



# Satiety and Satisfaction

Scientific evidence  
for food products  
that satisfy and satiate





The growing world economy and increasing affluence of many world citizens seems inevitably coupled to a growing number of overweight and obese people. In the past twenty years the number of overweight people has tripled. For the first time in history overweight people outnumber those who are suffering from malnutrition. According to the World Health Organisation (WHO) an estimated ten percent of the total health care expenditure is spent on treatment of obesity related diseases.

# Preface

Scientific evidence can back your health claims

Scientists have learned that overweight and obesity are life style conditions with severe impact on the quality of life. These conditions increase the risk of developing chronic diseases, such as heart failure, colon cancer and diabetes. Seeking solutions for the global obesity problem, aptly dubbed globesity, is imperative.

Wageningen University & Research Centre (Wageningen UR) has been engaged in food, nutrition and epidemiological obesity research for 40 years. As initiator and partner in many public and private programmes Wageningen UR has gained expertise in a wide range of obesity related issues, from nutrigenomics to consumer insight.

We are proud to announce that we have recently started a cutting edge R&D programme that focuses on satiety and satisfaction. We believe that globesity can be conquered by making interventions in food composition, producing functional foods, starting dietary programmes and educating consumers.

Scientific research can decisively determine which food intake patterns are healthy and why. Wageningen UR's extensive knowledge in the matter is accessible to companies in the agro-food sector. Using scientifically tested and supported products and techniques will give companies a solid evidence base for health claims about their products. This will enable them to expand the success of their products and services; indirectly helping consumers to a life style of healthier foods, sustainable food patterns and more physical exercise. Taken together, this programme will help to strengthen the evidence base and means to combat obesity and its health implications.

In this brochure we hope to inform and inspire your organisation and engage you to participate in our programme.

Dr. Charon Zondervan  
Prof. dr. Pieter van 't Veer



Healthy, safe and delicious food is omnipresent and easily accessible in modern society. That has substantially contributed to public health and quality of life for the majority of individuals. At the same time, however, we see a growing obesity epidemic, malnourished elderly people who do not meet their special nutrient needs and countries with a 'double burden': obesity in rich communities and starvation among the poor.

This demonstrates that food choice and health requirements are not in balance. New scientific strategies and market solutions are needed to tackle today's and tomorrow's issues in food, nutrition and health.

# Food, nutrition, health and behaviour in a broader scope

Making the healthy choice an easy choice

Our new 'Satiety & Satisfaction' programme focuses on the intriguing relationship between the immediate sensory effects of food and the long term health effects.

Moreover, the global food supply is increasingly shaped by public health issues. There is a growing demand for healthy alternatives and the market is changing accordingly.

Physiological, metabolic and molecular research has revealed which feedback mechanisms within the body trigger the urge to consume and how the body, in the short and long term, reacts to the intake of food. Whereas sociological research has proven that food choice and eating patterns are strongly influenced by the social environment. Scientists from Wageningen UR explore all these fields.

To provide practical alternatives for unhealthy eating habits, we compile conceptual designs for chilled meals, prepared with fresh, minimally processed, satiating ingredients. Solutions like these fit perfectly into current consumer trends like the 'on the go' life style, and responds to demands for organic, fresh and fair trade ingredients as well.



The 'satiety and satisfaction' program focuses its research on combating obesity by changing the satiating properties of food products, while exploring ways to reward consumers that make the healthy choice.

'Satiety & satisfaction' provides solid scientific evidence of the efficacy of nutrients. The results of our research are accessible for companies in the agro-food industry, which gives them an advantage in a highly competitive food market to deliver new products with a solid evidence base. It also helps policy makers to identify effective, evidence based interventions.

# R&D programme

Fourty percent of Dutch adults are overweight, ten percent are obese

Being overweight or obese poses a threat to those who suffer from it. Short-term physical problems are obvious: overall fitness decreases, joints and organs get strained and small seats in cars and planes lead to uncomfortable situations. Social problems are evident too: obese people have low self esteem (although the causal relationship works both ways) and are at risk of social isolation. Being overweight or obese is also a serious threat to the physiological state on the longer term, and the burden on health care is considerable. Currently, 40% of Dutch adults are overweight ( $25 \text{ kg/m}^2 > \text{BMI} < 30 \text{ kg/m}^2$ ) and 10% are obese ( $\text{BMI} > 30 \text{ kg/m}^2$ ). The figures have roughly doubled since the 1980s. The overweight epidemic among children is a special concern; some US researchers even suggest that parents may outlive the younger generation because of this.

However, explaining the situation may be simple, solving the problem is a major societal challenge. Overweight and obesity are truly societal issues: the factors that contribute to weight gain are diverse and complex. They are a combination of socio-economic and demographic aspects (activity-extensive jobs, abundance of food, wealth) and a gradually changed attitude towards food products and food consumption. It would be too simple to state that overweight is a problem of disinhibited (or morally weak) people, arguing that healthy eating is a choice all consumers can freely and willingly make. It is also too simple to regard the issue as a matter of 'more calories in than out'. Factors that prevent weight gain seem to differ from factors that improve weight loss.

We pose that increasing the satiating power of food products changes eating habits and positively influences the physiological condition of human beings



Difficulties in counter-acting obesity are for example:

- consumers' apparent inability to act on their own healthy intentions;
- a lacking choice of healthy food products amidst a huge availability of less healthy options;
- little consumer knowledge and awareness on the relationship between obesity and the onset of chronic diseases later in life.

A promising intervention to reduce food intake is to enhance an important asset: the power to satiate and satisfy the consumer. Processed foods have, to a large extent, lost the power to satiate. They are often energy dense and easy to chew; instantly providing the human body with a calorie overload, but lacking the ability to satiate. What's more, processed foods are predominantly consumed out-of-home, in a context where attention is focused on anything but the food.

These aspects lead to overconsumption and, ultimately, increased body weight. We pose that increasing the satiating power of food products changes eating habits and positively influences the physiological condition of human beings.

The objective of the programme could be summarized as finding the regulation of food consumption, in particular the relation between energy and macro-nutrient intake on the one hand and satiety and health on the other.

# Regulation of food consumption

Subprojects of the Satiety & Satisfaction Program



## 1 Plant derived foods

Projecttitle

Mum, can I have Brussels sprouts again?



## 2 Food pattern

Projecttitle

The effects of the introduction of satiety enhancing foods on consumer purchase, consumption and nutrient intake levels



## Food Guidelines & Goals

Food based dietary guidelines (GR)

Policy goals

(NL, EU, WHO)

'What shall we eat?'

(Wageningen UR, TNO, RIVM)

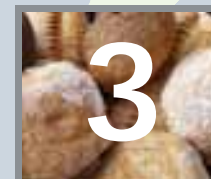
The obesogenic society (Rathenau / LEI Wageningen UR)



## 4 Regulation

Projecttitle

Fermentation to prolong satiety



## 3 Health effect

Projecttitle

Food, fiber and health, an integrated approach



# 1

## Mum, can I have Brussels sprouts again?

The aversion to vegetables is mainly caused by their low energy content

Prof. Kees de Graaf

The subproject 'Mum, can I have Brussels sprouts again?' will result in:

- tools to develop attractive, satiating and satisfying vegetable products for infants, adolescents and young adults;
- development of behavioural observation techniques to use on infants;
- know-how of food preferences of infants.

If all Europeans would abide by the daily recommended intake for fruit and vegetables, the turnover of the fruit & veg industry would increase by 40 billion euro a year. Stimulating vegetable consumption, among all age groups, is a major challenge. We can start by breaking the circle of taste preferences that are learned very early in life, which often lead to a persisting vegetable dislike. Exposing young children to tastes and flavours of vegetables with enhanced energy density, could stimulate an appetite for vegetables later in life.

<sup>1</sup> De Graaf, C. et al. (2008). 'The effect of viscosity on ad libitum food intake' *Int J Obesity* 32, 676 - 683.

Most human food preferences are learned through mere exposure, imitation and conditioning principles. The aversion to vegetables is mainly caused by the low energy content of vegetables. Food that does not lead to high satiety and satisfaction, does not activate the energy conditioned taste preferences.<sup>1</sup> In recent years it has become clear that food preferences are developed very early in life and that they are relatively stable; they commonly track into adulthood. Hence, in order to increase vegetable consumption it is essential to study the development of food preferences in early childhood and actively develop the taste preferences, perhaps by (artificially) enhancing the energy levels of vegetables.

# 2

## The effects of the introduction of satiety enhancing tools on consumer purchase, consumption and nutrient intake levels

Public health and economic value should be taken into consideration

Prof. Hans van Trijp

The subproject 'The effects of the introduction of satiety enhancing tools on consumer purchase, consumption and nutrient intake levels' results in:

- Optimal communication of the concept of satiety value to consumers and effective positioning of plant-derived satiety enhancing foods.
- Understanding the role and survival of physiological and psychological satiety indications in the context of other food-related cues that stimulate overconsumption both at the moment of purchase (in store) and consumption (eating situations).
- Developing methods to assess and quantify the impact of the market introduction of these new foods on the total food purchases, nutrient (caloric) intake, and substitution between food products in total food intake.
- Developing world-innovative methodology to exploit household purchase data (as continuously collected through market

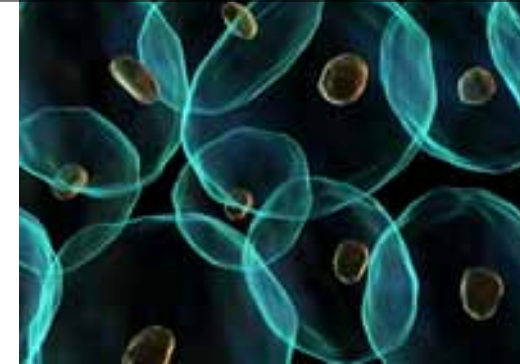
research) to understand nutrient intake at the individual level (i.e. linking household purchase data to VCP data).

Plant-derived foods with enhanced satiety properties provide economic and public health value if:

- 1 such qualities are effectively communicated to consumers;<sup>1</sup>
- 2 the satiety value positively affects food choice and consumption, even in competition with other food-related purchase and consumption cues;
- 3 they do not translate into undesirable; substitution effects in the total food basket,
- 4 lead to more desirable nutrient intake levels.

This subproject provides the scientific evidence base necessary to support the food industry and health organisations in their decisions to maximise the economic impact and public health value of plant-based satiety enhancing foods.

<sup>1</sup> Trijp, J.C.M. et al. (2008). 'Consumer acceptance of nutrigenomics based personalised nutrition' *Br J Nutr*, 13



# 3

## Functionality of dietary fibres in the gut

### Make fibre-rich foods more satiating

Prof. Edith Feskens

The subproject 'functionality of dietary fibres in the gut' will result in:

- knowledge of satiating effects of fibre-rich foods to improve health;
- role of processing in relation to satiating effects of fibre;
- physiological, metabolic and molecular effects of food fibres;
- biomarkers for long-term satiety.

In 2006 the Dutch Health Council judged that a daily fibre intake of 3.4 grams/MJ (14 grams/1000 kcal) is a suitable guideline for adults. That is considerably higher than the current actual intake of 2.3 g/MJ and may be difficult to realise. Dietary fibres are believed to prevent obesity and diabetes by affecting satiety. A variety of mechanisms are involved, such as increasing bulk weight and viscosity in the stomach, decrease in gastric emptying and a higher gut transit time resulting in a lower glycemic index. Other suggested

mechanisms are in fact incited by an increased release of satiety hormones or the later production of short chain fatty acids in the gut. It may well be that the mechanism of increased satiety depends on the type of fibre. This implies that the short-term effect may be different from the longer term effects.<sup>1</sup> Above mentioned nutritional effects of dietary fibre depend on the embedding of those fibres in the food matrix, the (in)solubility of the fibre, the physicochemical characteristics of the fibre (sugar-linkage-composition, molecular weight, charge, viscosity, etc.) and the presence of other fibre-bound food components, such as proteins. Hence, the satiating capacity of fibre-rich foods can be improved by food processing or adapting food composition. This would help consumers to maintain their energy intake at a level that is consistent with a healthy body weight. On the other hand, it would help food manufacturers to design tasty and satiating food products that contain the proper type and amount of fibres.

<sup>1</sup>E.J.M. Feskens et al. (2008). 'Glycemic index and glycemic load in relation to food and nutrient intake and metabolic risk factors in a Dutch population' *Am J Clin Nutr* 87, 655 - 661.

# 4

## Gut fermentation prolongs satiety

### Test results from pigs are often applicable to humans too

Prof. Michael Müller  
Prof. Bas Kemp

The subproject 'Gut fermentation prolongs satiety' will result in:

- an increased understanding of mechanisms in which fermentable non-starch polysaccharides (NSP) prolong satiety in obese vs. non-obese subjects;
- experience in applying an integral approach from molecule to organism; to study mechanisms explaining phenomena observed at the level of the phenotype.

vs. obese, level of physical activity). These detailed interactions between feedback mechanisms and diet- and subject-related factors is poorly understood and subject of this subproject.

The digestive tract in pigs, as well as satiety regulatory mechanisms, are very similar to those in humans. Numerous studies have shown that comprehensive models of digestive processes in pigs are also applicable to humans. The structure of the pig genome bears a lot of similarities with that of the human. Because variation in body condition can be imposed on pigs in a controlled manner (e.g. obesity or exercise), precise and highly relevant dietary intervention studies can be done and easily translated to the situation of humans. Many of these 'omics-tools' are already available for pigs.<sup>2</sup>

Extensive research of Wageningen UR has shown that the fermentable fraction of NSPs induce long term satiety in pigs.<sup>1</sup> Satiety is a result of the combined action of regulatory feedback mechanisms throughout the gastrointestinal tract, like intestinal peptides, hormones, receptors and the post-absorptive action of substrates of digestion e.g. fermentation products. Among these are diet related factors (e.g. nutrient exchanged for the NSPs) and characteristics of the subject (e.g. lean

<sup>1</sup>De Leeuw, J.A. et al. (2008). 'Effects of dietary fibre on behaviour and satiety in pigs'. *Proc. Nutr. Soc.* 67 (4), 334-342.  
<sup>2</sup>Müller, M.R. et al. (2006). 'Nutrigenomics: from molecular nutrition to prevention of disease'. *J Am Diet Assoc* 106 (4), 569 - 576.



The overall theme 'satiety' finds its roots in an increasingly unhealthy nutritional status and life style of modern consumers, in fact of consumers of almost all developed and urban areas of developing countries.

# Scientific basis and challenges

Unhealthy eating habits cause a third of the avoidable disease burden

This chapter does not give a full background on trends in food & nutrition or the growing numbers of overweight and obese people. The potential consequences of unhealthy food intake and dietary behaviour have been addressed in many policy papers. The recent 'white paper obesity' and the 'European Action Plan for Food and Nutrition Policy' are clear statements of their concern. Both documents are built on intervention possibilities, not just by governments on various scales but also by other actors (most notably companies and consumers themselves). Their concern is also evident in the research themes within the EC Framework Programmes, in which the societal angle is captured with 'the needs of consumers, healthy policy and food industry'.

**In the context of our own current strategic plan (2007-2010) the existing know-**

ledge base regarding unhealthy diets has been extensively mapped. This process has led to the present focus on satiety. More knowledge of satiety and the complex ways in which societal, psychological and physiological processes interplay in various time scales should lead to applications in products, services and education. The ultimately goal is improved health conditions and an improved standard of living of consumers, in other words: inducing satiety as well as satisfaction.

## **Changing the food environment**

In the Western world, food is overwhelmingly available, at each moment of the day and on every corner. A safe and efficiently organised food chain has become the basis for increased life expectancy and quality of life for many people. In just two to three generations, the food supply has changed rapidly from food shortage and marginal availability for



The challenge is to optimise the food composition and food patterns in order to comply with the nutrient needs of modern, affluent populations

This challenge requires a close collaboration between agricultural and food industry, food technology, nutritional sciences and consumer sciences



vulnerable children and mothers, into food abundance, widespread overconsumption and reduction of physical activity. This so-called nutrition transition has resulted in changing health and disease patterns, from infectious to chronic diseases, to overweight, diabetes, cardiovascular disease and cancer. Nowadays about one third of the avoidable disease burden can be attributed to an unhealthy diet (RIVM, Our food, our health). Increasing overweight and obesity eradicate prospects for long-term health of individuals and populations during their life span. The changed food and nutritional environment provokes challenges that require an adequate response by combined efforts from science and society.

#### **Nutritional revolution on top of biological evolution**

In contrast to the recent food and nutrition transition, the human genome and human behaviour have developed during thousands of generations under completely different

environmental conditions; thus, our genetic make-up and traditional food habits may not be adequate for today's abundant food supply; similarly, the cornerstones of our knowledge on healthy nutrition have basically developed in a context of undernutrition rather than overnutrition. Apparently, the challenge is to optimise the food composition and food patterns in order to comply with the nutrient needs of modern, affluent populations.

#### **Satiety: Challenge for nutrition and food research**

Our challenge is to develop foods that support adequate regulation of food intake. 'Satiety' is the cornerstone of the programme, since adequate regulation of food intake requires presence of satiating physiologic triggers, optimised composition of macro- and micronutrients for long term health, and suitable for the everyday lifestyle of modern consumers. This requires scientific knowledge

of food characteristics that affect food intake, both from the perspectives of nutrition-physiological and health, as well as from the psychological-sociological perspective. This challenge requires a close collaboration between agricultural and food industry, food technology, nutritional sciences and consumer sciences.

#### **Diverging objectives of food research and of nutrition research**

Nutritional sciences have traditionally focused on average daily requirements for energy and nutrients of individuals and populations, an example is the Dutch recommended daily intakes and the 'Guidelines for a healthy diet' (Netherlands Health Council December 2006). Contrary to this, food technology and industry have traditionally optimised products with respect to food safety, production costs and consumer trends such as convenience. Thus, there are apparently diverging objectives and

research issues in food technology and product development on the one hand, and nutrition and health research on the other hand. More recently, health issues have become leading in developing new products and market shares, as illustrated by slogans like: 'Make the healthy choice the easy choice'. The health issues of affluent populations indeed illustrate that large amounts of individuals fail to make their daily food choice a healthy choice. To answer this challenge food and nutrition research should formulate a common strategy.



Our program helps companies building scientific evidence to support 'satiety' claims that are needed to deliver the promises that are explicitly or implicitly made to improve the consumers wellbeing

# Commercial outlook

Given the number of recent product launches in weight management and appetite suppression, there is certainly a trend in the marketplace of fast moving consumer goods (40 new launches in Q1-08, compared to 60 in 2007 and 32 in 2006; Mintel. Appetite suppression 37 launches in 2007 and 22 in 2006, Innova). For these products 'satiety' is frequently used as unique selling point. The rapidly growing number of new introductions in recent years clearly reflects the consumer's desire to use tasty food products in the context of personal weight management strategies. Commercially, this offers new possibilities for new and existing brands. Our program helps companies building scientific evidence to support 'satiety' claims that is needed to deliver the promises that are explicitly or implicitly made to improve the consumers wellbeing.

We can assist companies in their R&D or innovation projects building on our core competences:

- Nutritional epidemiology
- Health marketing and consumer behaviour
- Intervention trials
- Markers of nutritional health
- Diagnostics
- Animal models for human health
- Food processing
- Food formulation
- Ingredient characterisation
- Ingredient metabolism
- Raw material quality.



# Contact

## Wageningen University and Research Centre (Wageningen UR)

Dr. Charon Zondervan (general information)

Prof. dr. Pieter van 't Veer (research & education)

PO Box 17 6700 AA Wageningen The Netherlands

Charon.Zondervan@wur.nl Pieter.Vantveer@wur.nl

www.satiety.wur.nl

## Partners

Graduate school VLAG (Food Technology, Agrobiotechnology, Nutrition and Health Sciences)

Graduate school Wageningen Institute of Animal Sciences (WIAS)

Mansholt Graduate School for Social Sciences (MG3S)

## Credits

Publisher Wageningen UR

Editor Charon Zondervan

Graphic Design, photoresearch and final editing

Wageningen UR Communication Services

i.c.w. Robbert Zweegman

Photography Shutterstock (8 - 17),

Hollandse Hoogte (1, 2, 4, 6, 18, 20)

Wageningen, January 2009

