Satiety Control Through Food Structures
Made by Novel Processing:

Generating Novel Food Structures to Aid Consumer Weight Management

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Department of Psychological Sciences, University of Liverpool

This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement n°289800
Despite advances in the
i) measurement of appetite expression and the biomarkers underpinning the processes of satiation and satiety,
ii) understanding of the impact of nutrient composition
iii) knowledge of the physical characteristics of food on eating behaviour

Few satiety-enhancing products have successfully remained in the European market, due to the failure of producing effective and appealing products.
Aim:
Translation of science and technology into product

The SATIN consortium aimed to develop novel food products for European consumers through processing innovation that will enhance satiety and help to achieve a balanced diet.

The multidisciplinary collaboration will develop food products that help regulate food intake by accelerating satiation during a meal, enhancing satiety and/or reducing appetite through novel processing methods and validate these products in human trials by examining key biomarkers, nutrient availability and behaviour.
The Consortium

SATIN consortium

7 SME’s

7 Universities

5 Industry Partners

Advisory Board

www.satin-satiety.eu
SATIN Objectives

1. INTEGRATE ADVANCED TECHNOLOGIES to screen novel food structures through in vitro models to isolate and refine products according to their satiating potential.

2. DEVELOP NOVEL FOOD PROCESSING TECHNOLOGIES that combine active ingredients and changes in food structure to produce a range of novel satiety enhancing ingredients.

3. PRODUCE FINISHED FOOD PRODUCTS that pass through safety analysis, early sensory evaluation and consumer testing.

4. DEMONSTRATE THE EFFECTS OF PROTOTYPE PRODUCTS on biomarkers of satiety and on nutrient bioavailability using in vivo studies and validating new in vivo approaches.

5. DEMONSTRATE THE EFFECTS OF FINAL FOOD PRODUCTS on within-meal satiation, post-meal satiety and/or reduced appetite using biomarkers of satiety.

6. DEMONSTRATE THE ENDURING EFFECTS OF INDIVIDUAL FOOD PRODUCTS on satiety and their potential to induce weight loss.

7. DEMONSTRATE THE LONG-TERM CONSUMER AND HEALTH BENEFITS of adhering to a diet containing satiety-enhancing products.

8. VALIDATE HEALTH CLAIM ENDPOINTS AND COMMERCIALISE.

Phase 1
WPs 1, 2 & 3
COMPLETE
80 prototypes

Phase 2
WPs 4, 5 & 6
ON GOING
8 clinical studies
Satiety Cascade
Concepts designed to hit multiple mechanisms

Meal Quality
- Consumer appeal
- Flavour
- Texture
- Nutrient composition

Meal Quantity
- Oral metering
- Osmotic load
- Gastric stretch
- Gastric emptying

Nutrient status
- Microbiota
- Gut biomarkers
- Nutrient absorption
- Substrate oxidation

Cognitive Sensory

Pre-Absorptive

Pre-prandial motivation
Food
Termination of meal
Inhibition of food intake
Onset of next meal

SATIATION
Satiety
SATIETY
SATIATION

early
late

Finlayson & Blundell, 2012

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# Acute trials: Prototypes moving from WP2 to WP4

<table>
<thead>
<tr>
<th>Short term study</th>
<th>Satin product</th>
<th>Lead partner</th>
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<tbody>
<tr>
<td>1</td>
<td>Yoghurt-pudding with modified texture and Satiagel 38</td>
<td>ULEE</td>
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<tr>
<td>2</td>
<td>Pineapple juice with Kemfe and Red Ginseng</td>
<td>ULEE</td>
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<td>3</td>
<td>Fishballs with Viscogum</td>
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<td>4</td>
<td>Tomato soup with Polydextrose</td>
<td>ULIV</td>
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<td>5</td>
<td>Orange Nectar with NAXUS LC fibre</td>
<td>UCPH</td>
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<tr>
<td>6</td>
<td>Pineapple juice with Viscofibre and Red Ginseng</td>
<td>UCPH</td>
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**Yoghurt/Pudding (Satiagel ADG38)**

**Fish balls (Viscogum)**

**Orange juice (Naxus LC)**

**Pineapple nectar (Red Ginseng; Viscofibre)**

**Tomato juice (Polydextrose)**
Yoghurt/Pudding Matrix

Functional optimised dairy structures

Multi-trigger product concept

- Yoghurt: flavour release & textural effects (EPS) → satiation (oral cavity)
- Pudding: protein-polysaccharide (carrageenan) interaction → early satiety (stomach).
- Potential post-absorptive effects when applying appropriate dosage

- 150 mL serving size; energy density 70-95 kcal per serving

<table>
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Within-subjects design

Acute study 1 - Yoghurt Pudding

Arrive at laboratory

Fixed Breakfast (25% RMR)

Fixed Lunch (20% RMR) Ad lib active or control dessert

Dinner Snack box

Free to leave laboratory

Subjects design

Acute study 1

Yoghurt Pudding
Results - Yoghurt Pudding
Enhanced satiation and lack of post meal caloric compensation

<table>
<thead>
<tr>
<th></th>
<th>Active</th>
<th>Control</th>
<th>% Difference</th>
<th>p value</th>
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<tbody>
<tr>
<td>Yoghurt pudding (g)</td>
<td>199.6 (117.2)</td>
<td>251.0 (149.2)</td>
<td>20.4</td>
<td>.002</td>
</tr>
<tr>
<td>Yoghurt pudding (kcal)</td>
<td>115.8 (68.0)</td>
<td>140.6 (83.5)</td>
<td>17.6</td>
<td>.006</td>
</tr>
<tr>
<td>Dinner (g)</td>
<td>774.6 (281.9)</td>
<td>790.3 (313.5)</td>
<td>2.0</td>
<td>.576</td>
</tr>
<tr>
<td>Dinner (kcal)</td>
<td>1569.1 (588.7)</td>
<td>1615.2 (696.8)</td>
<td>2.9</td>
<td>.458</td>
</tr>
<tr>
<td>Snacks (g)</td>
<td>198.7 (112.1)</td>
<td>211.1 (119.4)</td>
<td>5.8</td>
<td>.383</td>
</tr>
<tr>
<td>Snacks (kcal)</td>
<td>865.9 (505.2)</td>
<td>923.3 (532.2)</td>
<td>6.2</td>
<td>.367</td>
</tr>
<tr>
<td>Overall (g)</td>
<td>1724.4 (487.7)</td>
<td>1792.6 (525.4)</td>
<td>3.8</td>
<td>.055</td>
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<tr>
<td>Overall (kcal)</td>
<td>3261.8 (992.5)</td>
<td>3395.9 (1154.3)</td>
<td>3.9</td>
<td>.155</td>
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</table>

- Participants consumed fewer calories \(t (30) = 2.92, p<0.01\) and grams \(t (30) = 3.40, p<0.01\) from the active compared to the control yoghurt/pudding.
- Trend for the overall intake of grams \(t (30) = 1.99, p<0.055\) to be lower in the active compared to the control condition.
- Satiety quotient for the active product was greater than for Control yoghurt/pudding, reflecting same hunger suppression for a lower intake.
Tomato Soup with Polydextrose

Functionally optimised vegetable soup via ingredient addition.

- Utilizes processing steps were low pressure homogenization is carried out resulting in larger particle size.
  - Results in a rich mouthfeel that enhances the sensorial properties of the soup impacting the hedonic response of the product.
- Polydextrose ingredient delivers complex carbohydrate resistant to digestion that provides fermentable substrate
  - Aids in reducing energy density
  - Resulting in SCFA generation that may increase the endogenous secretion of gut hormones.

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Acute study 4 – Tomato Soup (on going)

Between-subjects design
4 week dosing
BMI-23-28 Males

Baseline, D1 and D28

-10 0 +60 +120 +180 +240 +300 +360 +420 +480

Free to leave laboratory
Snack box

Arrive at laboratory

Fixed Breakfast (25% RMR)
Fixed active/control Soup
Ad libitum Lunch
Ad libitum Test Meal

www.satin-satiety.eu
Preliminary Results – Soup
Hunger and Fullness – lasting effects?

First Dosing Hunger

Last Dosing Hunger

First Dosing Fullness

Last Dosing Fullness

Preliminary data with low power of detection to date; no significant differences between groups but large end dosing effect size for hunger ($\eta^2=0.30$) and fullness ($\eta^2 = 0.25$).
Volunteers data encrypted in a QR code (QR code scanner included in the App).

Can be used in smartphones and tablets (iphone and ipad to be developed)

Flexible (create your own questionnaires with differing formats (VAS, test, yes/no, true/false,…))

Alarm to fill in questionnaire at desired time (and days).

Excel data exportation
long-term consumer and health benefits WP5

The effect of satiety enhancing products on long-term weight regain prevention will be assessed in WP5 a **12 week multisite intervention**

1. A low calorie drinks containing dietary fibres
2. A pre-mixed pouch drinks containing dietary fibres
3. High protein products containing mycoprotein
Summary

1. Possible to develop product concepts from the platform which targeted multiple components of appetite

2. Two products (and pretested for acceptability) show early indications of potential satiety enhancing effects.

3. Effect sizes are small and it is unlikely any one of these products will be a dramatic effect on daily energy intake.

4. However, a combination of products could allow consumes to more effectively control their appetite and curb energy intake.

5. We lack sufficient proven products in the market to a whole diet approach but WP5 will allow us to examine some long-term metabolic effects and consumer benefits which may inform health-claims.
Thank You

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Dr. Michelle Dalton
Dr. Catherine Gibbons

Dr. Alexandra Johnstone
Prof. Harry Flint

Prof. Anders Sjodin

Santiago Ortega Pérez

Dr. Rianne Ruijschop
• **Acute study 1:** The acute effect of a modified texture and flavour release yoghurt/pudding with Satiagel® made by novel processing on satiety and satiation.
Yoghurt/Pudding (Satiagel ADG38)

**Multi-trigger concept** - product hypothesised to have an impact on both satiation and satiety.

- **SATIATION**: Enhanced flavour release and have textural effect in the oral cavity and alter oral processing of the food.
- **EARLY SATIETY**: protein-polysaccharide (Satiagel - Carrageenan) a gelling agent hypothesised to have an effect through matrix building in the stomach, which would result in a delay of gastric emptying

- 150 mL serving size; energy density 107 (control combi) and 111 (active combi) kcal per 100g

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Summary of findings

Energy intake

• Participants consumed fewer grams (20%) and calories (18%) from the Active compared to the Control yoghurt/pudding – supports the hypothesis.

• There was a trend for overall grams consumed to be less in the Active compared to the Control condition (4%) – suggests there was no compensation for the reduced intake of Active yoghurt/pudding.

Appetite ratings

• There were no differences between the Active versus the Control yoghurt/pudding on self-reported sensations of hunger, fullness, desire to eat or prospective consumption across the test days.

Satiety quotient

• The SQ for the Active product was greater than the SQ for the Control product (reflecting the same suppression in hunger for a lower intake).
Acute study 4: The effect of a high fibre, polydextrose-enriched tomato soup on food intake, the experience of appetite and biomarkers of satiation and satiety
Tomato juice (Polydextrose) – on going

Product concept:

- **SATIATION**: Polydextrose influences immediate satiation due to fibre adding viscosity;
- **SATIETY**: term satiety (after dosing) due to generation of short chain fatty acids (SCFAs) that may increase the endogenous secretion of gut hormones as well as stabilizing blood glucose levels (tested in subset of participants).
- **Adaptation**: 28 days dosing
- 410 g per tin; energy density 25 kcal/100g

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