AGRICULTURE
ENVIRONMENT

FOOD AND TASTE

INRA

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Taste, and more broadly all organoleptic aspects of food, play an essential role in our diet. Without taste, we would not be capable of choosing the food we need to cover our dietary requirements.

Taste is an important subject of multidisciplinary research. It includes the release of aromas in foods, their detection by receptors, and their transmission in the form of an infinite variety of signals. These allow the construction of a mental sensory image which will ultimately interact with other signals reflecting our social existence and memory, etc.

The taste and odours of foods exert a considerable influence over our dietary behaviour. A major aspect of hedonic pleasure, taste contributes to our quality of life. And of course, it is also an important factor in social recognition and identification. Culinary practices constitute a series of compromises between nutritional requirements and taste. Their transmission thus represents a fascinating synthesis between, on the one hand, the need to meet dietary requirements and the availability of nutrients, and on the other hand, the pleasure of eating.

Xavier Leverve
Scientific Director, Human Nutrition and Food Safety

The sensations perceived while chewing a cheese can be very numerous. A sensory analysis panel can describe each sensation and score its intensity. A sensory profile is thus generated.

A FEW FIGURES

25 000 natural molecules are responsible for taste, including **20,000** odorant or irritant molecules and **5000** sapid molecules.

347 different olfactory receptors in man.

26 different receptors for bitterness.

A human being is capable of perceiving **1 g of chloroanisole** (responsible for cork taint) **in 10 million cubic metres** of wine.

More than **150 compounds** are responsible for a vanilla flavour.

0.1 to 1%: the quantity of aroma in Provence herbs.

SCIENCE AND EDUCATION IN THE CANTEEN

The Edusens project studies the effects of sensory education on the dietary preferences and behaviour of 8 to 10 year-old children. Led by INRA researchers specialised in sensory analysis in Dijon, it involves the Institut du Goût – which founded the "Classes du Goût" (taste classes) – and partners in the social, statistical and medical sciences. The City of Dijon and local education authorities have allowed its conduct in the context of four Dijon schools. Agnès Le Grand, head of institutional food services at Dijon City Hall, explains their involvement.

Why were you attracted by the Edusens project?

Agnès Le Grand: The presentation of this project was very exciting. It looks at institutional catering in an attractive way which awakens children to sensory pleasures. The scientific approach ensures a serious image, which is indeed well-deserved by our profession!

How are you involved in the project?

A. L. G.: Its organisation has required many meetings in order to link research objectives and criteria with our constraints concerning feasibility. After a session of tests to familiarise themselves with the approach, about twenty children in each school, acting as "tasters" , will attend 20 weekly sessions, or five per theme: bread, fruits and vegetables, dairy-related products, meats and fish. For example, during a session, they will taste different types of white or toasted bread; another session will consist in comparing more or less sweet yoghurts, flavoured with jam or lemon. Another will focus on the flavour of cheese alone or spread on bread, etc. Then, during the meal which follows the tasting session, the products studies will be offered to the children again, and we shall see how they make their choices within the meal. Trained, non-teaching staff will manage the sessions, while the researchers will record all comments and dietary behaviour.

What are you hoping for from this partnership?

A. L. G.: I am looking forward to the results! Until then, there will obviously be some impact on how the teams organise themselves. Catering staff will discover new responsibilities and this will provide them with some ideas about how to interest recalcitrant children in new types of foods. A lot of information is being produced on diet with the National Nutrition and Health Programme. But this knowledge remains theoretical. In the present case, we can hope that these young "tasters" will modify their dietary habits.

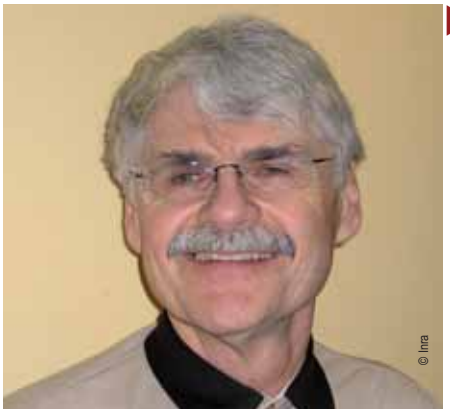
The INRA Sensorial Analysis Laboratory in Dijon also runs the Observatory on Food Preferences in Infants and Children (Opaline).

"A clearer understanding of taste should help to prevent high-risk behaviour"

The taste of foods is an area with major economic stakes. There is strong consumer demand for "tasty" foods. Some people think that fruits and vegetables cultivated in greenhouses or under soil-free conditions are tasteless. In parallel, the flavouring of industrial foods is not a simple task, particularly when it comes to restoring complex sensations such as freshness, creaminess or smoothness.

Taste has recently become the subject of a public health challenge. The immediate pleasure associated with the attractive taste of high-energy foods does indeed seem to play a key role in the development of obesity and type 2 diabetes in young people. Furthermore, it is possible that the dietary behaviour of a mother during pregnancy will exert a sustained effect on the functioning of genes in her baby, the ultimate result being repercussions on his or her dietary habits.

Scientists are also questioning the links between the genetic characteristics of individuals and their sensitivity to certain tastes. This could explain the very early and sustained rejection of foods, including certain fruits and vegetables which are bitter or smell strongly, such as cauliflower.



Patrick Étiévant

A clearer understanding of taste should allow us to prevent high-risk behaviour and encourage dietary habits more beneficial to good health and a perception of well-being.

INRA has considerable experience in this field and thus has a responsibility to provide some answers to the broad variety of questions posed regarding these challenges. To achieve this, ongoing research and partnerships are involving a growing number of skills in fields as varied as agricultural, genetic, physicochemical, physiological, human and social sciences.

Patrick Etiévant
Head, Human Food and Nutrition Department, INRA

AROMAGRI, A NETWORK TO UNDERSTAND OLFACTION

Dietary behaviour depends on detecting and identifying the taste of foods, i.e. principally their odour and flavour. Sensorial maps of the brain have revealed the regions activated by olfactory and gustatory stimulations. These evolve as a function of age or certain pathological conditions which can alter perceptions of food flavours (loss of appetite, excessive consumption of salt, etc.).

Drawing up these sensorial maps is one of the purposes of the Aromagri network which involves nearly 80 researchers from INRA and other public-sector research agencies: chemists, cell and molecular biologists, neurobiologists, experts in cerebral imaging, neuroendocrinologists, behavioural specialists, cognitive psychologists, knowledge engineers or geneticists. Animal models are particularly useful when trying to understand the phenomena which occur in man. Indeed, unlike sight or hearing, olfaction has been a highly conserved sensorial modality during evolution.

GLOSSARY

Olfactometer: A device which measures odorant components at concentrations known to the subjects who then evaluate their quantitative and qualitative effects.

Reward process: Production by the subject himself of substances which can activate the neuronal pathways triggering a sensation of intense pleasure.

Somesthesia: A mechanical sense which enables perception of the consistency and temperature of a food.

Umami: A term which means delicious in Japanese and which characterises the taste of the glutamate present in meat juices; it is the only amino acid whose perception we now how to detect at present.

A COMPOSITE SYSTEM OF TASTE RECEPTORS

Jean-Claude Pernollet
Team Leader, Biochemistry of Olfaction and Gustation, Jouy-en-Josas Research Centre

Taste results from three sensorial systems: olfaction, gustation and somesthesia - but we are incapable of making a distinction between these perceptions. For example, we do not know how to discern the fresh sensation of the odour of mint.

Olfaction detects the volatile compounds which reach the sensorial system (receptors), either via the nose or via the retronasal pathway, revealing the flavour released during chewing. For example, the olfactory perception of a wine involves about a hundred receptors, without there being any analytical knowledge of each of them separately.

Gustation, which involves the tongue and palate, produces a "sensory image" which is built up with that of olfaction. It distinguishes between the five "tastes" in the strictest sense of the term: sweet, salt, sour, bitter and umami. Because of glutamate, the latter (like sucrose) benefits from flavour enhancing potential. Industry uses these tastes to enhance the flavour of food products. Thus a strawberry has more flavour when it is sweetened than when it is eaten alone. We still do not know how to explain this phenomenon, but we are studying how the perception of sweetness influences weight gain in children.

The agrifood industry is interested in somesthesia, the aim being to isolate the sensation of freshness (or warmth) of olfaction: for example, to obtain a fresh sensation such as that provided by mint, but without its aroma.

As for aroma, this is a complex notion which concerns both odorant compounds and the sensation of odour. INRA is working on olfactory receptors and molecule transporters which produce odours and aromas. One research programme is trying to integrate different findings in order to characterise a mental "sensory image" in the form of a map.

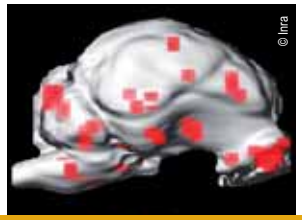
VISUALISING THE PERCEPTION OF SATIETY

Charles-Henri Malbert
Team Leader, Control of Ingestion, Rennes Research Centre

A sensation of satiety is born of the conscious and unconscious perception of numerous signals from the brain and digestive organs: stomach, small intestine, liver. The cerebral mechanisms involved in the genesis of this perception are poorly understood. However, study of these mechanisms has been revolutionised by the emergence of functional cerebral imaging which allows us to "see" the brain functioning.

In Rennes, the imaging platform developed by INRA is equipped with machines which can evaluate the responses of a pig's brain to the different stimuli triggered following a meal: distension of the stomach, input of nutrients, etc. Visualising brain function involves assembling images of an anatomical (CT scan, MRI) and functional (e.g. neuron metabolism) nature. The informatics tool then integrates these different imaging methods to supply scientists with a synthetic image of the cerebral structures involved during a meal.

In collaboration with the Cemagref and Rennes University Hospital, we have recently shown that stomach distension following the ingestion of a meal triggers the activation of neuronal networks involved in reward processes. Similarly, we have demonstrated activation of the olfactory bulb during fictitious stimulation mimicking the arrival of a meal in the digestive tract. The combined use in animals of imaging methods and those arising from physiology means that nutritionists will no longer have to consider the brain as a black box.



FROM ODOUR TO AGRIFOOD PROCESSING

Jean-Louis Berdagué
Team Leader, Aromatic Typicality and Authentication. Clermont-Ferrand-Theix Research Centre

A Saint-Nectaire cheese is appreciated for its characteristic aroma, but producers and processors do not know how to act in a reasoned fashion on this aroma. It is this obstacle that our research is currently trying to overcome. INRA can now perform detailed analyses of the components of the aroma of a product, and determine why it is unique. We have thus developed and patented an olfactometric system which, based on a panel of "sniffers", makes it possible to identify the ten or so key odorant substances in the aroma of a food, amongst the 300 to 400 molecules which it comprises. Our AcquiSniff® software generates relevant olfactometric data and links them to mass spectrometry findings. The olfactometer and the software act in tandem to only specify odorant molecules; in this way, it is possible to acquire and process the data in record time.

Because the odorant molecules are finely identified, it becomes possible to determine their biochemical origins and thus understand the aromatic characteristics of a food. Tested over the past two years, these systems are being used under a licensing contract by numerous companies in the agrifood industry (cheeses, meats, cured meat products, etc.).

These systems have allowed us to pursue our research and envisage new technological sequences to develop foods with well-defined sensory propeties. It may thus be possible to manage the production of odorant molecules or, on the contrary, eliminate them when they detract from the quality of a product. For example, one research project is focused on the aromas of raw ham, while another concerns newly-formed products during the cooking of certain foods.

BIODIVERSITY IMPROVES THE TASTE OF TOMATOES

Mathilde Causse
Director, Fruit and Vegetable Genetics and Breeding Unit, Avignon

For more than 10 years, INRA has been working on the taste of tomatoes. During the early years, we deciphered the sensory perceptions of consumers in order to distinguish between varieties. We then developed analytical tools to link consumer perceptions to the physicochemical characteristics of fruits.

We have now characterised the genetic diversity of old and new tomato varieties as a function of flavour or texture criteria, etc. Blind tests showed that old varieties were not the most appreciated, contrary to well-established prejudices, because they were not firm enough. It is the long-storage varieties developed during the 1980s which are partly responsible for consumer discontent.

We have also studied environmental influences: a greenhouse crop does not produce tomatoes with the same flavour as one grown in the open; a tomato which ripens on the vine has a better taste than one harvested when green; and cold storage (at below 4°C) disrupts aromatic potential.

Current studies are seeking to better characterise the genetic sites in the tomato genome which may be involved in flavour. This is the objective of the new European project, Eusol.

INRA holds a collection of more than 1000 tomato varieties out of the 10,000 or so varieties which exist worldwide. INRA is not longer breeding new tomato varieties, because of the dynamism of the private sector. However, the Institute is studying the consequences of varietal diversification and the organisation of the sector from agronomic techniques to economic analyses.

FLAVIC, THE JOINT RESEARCH UNIT IN DIJON

Elisabeth Guichard, Director of FLAVIC

The INRA-ENESAD Joint Research Unit for Flavour, Vision and Consumer Behaviour (FLAVIC) focuses on the relationships between food quality, sensorial perception and consumer preferences. Its three research teams are central to implementation of the INRA "Sensorality" cluster, and are also involved in the Dijon competitiveness cluster, Vitagora. A first team is studying the mechanisms which govern the release during mastication of aromatic and sapid substances from foods. The aim is to understand the formation of the sensory image and its associated pleasure.

A second team is characterising the links between sensory perception and food preferences: rejection or attraction reactions, evaluation of the respective weight of factors such as brand, nutritional allegations, the sensorial memory of the consumer, etc.

A third team, "Vision and Nutrition" is studying lipid metabolism in the functioning of the ocular sphere, the aim being to prevent eye diseases.

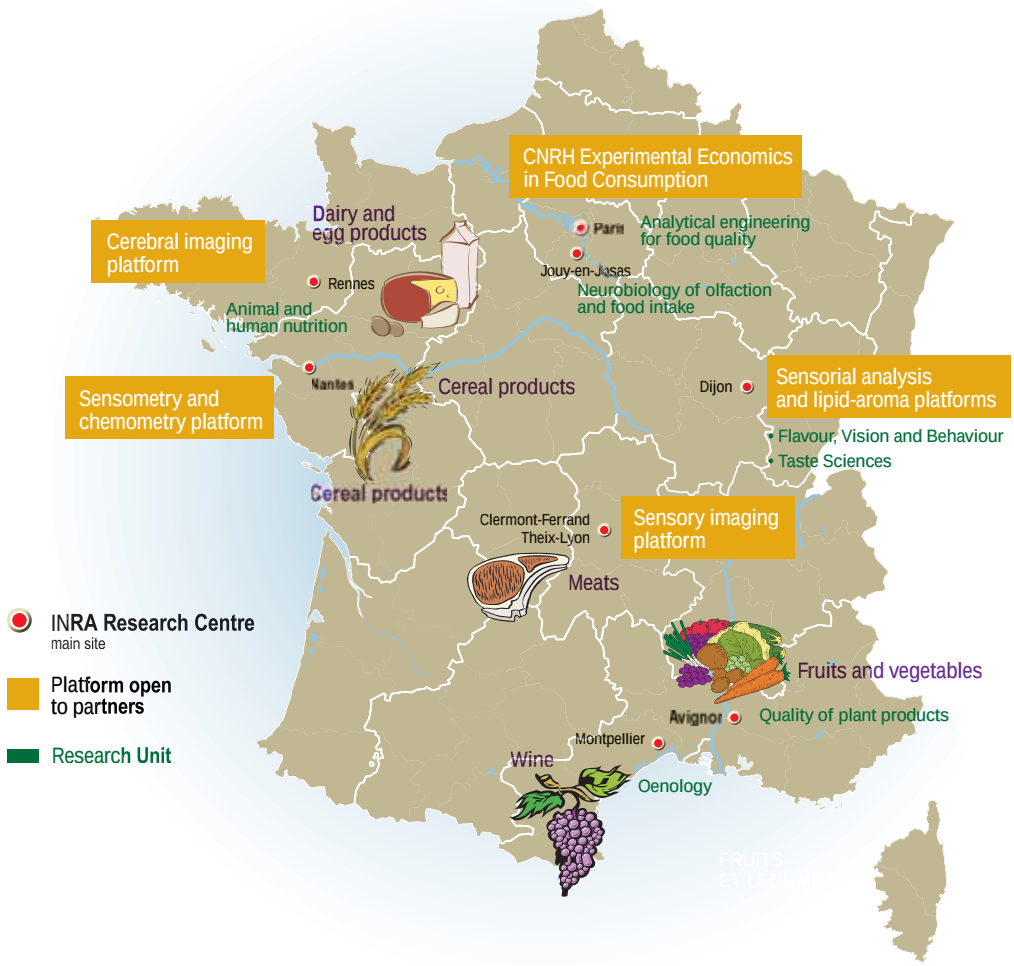
FLAVIC benefits from several technical platforms, some of them shared with the University of Burgundy and the CNRS. It also houses two start-up companies: Aromalyse (specialised in studying aromas) and Omega21 (specialised in lipid analysis).

THE ARLE PROJECT

The Arle project is studying the interactions between aromas, foods and packaging. In the case of products such as orange juice, sponge cake or flavoured yoghurts, stored in different types of packaging, measurements are made of the stability of aromas in the foods, their release and their perception by consumers. The aim is to demonstrate the phenomena which affect sensory perception. Indeed, manufacturers often modify their formulations empirically, using texture agents which can sometimes affect flavour. Similarly, packaging plays a not inconsiderable role in the composition and availability of odorant compounds in a food.

RESEARCH UNITS ON TASTE

INRA Units and Joint Research Units with other agencies



A FEW RESULTS

Research

- Modelling of the remarkable effects of odour mixtures (synergy, masking and aromatic accords).
- Relationships between food texture and odour perception in gels.
- Detection of fats in foods by specific receptors in the mouth.
- Sensitivity to sulphur compounds present in cauliflower which varies from one individual to another.

Valorization

- In 2006, INRA generated three patents and two active software programs on procedures for the analysis of aromas, the release or retention of aromas in foods and a raspberry aroma molecule.
- Some fifteen transfer contracts resulting from these patents or concerning the use of yeast or bacterial strains involved in winemaking or cheese manufacture.
- Five start-ups have based their activities on INRA innovations.

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PUBLICATIONS

- Flavour in food
Andrée Voilley et Patrick Etiévant
Woodhead Publishing limited, 2006

- Les fermentations au service des produits de terroir
Marie-Christine Montel, Claude Béranger, Joseph Bonnemaire - Editions Inra, 2005

- Physiologie sensorielle à l'usage des IAA
Annick Faurion - Editions Lavoisier, 2004

- Les ateliers expérimentaux du goût
Hervé This - Académie de Paris, 2001

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