COMBINED DEHYDRATION METHODS
FROM FRESH FRUIT TO HIGH-QUALITY INGREDIENTS

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The thesis will be publicly defended on Friday the 17th of January, 2003, at 1.15 p.m. in lecture hall Enoch Thulin, House Beta, Scheelevägen 17, Ideon, Lund, Sweden.

**Opponent:** Professor José Miguel Aguilera, Pontificia Universidad Católica de Chile, Dept. of Chemical Engineering and Bioprocesses, Santiago, Chile.
La destination du chercheur dépend de la route qu’il suit.
[ Ibn Al-ʿArabi XIIIᵉ s.]
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ABSTRACT
Numerous products from the food industry contain fruit and/or berries, in the form of fillings or ingredients, e.g. in yoghurt, some bread products/cereal products, ice cream, etc. In order to produce these ingredients and improve their characteristics, many processing techniques are available. This thesis focuses on dehydration methods that take into account the fragile and complex cellular tissues of fruit and facilitate the incorporation of fruit pieces into numerous industrial recipes. The target product should have an acceptable ability to rehydrate and to regain a texture that is as near to fresh as possible.

The structural changes and the stabilisation in terms of water activity were particularly studied. Water and its functionality at macro- and micro-levels of the cellular tissue were reviewed as well as its transfer during dehydration. In the context of dehydration, fruit and vegetables collapse as a result of water loss when water is transported from the cells to the surroundings via the cell walls and the intercellular spaces. Collapse can be partially prevented by reinforcing the cell walls and filling the intercellular spaces with carbohydrate solutions and other biopolymers before dehydration with methods such as osmotic treatment or vacuum impregnation.

Microwave-assisted air-drying with controlled temperatures at 50, 60 and 70°C was applied to apple cubes after different pre-treatments. The use of microwaves shortened the time of drying compared with air-drying alone. The combination of osmotic treatment and microwave-assisted air-drying produced dehydrated samples of improved appearance and higher volume compared with the samples obtained without osmotic pre-treatment. Other pre-treatments were also studied in combination with microwave-assisted air-drying, and the best results were obtained with calcium infusion at ambient temperature, particularly with the rehydrated texture. Pre-freezing was the most damaging process for the apple tissue.

Important parameters of osmotic treatment of apple were also studied. When trehalose was used as the osmotic agent it was shown to be at least as efficient as sucrose in removing water except when applied in crystalline form. Vacuum application in combination with osmotic treatment had an immediate and significant effect on the composition of the samples. It enhanced the solid gain by filling most of the extracellular spaces. Modelling of the relation between water activity and moisture content during osmotic treatment was also successfully accomplished. In conclusion, this thesis showed that a combination of different techniques is a good way to achieve high-quality ingredients from fresh fruit, but more research is needed to better understand the complexity of the plant tissue and its behaviour during processing.

Keywords: dehydration; osmotic treatment; microwave-assisted air-drying; apple; collapse; agent; semi-finished product.

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This thesis is based on the following Papers, referred to in the text by their respective Roman numerals (I-VII). The papers are attached as appendixes at the end of the thesis.

**Paper I:** Mechanisms and prevention of plant tissue collapse during dehydration.
Prothon, F., Ahrné, L. & Sjöholm, I.
(Accepted 2002-02 for publication in *Critical Reviews in Food Science and Nutrition*, in Press)

**Paper II:** Effects of combined osmotic and microwave dehydration of apple on texture, microstructure and rehydration characteristics.

**Paper III:** Microwave and convective dehydration of ethanol treated and frozen apple – physical properties and drying kinetics.
Funebo, T., Ahrné, L., Prothon, F., Kidman, S., Langton, M. & Skjöldebrand, C.

**Paper IV:** Comparison of drying kinetics and texture effects of two calcium pre-treatments before microwave assisted dehydration of apple and potato
Ahrné, L., Prothon, F. and Funebo, T.
(Accepted 2002 for publication in *International Journal of Food Science and Technology*, in Press)

**Paper V:** Comparison of sucrose and trehalose as osmotic agents. Study of the changes in water activity, water loss and product quality at different temperatures.
Prothon, F., Teixeira, C., Sjöholm, I. & Ahrné, L.
(Submitted)

**Paper VI:** Research Note - Application of the Guggenheim, Anderson and De Boer model to correlate water activity and moisture content during osmotic dehydration of apples.
Prothon, F. & Ahrné, L.
(Accepted 2002-11 for publication in *Journal of Food Engineering*)

**Paper VII:** Vacuum-assisted osmotic treatment of *Mutsu* apples prior to further stabilisation:
Prothon, F., Smärgel, E. & Sjöholm, I.
(Manuscript)

**Proceedings**
Parts of the work have also been presented at two international conferences under the following references:
