

Format rapportage projectinformatie PPS-en Landbouw, water, voedsel

Datum versie: 7 december 2020

Uit projectplan (svp zoveel mogelijk invullen)

1. Projectinformatie

1.1 Organisatie/financiering (keuze maken)	TKI A&F/overig
1.2 Projectnummer	AF-15504 TIFN nr 16SS01
1.3 Project titel	Smooth Bite for All
1.4 Projectleider (naam en emailadres)	Markus Stieger markus.stieger@wur.nl
1.5 Startdatum (dd-mm-jjjj)	01-02-2016
1.6 Einddatum (dd-mm-jjjj)	31-03-2020
1.7 MMIP primair (nummer en naam van het MMIP, zie overzicht bijlage 1)	D2 Gezonde voeding een makkelijke keuze
1.8 MMIP secundair (deze alleen invullen als er een 2 ^e MMIP is waar het project aan bijdraagt)	-

2. Projectomschrijving

2.1 Samenvatting

The "Smooth Bite for All" project focused on oral mechanisms involved in sensory perception and food intake regulation in relation to food structure. Factors which contribute to dynamic sensory perception and food intake regulation were established by determining relationships between food properties, oral behaviour and consumer characteristics. The SBfA project contributed to a more comprehensive understanding of how transformations of structural heterogeneities during oral processing provide signals for sensory perception and liking; and how a variety of food structure and texture modifications can be used to steer oral processing behaviour and regulate food intake. The SBfA project demonstrated how oral behaviour can determine bolus properties and consequently explain inter-individual differences in dynamic sensory perception consumers. The SBfA project demonstrated how desired texture and taste sensations can be enhanced by modifications of the food structure (texture contrast). The fundamental knowledge generated by the project helped food industry to develop healthier products. The SBfA project provided guidelines for food industry to stratify and customize product formulations.

2.2 Doel van het project

The aim of the project was to determine the influence of structural and textural food properties and expectations of foods on bolus properties, oral processing behaviour, dynamic sensory perception and liking in consumer groups varying in age, ethnicity and eating capability.

2.3 Motivatie

Increasing concerns regarding overweight and obesity require a better understanding of factors contributing to energy intake. It is of great interest to quantify the extent to which the modulation of food properties such as its texture can be used to steer oral processing behaviour in order to

regulate the amount and energy of food consumed. The SBfA project developed relationships between rheological, mechanical, tribological and texture properties of foods and energy intake.

2.4 Resultaat

The SBfA project demonstrated that oral processing behaviour of a broad range of foods and beverages depends on both food properties and consumer characteristics. The SBfA project described how oral processing behaviour of drinkable, spoonable and chewable foods is determined by rheological and mechanical properties, rather than liking of and familiarity with the foods. We determined inter-individual variability in eating behaviour in consumer groups differing in age, gender and ethnicity. The SBfA project revealed consistent differences in eating rate of a broad range of foods and beverages between males and females, between adults and elderly as well as between Chinese and Dutch consumers. The SBfA project observed that oral physiological characteristics of consumers explain inter-individual variations in oral processing behaviour only to a very limited extend and suggested that other physiological and cultural factors might explain the inter-individual variations better. This knowledge can be used to contribute to the development of customized foods targeted towards specific consumer groups.

The SBfA project demonstrated how food structure and texture modifications can be used to influence eating behaviour and regulate food intake. Structure and texture manipulations cause considerable changes in dynamic sensory perception and can be applied to regulate energy intake. The SBfA project showed how addition of particles such as fruit, granola or vegetable pieces to food matrices such as yogurts, soups and processed cheeses affects eating behaviour and eating rate. The SBfA project revealed which specific properties of the added particles (Young's modulus, fracture stress and strain, particle size and number) steer oral processing behaviour. Eating rate of semi-solid foods can be slowed down by addition of particles by up to 60% while increasing liking. The SBfA project showed that more subtle, smaller modifications of food texture, for example size of granola particles added to yogurt, can be sufficient to influence oral processing behaviour and consequently regulate food and energy intake. The SBfA project demonstrated that the addition of particles to food matrices with undesirable texture properties can be used to shift consumers perception towards desirable sensations. The SBfA project suggested that this approach can be used as a novel strategy to compensate for undesired texture perception in, for example, high-protein foods.

Many foods that are consumed on a daily basis are combinations of food items with very different properties, so called composite foods. Examples of composite foods include combinations of toppings such as cheeses with breads or combinations of condiments such as mayonnaises with French fries or salads. Little is known about how the properties of condiments and toppings influence oral behaviour, sensory perception and food intake of composite foods. The SBfA project demonstrated that for composite foods texture perception is driven by the solid carrier whereas flavour perception is driven by the condiments. The SBfA project showed that the sensitivity to discriminate between condiments differing in fat level and viscosity decreases considerably when they are consumed together with carrier foods which has major implications for the development of reformulated, low fat condiments by food industry. The SBfA project showed that addition of condiments to carrier foods assists saliva in the formation of a safe-to-swallow bolus which increases eating rate and can consequently be used to increase vegetable and energy intake in vulnerable populations such as the elderly. The SBfA project demonstrated how the shape and size into which vegetables are cut during food preparation controls eating rate of vegetables and could potentially be used to increase vegetable intake in children and adults. By those means the project revealed several ways how food structure and texture can be modified to influence eating behaviour and regulate food intake.

Regarding food structure modifications at smaller length scales to optimize sensory perception, the project demonstrated how oil droplets in liquid o/w emulsions and semi-solid emulsion-filled gels can

be clustered to modify rheological, mechanical, tribological and sensory properties of foods. The SBfA project developed new methodologies to cluster oil droplets in model o/w emulsions and model emulsion filled gels, so that aqueous phase is entrapped within the oil droplet cluster which increases the effective volume fraction of the oil phase and alters rheological and tribological properties by up to three order of magnitude. The SBfA project showed that the clustering of oil droplets in o/w emulsions and emulsion-filled food gels can be controlled using a variety of methodologies (charge based hetero-aggregation, protein-polyphenol interactions). The SBfA project demonstrated that the length scale of the oil droplet clusters and the interaction strength between oil droplets in a cluster determine sensory perception. The SBfA project suggests that clustering of oil droplets might be used to enhance perception of fat-related sensory attributes and might therefore potentially be a novel tool to reduce fat content in foods without affecting sensory perception.

Furthermore, the SBfA project investigated conceptual ideas and processes underlying dynamic sensory perception, hedonic perceptions and food-evoked emotions of consumers. The SBfA project investigated how consumers conceptualize dominance of sensations using TDS by comparing sensory profiles obtained with different definitions for dominance. The SBfA project demonstrated that different task instructions given to the consumer resulted in similar sensory profiles or as you put it "Instructions do not matter much". The SBfA project modified the TDS methodology by introducing a Hold-down procedure where consumers actively hold down an attribute button to describe their dominant sensation, and release the button when they no longer perceive the attribute as dominant. This 'hold-down' procedure allows to quantify implicit indecisive behaviour in attribute selection. However, no dominance durations between attribute selections were too short to reflect periods of true hesitation of consumers. In sensory evaluations, consumer taste and evaluate usually single bites of foods. Since this does not necessarily reflect perception during normal food consumption, the SBfA project explored perception and liking of foods consumed with multiple bites. The SBfA project demonstrated convincingly that some sensations built-up from first to last bite suggesting that multiple bite sensory evaluations provide additional information about products which cannot be captured by standard single bite evaluations. These findings could be generalized to a broader range of products ranging from cheeses, breads, drink yogurts to vegetarian sausages. Sensory perceptions changed from first to last bite for all products further strengthening the evidence that multiple bite assessments provide additional information about a consumer's food experience beyond first bite perception. The SBfA project demonstrated that the decline of desired and built-up of undesired sensory perceptions from first to last bite contributed to the decline in product liking during consumption. Food-evoked emotions have been suggested to add to the understanding of food choice. The SBfA project compared implicit and explicit measures of food evoked emotions during multiple bite food consumption. The SBfA project observed that the food evoked emotions determined implicitly by facial expressions and explicitly by TDE showed little overlap and were not directly comparable. Only limited changes in food-evoked emotions were observed from first to last bite. The SBfA project showed that food-evoked emotions directly reflect liking and did not provide additional information beyond liking.

The SBfA project published over 30 papers in scientific, peer-reviewed journals. Over 90% of the publications of the SBfA are published in Q1 journals. Some of the publications of the SbfA journal belong to the top 1% and top 10% of the most cited publications in the field. All six PhD projects of the SBfA project were completed and successfully defended in-time. Five out of six PhD's started to work for food industry or in academia shortly after completion of the PhD thesis. All team members of the SBfA project including its industrial partners Groupe Bel, Unilever and FrieslandCampina meet three times per year. In addition, the project team visited each company once per year on their location to ensure knowledge transfer.

Jaarrapportage (svp ook laatste jaar invullen)

3. Status project

3.1 Status project (keuze maken)	<i>Project completed.</i>
3.2 Toelichting incl. voorziene wijzigingen t.o.v. het oorspronkelijke werkplan	-

4. Behaalde resultaten

4.1 Korte beschrijving van de inhoudelijke resultaten

The "Smooth Bite for All" project focused on oral mechanisms involved in sensory perception and food intake regulation in relation to food structure. Factors which contribute to dynamic sensory perception and food intake regulation were established by determining relationships between food properties, oral behaviour and consumer characteristics. The SBfA project contributed to a more comprehensive understanding of how transformations of structural heterogeneities during oral processing provide signals for sensory perception and liking; and how a variety of food structure and texture modifications can be used to steer oral processing behaviour and regulate food intake. The SBfA project demonstrated how oral behaviour can determine bolus properties and consequently explain inter-individual differences in dynamic sensory perception consumers. The SBfA project demonstrated how desired texture and taste sensations can be enhanced by modifications of the food structure (texture contrast). The fundamental knowledge generated by the project helped food industry to develop healthier products. The SBfA project provided guidelines for food industry to stratify and customize product formulations.

4.2 Deliverables

- *Scientific knowledge on interrelationships between food structures, structural heterogeneities, bolus properties, food oral processing, expectations, sensory and emotion perception and liking in different consumer groups*
- *Understanding of interactions between temporal sensory, emotional and hedonic perceptions*
- *Guidelines for food industry to efficiently and selectively stratify and customize product formulations*
- *Over 30 publications in scientific, peer reviewed journals*
- *6 PhD theses*
- *Expert discussion meetings: All team members meet with the the industrial partners of the project (Groupe Bel, Unilever and FrieslandCampina) three times per year (12 times in total)*
- *SBfA project team visited each company around once per year at their R&D centre.*

4.3 Communicatie (lijsten)

4.3.1 Wetenschappelijke artikelen en hun doi (*Digital Object Identifiers*)

29. Ketel, E.C.; Zhang, Y.; Jia, J.; Wang, X.; de Wijk, R.; Chen, J.; Stieger, M. (2021) Comparison of and relationships between oral physiology, anatomy and food oral processing behavior of Chinese (Asian) and Dutch (Caucasian) consumers differing in age. *Physiology & Behaviour.* 113284. <https://doi.org/10.1016/j.physbeh.2020.113284>
28. Aguayo-Mendoza, M.G.; Chatonidi, G.; Piqueras-Fiszman, B.; Stieger, M. (2021) Linking oral processing behavior to bolus properties and dynamic sensory perception of processed cheeses with bell pepper pieces. *Food Quality and Preference.* 88: 104084. <https://doi.org/10.1016/j.foodqual.2020.104084>
27. Ketel, E.; de Wijk, R.A.; de Graaf, C.; Stieger, M. (2020) Effect of cross-cultural differences on thickness, firmness and sweetness sensitivity. *Food Research International.* 109890. <https://doi.org/10.1016/j.foodres.2020.109890>
26. Aguayo-Mendoza, M.G.; Martinez, E.; Piqueras-Fiszman, B.; Stieger, M. (2020) Differences in oral processing behavior of consumers varying in age, gender and ethnicity lead to changes in bolus properties but only small differences in dynamic texture perception of sausages. *Food & Function.* 11: 10022-10032. DOI: [10.1039/D0FO01835J](https://doi.org/10.1039/D0FO01835J)
25. van Eck, A.; Stieger, M. (2020) Oral processing behavior, sensory perception and intake of composite foods. *Trends in Food Science and Technology.* 106: 219-231. <https://doi.org/10.1016/j.tifs.2020.10.008>
24. van Eck, A.; Franks, E.; Vinyard, C. J.; Galindo-Cuspinera, V.; Fogliano, V.; **Stieger, M.**; Scholten, E. (2020) Sauce it up: Influence of condiment properties on chewing behavior, bolus formation and sensory perception of solid foods. *Food & Function.* 11: 6186-6201. DOI: [10.1039/D0FO00821D](https://doi.org/10.1039/D0FO00821D)
23. van Eck, A.; van Stratum, A.; Achlada, D.; Goldschmidt, B.; Scholten, E.; Fogliano, V.; Stieger, M.; Bolhuis, D. (2020) Cracker shape modifies *ad libitum* snack intake of crackers with cheese dip. *British Journal of Nutrition.* 124(9): 988-997. <https://doi.org/10.1017/S0007114520002056>
22. van Bommel, R.; Stieger, M.; Visalli, M.; de Wijk, R.; Jager, G. (2020) Does the face show what the mind tells? A comparison between dynamic emotions obtained from facial expressions and Temporal Dominance of Emotions (TDE). *Food Quality and Preference.* 85: 103976. <https://doi.org/10.1016/j.foodqual.2020.103976>
21. Aguayo-Mendoza, M.; Santagiuliana, M.; Ong, X.; Piqueras-Fiszman, B.; Scholten, E.; Stieger, M. (2020) How addition of peach gel particles to yogurt affects expectations, sensory perception and oral behavior of consumers differing in age. *Food Research International.* 134: 109213. <https://doi.org/10.1016/j.foodres.2020.109213>
20. Fuhrmann, P.L.; Sala, G.; Scholten, E.; Stieger, M. (2020) Influence of clustering of protein-stabilised oil droplets with proanthocyanidins on mechanical, tribological and sensory properties of o/w emulsions and emulsion-filled gels. *Food Hydrocolloids.* 105: 105856. <https://doi.org/10.1016/j.foodhyd.2020.105856>
19. Ketel, E.C.; de Wijk, R.; de Graaf, C.; **Stieger, M.** (2020) Relating oral physiology and anatomy of consumers varying in age, gender and ethnicity to food oral processing behaviour. *Physiology & Behaviour.* 215: 112766. <https://doi.org/10.1016/j.physbeh.2019.112766>

18. Santagiuliana, M.; Broers, L.; Sampedro Marigómez, I.; Stieger, M.; Piqueras-Fiszman, B.; Scholten, E. (2020) Strategies to compensate for undesired gritty sensations in foods. *Food Quality and Preference*. 81: 103842. <https://doi.org/10.1016/j.foodqual.2019.103842>
17. Fuhrmann, P.L.; Sala, G.; Stieger, M.; Scholten, E. (2020) Effect of oil droplet inhomogeneity at different length scales on mechanical and sensory properties of emulsion-filled gels: Length scale matters. *Food Hydrocolloids* 101: 105462. <https://doi.org/10.1016/j.foodhyd.2019.105462>
16. Fuhrmann, P.L.; Aguayo-Mendoza, M.G.; Jansen, B.; Stieger, M.; Scholten, E. (2020) Characterisation of friction behaviour of intact soft solid foods and food boli. *Food Hydrocolloids*. 100: 105441. <https://doi.org/10.1016/j.foodhyd.2019.105441>
15. van Eck, A.; Wijne, C.; Fogliano, V.; Stieger, M.; Scholten, E. (2019) Shape up! How shape, size and addition of condiments influence eating behaviour of vegetables. *Food & Function*. 10 : 5739-5751. DOI: [10.1039/C9FO01206K](https://doi.org/10.1039/C9FO01206K)
14. Santagiuliana, M.; Marigómez, I.S.; Broers, L.; Hayes, J.; Piqueras-Fiszman, B.; Scholten, E.; Stieger, M. (2019) Exploring variability in detection thresholds of microparticles through participant characteristics. *Food & Function* 10 (9): 5386-5397. <https://doi.org/10.1039/C9FO01211G>
13. van Bommel, R.; Stieger, M.; Boelee, N.; Schlich, P.; Jager, G. (2019) From first to last bite: Temporal dynamics of sensory and hedonic perceptions using a multi-intake approach. *Food Quality and Preference*. 78: 103748. <https://doi.org/10.1016/j.foodqual.2019.103748>
12. Fuhrmann, P.L.R.; Kalisvaart, L.C.M.; Sala, G.; Scholten, E.; Stieger, M. (2019) Clustering of oil droplets in o/w emulsions enhances perception of oil-related sensory attributes. *Food Hydrocolloids* 97: 105215. <https://doi.org/10.1016/j.foodhyd.2019.105215>
11. Doyennette, M.; Aguayo-Mendoza, M.G.; Williamson, A.M.; Martins, S.I.F.S.; Stieger, M. (2019) Capturing the impact of oral processing behaviour on consumption time and dynamic sensory perception of ice creams differing in hardness. *Food Quality and Preference*. 78: 103721. <https://doi.org/10.1016/j.foodqual.2019.103721>
10. Santagiuliana, M.; Scholten, E.; Piqueras-Fiszman, B.; Stieger, M. (2019) Don't judge new foods by their appearance! How visual and oral sensory cues affect sensory perception and liking of novel, heterogeneous foods. *Food Quality and Preference*. 77: 64-77. <https://doi.org/10.1016/j.foodqual.2019.05.005>
9. Fuhrmann, P.L.R.; Sala, G.; Stieger, M.; Scholten, E. (2019) Clustering of oil droplets in o/w emulsions: Controlling cluster size and interaction strength. *Food Research International*. 122: 537-547. <https://doi.org/10.1016/j.foodres.2019.04.027>
8. Ketel, E.C.; Aguayo-Mendoza, M.G.; de Wijk, R.A.; de Graaf, C.; Piqueras-Fiszman, B.; Stieger, M. (2019) Age, gender, ethnicity and eating capability influence oral processing behaviour of liquid, semi-solid and solid foods differently. *Food Research International*. 119: 143-151. <https://doi.org/10.1016/j.foodres.2019.01.048>
7. Santagiuliana, M.; van den Hoek, I.A.F.; Stieger, M.; Scholten, E.; Piqueras-Fiszman, B. (2019) As good as expected? How consumer expectations and addition of vegetable pieces to soups influence sensory perception and liking. *Food & Function*. 10: 665-680. <https://doi.org/10.1039/C8FO01800F>

6. van Eck, A.; Fogliano, V.; Scholten, E.; Stieger, M. (2019) Adding condiments to foods: How does static and dynamic sensory perception change when bread and carrots are consumed with mayonnaise? *Food Quality and Preference* 73: 154-170. <https://doi.org/10.1016/j.foodqual.2018.11.013>

5. van Eck, A.; Hardeman, N.; Karatza, N.; Scholten, E.; Fogliano, V.; Stieger, M. (2019) Toppings assist saliva in bolus formation: Oral processing behavior and dynamic sensory perception of bread and crackers with and without toppings. *Food Quality and Preference*. 71: 497-509. <https://doi.org/10.1016/j.foodqual.2018.05.009>

4. van Bommel, R.; Stieger, M.; Schlich, P.; Jager, G. (2019) Dutch consumers do not hesitate: Capturing implicit 'no dominance' durations using Hold-down Temporal Dominance methodologies for sensations (TDS) and emotions (TDE). *Food Quality and Preference* 71: 332-342. <https://doi.org/10.1016/j.foodqual.2018.08.008>

3. Aguayo-Mendoza, M.G.; Ketel, E.C.; van der Linden, E.; Forde, C.G.; Piqueras-Fiszman, B.; Stieger, M. (2019) Oral processing behavior of drinkable, spoonable and chewable foods is primarily determined by rheological and mechanical food properties. *Food Quality and Preference* 71: 87-95. <https://doi.org/10.1016/j.foodqual.2018.06.006>

2. Santagiuliana, M.; Christaki, M.; Piqueras-Fiszman, B.; Scholten, E.; Stieger, M. (2018) Effect of mechanical contrast on sensory perception of heterogeneous foods: a mechanistic approach. *Food Hydrocolloids* 83: 202-212. <https://doi.org/10.1016/j.foodhyd.2018.04.046>

1. Santagiuliana, M.; Piqueras-Fiszman, B.; van der Linden, E.; Stieger, M.; Scholten, E. (2018) Mechanical properties affect sensory detectability of texture contrast in heterogeneous food gels. *Food Hydrocolloids* 80: 254-263. [10.1016/j.foodhyd.2018.02.022](https://doi.org/10.1016/j.foodhyd.2018.02.022)

Submitted papers

1. van Eck, A.; Pedrotti, M.; Brouwer, R.; Supamong, A.; Fogliano, V.; Scholten, E.; Biasioli, F.; Stieger, M. Cognitive factors drive flavor perception of composite foods more than in-nose flavor release. (under review)

2. van Bommel, R.; Stieger, M.; Jager, G. Beyond the first bite and sip: Temporal dynamics of foods using multiple bite/sip evaluations employing TDS and TCATA. (under review).

3. van Bommel, R.; Stieger, M.; Jager, G. Instructions do not matter much: Definition of dominance (attentional capture vs. intensity) provided to consumers in Temporal Dominance of Sensations (TDS) does not influence dynamic sensory profiles. (under review).

4. Fuhrmann, P.L.; Breunig, S.; Sala, G.; Sagis, L.; Stieger, M.; Scholten, E. Rheological behaviour of attractive emulsions with tuneable droplet-droplet interactions. (under review).

4.3.2 Rapporten/artikelen in vakbladen

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4.3.3 Overige communicatie-uitingen

- >60 oral presentations at international conferences
- >40 poster presentations at international conferences
- 6 PhD theses

4.4 Overige resultaten
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4.5 Projectwebsite
https://www.tifn.nl/smooth-bite-for-all/

Eindrapportage

5. TRL bij afsluiting van een project

Technology Readiness Level (TRL) van de technologie bij afsluiting van het project. Er zijn twee indicatoren die verschillen in detailniveau. Vul zo mogelijk het detailniveau in. Als dat niet mogelijk is, vul dan de hoofdcategorie in.

5.1 Hoofdcategorie (<i>keuze maken</i>)	Fundamenteel onderzoek (TRL 1-3)
5.2 Detailcategorie bij start van het project (<i>in cijfers, nummer van de betreffende categorie, zie bijlage voor toelichting</i>)	TRL 1-2
5.3 Detailcategorie bij afsluiting van het project	TRL 2-4

6 Status project bij afronding

Status project (<i>keuze maken</i>)	1. Het project is afgerond conform de oorspronkelijk scope. Alle mijlpalen zijn behaald.
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7 Output over het hele project

		aantal
7.1	Aantal gerealiseerde wetenschappelijke publicaties <i>gepubliceerde artikelen in peer-reviewed journals</i>	30
7.1 lijst	Zie lijst onder 4.3.1 (incl. doi)	
7.2	Aantal verwachte wetenschappelijke publicaties <i>publicaties waarvan verwacht wordt dat ze gepubliceerd zullen worden in een peer-reviewed journal</i>	4
7.2 lijst	Zie lijst onder 4.3.1	
7.3	Aantal gerealiseerde niet-wetenschappelijke publicaties <i>rapporten, vakbladartikelen</i>	0
7.4	Aantal aangevraagde patenten <i>Het aantal patenten die op basis van onderzoek uit het project zijn aangevraagd</i>	0

7.5	Aantal verleende licenties <i>Het aantal verleende licenties die op basis van onderzoek uit het project zijn verleend</i>	0
7.6	Aantal prototypes <i>Het aantal gerealiseerde prototypes die op basis van onderzoek uit het project zijn ontwikkeld</i>	0
7.7	Aantal demonstrators <i>Het aantal gerealiseerde demonstrators die op basis van onderzoek uit het project zijn ontwikkeld</i>	0
7.8	Aantal spin-offs/ spin-outs <i>Het aantal spin-offs en spin-outs die op basis van onderzoek uit het project zijn voortgekomen.</i>	0
7.9	Aantal nieuwe of verbeterde producten/ processen/diensten geïntroduceerd <i>Het aantal producten dat verbeterd of nieuw ontwikkeld is/wordt en het aantal processen en diensten die verbeterd of nieuw is op basis van onderzoek uit het project.</i>	?
7.9 lijst		

8 Impact

Beschrijf de impact van het project

The "Smooth Bite for All" project contributed to a more comprehensive understanding of how transformations of structural heterogeneities during oral processing provide signals for sensory perception and liking; and how a variety of food structure and texture modifications can be used to steer oral processing behaviour and regulate food intake. The SBfA project demonstrated how oral behaviour can determine bolus properties and consequently explain inter-individual differences in dynamic sensory perception consumers. The SBfA project demonstrated how desired texture and taste sensations can be enhanced by modifications of the food structure (texture contrast). The fundamental knowledge generated by the project helped food industry to develop healthier products. The SBfA project provided guidelines for food industry to stratify and customize product formulations targeted towards the needs of consumers. The guidelines provided by the SBfA project contributed to the research and product development activities of Groupe Bel, Unilever and FrieslandCampina. The SBfA project performed fundamental scientific research (TRL 1-3) and delivered over 30 publications in excellent journals. The project considerably strengthened the networks of all partners involved.

Bijlage 1 MMIP's

KIA: Landbouw, water en voedsel	
MMIP	A1 Verminderen fossiele nutriënten, water en stikstofdepositie
	A2 Gezonde, robuuste bodem en teeltsystemen gebaseerd op agro-ecologie en zonder schadelijke emissies naar grond- en oppervlaktewater
	A3 Hergebruik zij- en reststromen
	A4 Eiwitvoorziening voor humane consumptie uit (nieuwe) plantaardige bronnen
	A5 Biodiversiteit in de kringlooplandbouw
	B1 Emissiereductie methaan veehouderij
	B2 Landbouwbodems, emissiereductie lachgas en verhoging koolstofvastlegging
	B3 Vermindering veenoxidatie veenweide
	B4 Verhoging vastlegging koolstof in bos en natuur
	B5 Energiebesparing, -productie en -gebruik
	B6 Productie en gebruik van biomassa
	C1 Klimaatbestendig landelijk gebied voorkomen van wateroverlast en watertekort
	C2 Klimaatadaptieve land- en tuinbouwproductiesystemen
	C3 Waterrobuust en klimaatbestendig stedelijk gebied
	C4 Verbeteren waterkwaliteit
	D1 Waardering van voedsel
	D2 Gezonde voeding een makkelijke keuze
	D3 Veilige en duurzame primaire productie
	D4 Duurzame en veilige verwerking
	E1 Duurzame Noordzee
	E2 Natuur-inclusieve landbouw, visserij en waterbeheer in Caribisch Nederland
	E3 Duurzame rivieren, meren en intergetijdengebieden
	E4 Overige zeeën en oceanen
	E5 Visserij
	F1 Verduurzamen en kostenbeheersing uitvoeringsprojecten waterbeheer
	F2 Aanpassen aan versnelde zeespiegelstijging en toenemende weersextremen
	F3 Nederland Digitaal Waterland
	F4 Energie uit water
	ST1 Smart Agri-Horti-Water-Food
	ST2 Biotechnologie en Veredeling

Bijlage 2 TRL-categorieën

De detailcategorieën bestaan uit:

TRL 1 – basisprincipes zijn geobserveerd en gerapporteerd

TRL 2 – technologisch concept en/of toepassing is geformuleerd

TRL 3 – kritische functie of karakteristiek is analytisch en experimenteel bewezen

TRL 4 – component of experimenteel model is gevalideerd in laboratoriumomgeving

TRL 5 – component of experimenteel model is gevalideerd in relevante omgeving

TRL 6 – systeem/subsysteem model of prototype is gedemonstreerd in een relevante omgeving

TRL 7 – prototype van het systeem is gedemonstreerd in een operationele omgeving

TRL 8 – daadwerkelijk systeem is compleet en gekwalificeerd door test en demonstratie

TRL 9 – daadwerkelijk systeem is bewezen door succesvol operationeel bedrijf