# Organic food and health

## A new project to study the effects of plant cultivation methods on nutritional value and on health and reproduction in an animal experiment

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### Introduction

Many consumers believe that organic food benefits health more than conventional food. This cannot be determined simply by analysing the material, since our understanding of the connections between food components and health is still to imprecise for such a purpose. More basic research is necessary, before we know what food should contain to benefit health.

Instead it is possible to study physiological effects of plant quality directly, in animal experiments. We can not be sure that health of animals will benefit from the same components than for humans, but if there is an effect on animals, it is likely also to be the case for humans.

So in the spring of 2001 a project has started, to assess the long-term effects of cultivation strategy on animal health. Two factors are included, fertilisation and the use of pesticides, which together define major differences between organic and conventional farming systems.

Experimental field for organic vegetable production.

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**List** of analyses planned within the project.

Plant material:
All: dry matter, crude fat, crude protein, ash, crude fibre. Biocrystallization pictures.
Wheat, peas and potato: Energy content, phytin and biological value (BV) of protein.
Vegetables, apple and potato: Vitamin C. Phenolic profile (free and bound compounds), comprising phenolic acids, coumarins and flavonoids where relevant. Up to 6 compounds for which the concentrations are significantly different in the agricultural treatments will be isolated and characterised.
Carrot, kale, apple and rapeseed oil: Volatile compounds and carotenoids.
Kale: Glucosinolates.
Potatoes: Glycoalkaloids.
Carrots: Polyacetylenes.
Feed mixtures: Energy content and biological value (BV) of protein. Biocrystallization pictures. Minerals and trace elements: Ca, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, P, S, Se, Zn, Ba, Cd, Pb, Sr, Ce, Cs, Rb, and V. Standard pesticide analysis (150 compounds).

Animals:
Reproduction: numbers of attempts before pregnancy, litter size, female/male ratio, stillborn/live born pups, litter size at weaning and possibly age of sexual maturity and anugenital distance.
Health and well being:
All: Weight curves, diseases.
Middle generation: Feed preference.
Last generation: Energy and protein utilisation, bioavailability of minerals and some secondary metabolites. Spontaneous physical activity. Macroscopic analysis of the organs and a visual determination of the health status. Length and enzyme activity of intestine. Blood lipids and antioxidant status. Level of antibodies. Longevity and natural cause of death (as far as funding permits, planned for 10 animals per treatment).

### Background

Organic agriculture does not allow the use of pesticides and synthetic fertiliser. There is some knowledge about how different levels of fertilisation affects nutritionally relevant components, and it corresponds with the observation that organic plant products tend to have lower protein content and higher vitamin C levels than conventional ones. There is virtually no knowledge about how the use of pesticides per se affects the contents of the "traditional" nutrients (vitamins, minerals, fibres, protein and energy). And it is very likely that differences in other aspects of plant composition, such as secondary metabolites, nutrient bioavailability and the characteristics that define the picture-developing properties may be at least as important for impact on health.

### Concept

Young rats will be fed with 3 thoroughly controlled and analysed diets made from plants from controlled cultivation treatments. They will breed for two generations, and the health status of the last generation will be thoroughly assessed.

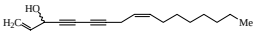
### Methods

**Plants** used are chosen as nutritionally relevant to both humans and rats: potato, mature peas, kale, spring wheat, oilseed rape, carrots and apples. They will be processed in the same ways as in human diets: Potato, mature peas and kale will be cooked and freeze-dried, wheat is ground and baked to biscuits, oil is produced from the rapeseed, and raw carrots and apples are shredded and freeze dried, before feed pellets with the desired composition are prepared from the material.

**Cultivation** is done in 3 treatments:
1. A model of a distinct conventional cultivation system, with high input of mineral nutrients and intensive use of pesticides.
2. A model of a distinct organic cultivation system, with low input of organic plant nutrients and no use of pesticides.
3. A combination of model 1 and 2, with low input of nutrients and intensive use of pesticides.

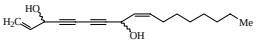
**Analysis** of plant materials from each cultivation treatment comprise measurement of contents of nutrients (protein, minerals, energy content, vitamins), the biological value of protein, contents of selected secondary metabolites, including known anti-nutrients, and other quality indicators, including biocrystallization. See list for details.

Example of secondary metabolites:

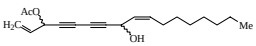


Falcarinol

Polyacetylenes from carrot:



Falcarindiol



Falcarindiol-3-acetate

**Preparation** of 3 feed mixtures based on these results. If the biological value of protein and energy is similar for the 3 treatments, the feed mixtures will be based on defined weight percentages of each material from each treatment. If large variation in is found, one or two feed mixtures from low-input cultivation can be adjusted to provide the same availability of protein and energy as the reference treatment (model 1).

### Achievements (deliverables) expected:

1. Improved understanding of differences in plant composition to cultivation conditions.
2. Improved understanding of differences in biological value and other properties of plant derived food due to cultivation conditions.
3. Quantification of effects of differences in food composition on reproductive characteristics.
4. Quantification of effects of differences in food composition on health and metabolic characteristics.
5. Assessment of whether the differences are large enough to indicate that human health is affected by differences in cultivation methods of plant foods.

Balance trials with rats

### Project organisation and timetable

The project consists of 9 workpackages:

**WP1**: Cultivation of feed plants
**WP2**: Picture-developing properties
**WP3**: Secondary metabolites
**WP4**: Biological value
**WP5**: Minerals and pesticide residues
**WP6**: Breeding of rats
**WP7**: Health status of rats
**WP8**: Data management and analysis
**WP9**: Coordination & dissemination

and will be carried out according to this:

### Timetable

| Year | 2001 | | | | 2002 | | | | 2003 | | | | 2004 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Qtr.** | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| WP1 | | | | | | | | | | | | | | | | |
| WP2 | | | | | | | | | | | | | | | | |
| WP3 | | | | | | | | | | | | | | | | |
| WP4 | | | | | | | | | | | | | | | | |
| WP5 | | | | | | | | | | | | | | | | |
| WP6 | | | | | | | | | | | | | | | | |
| WP7 | | | | | | | | | | | | | | | | |
| WP8 | | | | | | | | | | | | | | | | |
| **WP9** | | | | | | | | | | | | | | | | |

**Collaborative**, additional research:
Apart from the planned analyses (listed in below to the left) many other tests and investigations are possible in connection with the project.
We hereby invite potential collaborators to consider if they would be interested and able to carry out such additional work in a collaborative setting. Volume of plant production is planned so feed for additional experiments will be available (within reasonable limits). Discussions are underway with some groups already, but there are many more possibilities. Non-exclusive suggestions are:

Additional analyses of plant material: Vitamins ($B_{123456}$, E, folate). Amino acid composition. Fibre composition. Other picture-developing methods. Antioxidant activity. Relevant plant enzymes. Electronic nose characterisation.
Analyses of elements and pesticides in each plant species separately.
Repetition of the cultivation experiment and the analyses and characterisations involved.

Additional tests of animals: Tests of resistance to diseases and stress factors by challenges with bacteria, vira or parasites, carcinogens or high-fat feed mixtures (to induce obesity and/or cardiovascular disease). Tests of a variety of physiological or behavioural characteristics. Longevity and natural cause of death for more than 10 animals/treatment.

Organic apples (cv. Otava) grown with low (left) and high (right) nutrient input.

Danish Research Centre for Organic Farming

Danish Research Centre for Organic Farming (DARCOF) coordinates Danish research into organic farming. The purpose is to secure the optimum benefit of the resources allocated to the research.

DARCOF is a so called "research centre without boundaries" where the research qualifications is composed by the approx. 100 scientists and 15 institutes participating in the research programs. At the moment there are 26 major research projects in progress.

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