific food products and categories.

For Clean label Processed Food Products the long term objectives are:

- To better understand the functionality of specific additives in relation to product stability and organoleptic properties
- Make better use of current processing technologies to increase shelf-life and stability

- To find new processing methods to remove, replace and reduce undesired additives

For Reformulation the long term objectives are

- To develop physical models that predict how of specific components such as sugar, fats and proteins modulate organoleptic quality of processed food products
- To measure and understand microstructure and texture relations
- To understand how consumers perceive the reformulated products and adjust their preference for reformulated
- To provide new technology to the food industry to improve the healthy composition of processed food products

For Customisation and personal products the long term objectives are

- To understand the specific material properties that allow additive manufacturing of processed food products
- To create new product micro-structures with unique properties
- To develop new production chains that aim at personalised products for specific groups adapted to new information technological possibilities

The exact knowledge development and timing will obviously depend on further scoping of the program in terms of long-term deliverables and anticipated short-term industrial participation. This will be established in discussions with partners and stakeholders in 2015. Furthermore, a number of PPP projects that have been submitted in the recent call for projects from the Topsector Agri-Food also can potentially contribute. Short-term innovation objectives for projects to be defined in this programme are:

- to improve the quality of mixed high protein products
    - For this a project will be set-up in 2015 with industrial partners DSM, Darling, and Friesland Campina
- To improve the healthy composition of products in terms of sodium, sugar and fat content
    - For this a project will be set-up in 2015 to industrial partners specifically looking for new solutions in this area.

More-over the programme will enable collaboration between Dutch innovation centres as outlined in the "Grand Design" document.

4. Impact

Societal, economic and scientific impact

Food Industry has a major influence on our society. From sustainable agricultural production to obesity as a global problem, much of our daily lives depend on the production, availability and consumption of food. Specific societal issues addressed by this programme revolve around the imminent merging of Food and High Tech Systems. The Dutch Top Sectors Agri Food and High Tech Systems and Materials are joining forces to stay frontrunners in these developments. New technology is changing the ways in which the industry produces food ingredients, manufactures food products and distributes them to end users. On the other hand, new technology allow individuals to be more aware of their health status and environmental impact which may result in a more conscious choice of meal components. The strategic innovation program "Customised Processed Food" will allow industry to keep in pace with these developments by linking scientific insights to direct technological advances that are driven by industrial demand. It will empower consumers to eat what they like, while staying healthy and reducing the environmental burden of their food consumption. Innovations in food technology developed in this programme will contribute to:

- Reduction of carbon foot print of food production and consumption education in food waste
- Healthy Diet Choices in a modern society

- Increasing healthy life expectancy
- Enabling elderly a longer independent life style
- Increasing flow of knowledge and new technology into the (classical and slow) food production business, which creates new ventures and new jobs

The economic impact of the food industry is large. In the Netherlands, the topsector AgriFood is the third largest in terms of production next to Chemistry and High Tech Systems and Materials with a net production of 72 Billion Euro's in 2010. In contrast to these other sectors, the expenditure in R&D is rather low around 5% of the added value, resulting a less than average share of knowledge intensive jobs. Financial institutions[2] point out that the main chances for growth are in intrasectoral activities. Thus, co-designing products, integrating value chains which are more open to new partners should arise to keep this sector strong and competitive. the knowledge output of this programme will:

- Enable food ingredient companies to become B2C companies and move forward in the value chain;
- Enable food companies and innovative engineering companies to create new business opportunities by tapping into the larger trend of mass customisation and self-measurement that is driven by ICT;

The net industrial impact will become clear after discussions with potential industrial partners and full definition of the individual projects within the programme.

Importance for TNO/DLO

The global food industry will recognize the joint TNO-DLO expertise build-up in this program and leading multinational food companies will be preferred partner for joint research and development. This collaboration will take an imported role in the Dutch R&D infrastructure. This will result in achieving the specific goals set by the Dutch government, Industry and Knowledge Institutes in the Innovation Contract of the Topsector Agri-Food. Last but not least, the Netherlands will be founding a large scale food research infrastructure capable of taking up a leading role in solving some of the European Horizon 2020 Programme's Societal Challenges.

Knowledge protection

General rules regarding knowledge and IP protection will be determined at a later stage. In principle we will follow the IP and confidentiality arrangements that follow from the PPP-model 1, that complies with the most recent changes in the European State aid framework.

5. Program description

To achieve the desired impact and assure that consumers choose more healthy and sustainable diets consistently, technology that allows industry to make high quality attractive product formats that fit the more individual lifestyle of consumers. The basis for creating these products are a changing set of ingredients as production is becoming more sustainable and changing set of processing conditions as a result of removing undesirable additives. Thus we aim to provide industry with knowledge and technology to more rapidly turn complex food compositions into high quality products. The proposed knowledge development in this programme focusses on 4 important technological development lines that are described as work packages below: Ingredient Functionality, Texture Design, Healthy Composition and Consumer Interaction.

[2] ING rapport Voedingsmiddelenindustrie 2013-2018
Een visie op productie, investeringen en assets in vier branches

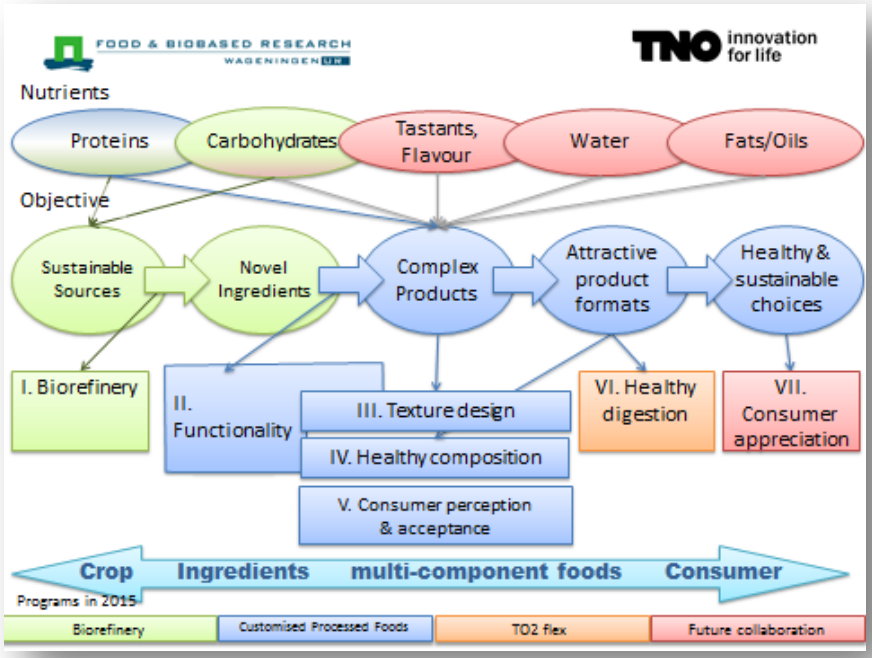

Figure 2. Schematic representation of work packages within this strategic Innovation program and their relation to the other collaborative programs between TNO and DLO

Work package Ingredient Functionality

Development of strategies to rapidly asses the functional properties of ingredients as related to the final organoleptic properties of the product. Technological challenges to be solved are:

- *Development of processing methods to increase the use and technical/functional quality of (natural) ingredients;*
- *Augment flexibility in ingredients exchangeability and robustness of product recipe's;*

The underlying knowledge questions are:

- Understanding the functionality of pure ingredients, partially purified ingredient mixtures and ingredient blends in terms of molecular and supramolecular properties
- Functional synergy of ingredients in complex systems: How to predict the functionality of changing single ingredients in food matrices.
- Understand specific ingredient requirements for Additive Manufacturing processes.

Work package Texture Design:

Develop strategies to rapidly optimize the texture of High Protein, High Fiber products

- Develop new methods for quantitative analysis of microstructure and texture when changes in ingredients composition
- Methods to compensate texture after increasing the sustainable protein content in final products and model products for typical food structures (gels, foams, bi-continuous solids etc)
- Methods to compensate texture after modifying the liquid healthy fats composition in final products and model products for typical food structures (gels, foams, bi-continuous solids etc)
- Methods to compensate texture after incorporating clean label ingredients such as physically modified carbohydrates in final products products and model products for typical food structures (gels, foams, bi-continuous solids etc)
- Synergy in carbohydrate blends, clean label modifications

- Production methods for personalized food products directly related to personal health status for individual consumers.

The underlying knowledge questions are:

- *What are clean label ingredients and clean label modification strategies;*
- *What are specific textural requirements for target groups such as elderly;*

Work package Healthy Composition

Understand the influence of LMW components that contribute to healthy composition and modulate taste and flavour

- Understand and use molecular interactions with of LMW components Ingredients. How do small solutes like salt replacing components and lmw sugars influence solubility / phase
- How do small molecule solutes influence stability Stability of filled emulsion gels and other typical food structures
- Modulate the changes in release / availability that occur under large deformation: melting and breakdown

The underlying knowledge questions are:

- *What are desired nutritional composition in terms of macronutrients;*

Heinz, Mars, Euroma, Fromagerie Bel

Work package Consumer Interaction

aanvullen met perception, acceptance en appreciation doelstellingen

- *Understand consumer perception of naturalness and clean label to guide development of ingredients and product;*
- *Better understanding of consumer acceptance of reformulated and healthy product concepts and development of better methods to predict consumer choice/behaviour;*
- *Study the needs and preferences of target groups to enable the development of technical and virtual tools for production of personalized foods for such target groups ultimately based on personal dietary advice.*

The following issues are also relevant to the aim, but at this point outside the scope of the proposed program.

- Biorefinery of Raw Materials, this is currently developed in the SIP programme "Biorefinery for Raw Material availability and flexibility"
- Healthy Digestion, this is currenty developed in the TO2-Flex program Intestinal Health Screening"
- Understanding and implementing the potential of additive manufacturing technology for the production of customized processed food. Here we envision projects that involve industrial experts to re-evaluate production chains from this new perspective. What-if scenario's that analyse costs and benefits in terms of capex, opex as well as health benefits, ecological footprints and intelligent combinations of these benefits.
- Development of technical & logistic concepts to enable mass customization of processed consumer food product. Here we envision pilot's that demonstrate the full potential of being able to customize processed food products and producing such products on demand.
- Understanding the scale of individualisation and customisation.
- Understanding non-technical barriers in implementation of customized processing techniques for high quality, safe and healthy food products, e.g. food legislation.

6. SIP organisation

Program management

Proper governance of this programme with a portfolio of mixed-funded projects is needed to secure high quality output, monitoring of deliverables, objective and transparent process of initiating and granting project within the program, etc. TNO and DLO will build on existing experience from previous and running PPP's to develop a suitable governance model this year.

Collaboration TNO-DLO

Evidently, all available expertise within TNO and DLO are accessible for this SIP. Some typical fields of expertise the program will invest in are processing technology, microbiology, food physics, ingredient (modification) technology , consumer science , information technology. TNO and DLO are complementary in most of these fields. To fully realise the potential of the program, other Dutch knowledge institutes can and will participate.

Planning

A detailed planning for the coming years will be written after a consultation phase with industry. We also propose to identify running and upcoming topsector PPP-projects and to "use" these as a conceptual first set of projects that will be supported by the knowledge development of this SIP.

2015:

February	- Agreement by theme committee on scope of expertise development
February	- Finalise contracts and governance
March	- Engage and contract Industrial partners
April	- Start of first collaborative projects with completed goals and workplans
July	- fully developped project organisation,
November	- First round of dissemination

Finance

This strategic collaboration serves as a catalyst for joint programming and joint R&D&I in the period 2014-2016, ultimately leading to a solid portfolio of mixed-funded projects with industrial clients, set against the societal challenges mentioned above. This portfolio is built on topsector capacity TNO-DLO, EU, NWO, regional funds, etc.

Breakdown structure of project costs (indicative budget in EUR * 1000)

Year	Budget	Core activities	External funding
2015	500 DLO 500 TNO	Developing first projects with mixed funds; bringing R&D organisation up to speed; Integrating running PPP-projects in the program; setting up and monitoring new projects portfolio management with a permanent stakeholder and partner dialogue; finding continuity in funding	> 250
2016	500 DLO 500 TNO	Id.	> 500
2017 ->	t.b.d.	Leading and managing total portfolio	> 4.000