ELSEVIER

Food Chemistry 82 (2003) 533–537

Food Chemistry

www.elsevier.com/locate/foodchem

Effect of food-processing on the degradation of fructooligosaccharides in fruit

C. L'homme, A. Puigserver, A. Biagini*

Institut Méditerranéen de Recherche en Nutrition, UMR 1111, Université Aix-Marseille III-INRA, Faculté des Sciences et Techniques de Saint-Jérôme, 13397 Marseille Cedex 20, France

Received 15 August 2002; received in revised form 30 December 2002; accepted 30 December 2002

Abstract

The effect of process on fructooligosaccharide degradation in stewed apple-banana and three apple dessert was studied. 1-Kestose was analysed using an accurate analytical method for carbohydrate determination (high-performance anion exchange chromatography with pulsed amperometric detection, HPAEC–PAD). It appears that the content of 1-kestose in raw material was much higher than in the finished product. Furthermore, a banana puree incubated for 30 min over a temperature range (80–110 °C), supposed to favour degradation, appeared stable. This indicate that its the formulation rather than cooking or pasteurization which is responsible for the fructooligosaccharide loss.

Keywords: HPAEC–PAD; Amperometric detection; 1-Kestose; Nystose; Fructofuranosylnystose; Food composition

1. Introduction

Fructooligosaccharide (FOS) have been defined as a combination of the three sugars 1-kestose (β-D-Fru-(2→1)$_2$-α-D-glucopyranoside, GF2), nystose (β-D-Fru-(2→1)$_3$-α-D-glucopyranoside, GF3) and fructofuranosylnystose (β-D-Fru-(2→1)$_4$-α-D-glucopyranoside, GF4) in wich fructosyl units (F) are bound at the β (2→1) position of sucrose (GF) (Lewis, 1993).

They are widely distributed in plants and vegetables, including banana, plum, onion, shallot, chicory and artichoke (Campbell, Bauer, Fahey, Hogarth, Wolf, & Hunter, 1997; Hogarth, Hunter, Jacobs, Garleb, & Wolf, 2000) and can be produced on a commercial scale, from sucrose, using a fungal enzyme from either *Aureobasidium* sp. (Yun, 1996; Yun & Song, 1993) or *Aspergillus niger* (Hidaka, Eida, Takizawa, Tokunaga, & Tashiro, 1986).

In a previous paper (L'homme, Peschet, Puigserver, & Biagini, 2001), we have analysed fructans (inulobiose, GF2 and GF3) using the CarboPac PA 100 column, an anion-exchanger, and with the quadruple-potential waveform developed for enhanced chromatography of oligosaccharides (refs). This methodology proved suitable for fructans analysis in a food matrix such as fresh and stewed fruit obtained from a local manufacturer.

A kinetic study of the chemicals hydrolysis of 1-kestose (β-D-Fru-(2→1)$_2$-α-D-glucopyranoside, GF2), nystose (β-D-Fru-(2→1)$_3$-α-D-glucopyranoside, GF3) and fructofuranosylnystose (β-D-Fru-(2→1)$_4$-α-D-glucopyranoside, GF4) in buffered aqueous solutions was realized previously (L'homme, Arbelot, Puigserver, & Biagini, in press). Five temperatures (80, 90, 100, 110 and 120 °C) and three pH values (4.0, 7.0 and 9.0) were assayed. Half-life and activation energy of a FOS hydrolysis at pH 4.0 and pH 7.0 have been previously estimated.

Fruits are an important component of the diets elaborated by dieticians. They are, together with vegetables, cereals, fish and olive oil, one of the principal components of the Mediterranean diet. The nutrient content of foodstuffs provided by a firm may differ from a home-cooked meal, because of differences in the preparation, storage, and cooking methods and also because of the choice and composition of ingredients and supplies. Since cooking and pasteurization might

* Corresponding author. Tel.: +33-491-28-88-64; fax: +33-491-28-84-40.

E-mail address: anne.biagini@univ.u-3mrs.fr (A. Biagini).

0308-8146/03/$ - see front matter © 2003 Elsevier Ltd. All rights reserved.
doi:10.1016/S0308-8146(03)00003-7

alter composition of food and as a consequence its nutritional value, this study was conducted to evaluate the effects of process and cooking on FOS composition.

2. Materials and methods

2.1. Chemicals

The standard sucrose, D-glucose and D-fructose were purchased from Sigma (S^t Quentin Fallavier, France), while the standard fructooligosaccharides set containing GF2, GF3 and GF4 was from Wako (Neuss, Germany). Disodium tetraborate decahydrate (Borax, ACS grade), sodium acetate (No. 1.06268), citric acid monohydrate (No. 1.00244) were purchased from Merk (Nogent-sur Marne, France). Sodium hydroxide 46/48% (w/w) aqueous solution (S/4930) was from Fisher Scientific (Elancourt, France). Ultra pure 18 Ωcm deionized water used in the experiments, including that used as high-performance anion exchange chromatography with pulsed amperometric detection (HPAEC–PAD) solvent was obtained using a Maxima Ultra Pure Water sytem (Elga, Decines, France). Sodium dihydrogenophosphate dihydrate and hydrochloric acid (min. 36%) were obtained from Prolabo (Fontenay s/bois, France).

2.2. Analysed food products

Apples puree (Golden, Braeburn, Jonagold), apple juice concentrates, three apple dessert, appel puree (Golden, Redchief), banana puree, stewed apples–bananas were a gift from a local manufacturer (Société de Conserverie Alimentaire, Charles Faraud).

2.3. Storage conditions and pre-analysis treatment

Forty grams of stewed apples–bananas were incubated in a thermostated water bath at desired temperatures between 80 and 110 °C. At 10-min intervals, samples of 5 g were recovered and kept on the ice for 5 min. To each sample, 25 ml of pure water was added. The mixture was filtered using a Whatman paper no, and centrifuged at 15 000 rpm for 10 min. The supernatant was filtered using a 0.2-μm microfilter before analysis on the Dionex system.

2.4. Analysis by HPAEC–PAD

Quantitative determination of 1-kestose contained in purified samples, was carried out by injection into a Dionex system DX500 (Sunnyvale, CA, USA). This system consists of a GP 50 gradient pump with an on-

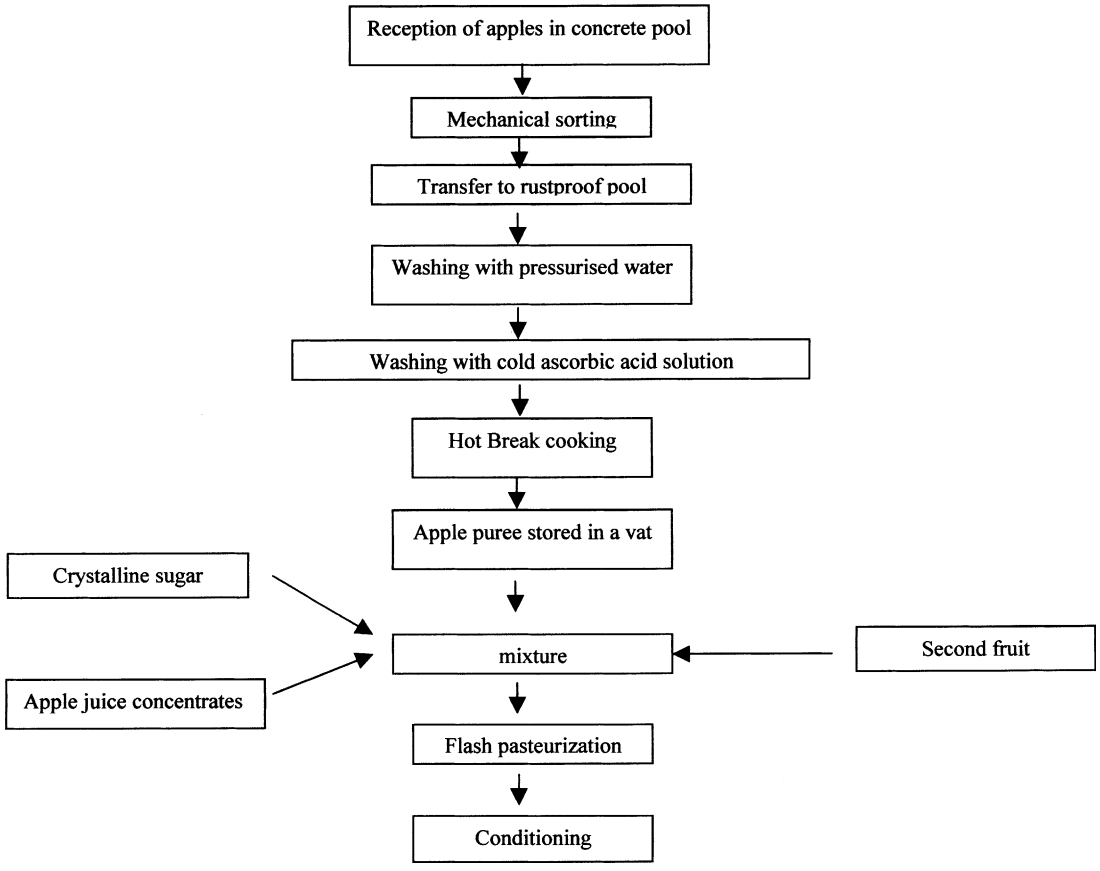

Fig. 1. Flow diagram of the stewed fruits and dessert process in the Charles Faraud firm.

line degasing, an analytical anion-exchange column and an ED40 electrochemical detector. The anion exchange system consists of a CarboPac PA-100 analytical anion exchange column (250×4 mm) equipped with a guard column CarboPac PA-100 (50×4 mm). Gradient elution was applied using two solvents: 0.1 M aqueous sodium hydroxyde (A) and 0.1 M aqueous sodium hydroxyde containing 0.5 M sodium acetate (B). Total run time per sample was 36 min. The elution began with 100% solvent A for 8 min at a flow-rate of 1 ml/min. This was followed by a linear gradient from 0 to 12% solvent B in solvent A for 22 min and maintained at 12% solvent B for 6 min. The column was then washed for 5 min with 50% solvent B. The next injection was performed after equilibrating the column with 100% solvent A for 19 min. Peak identification was realized using commercial

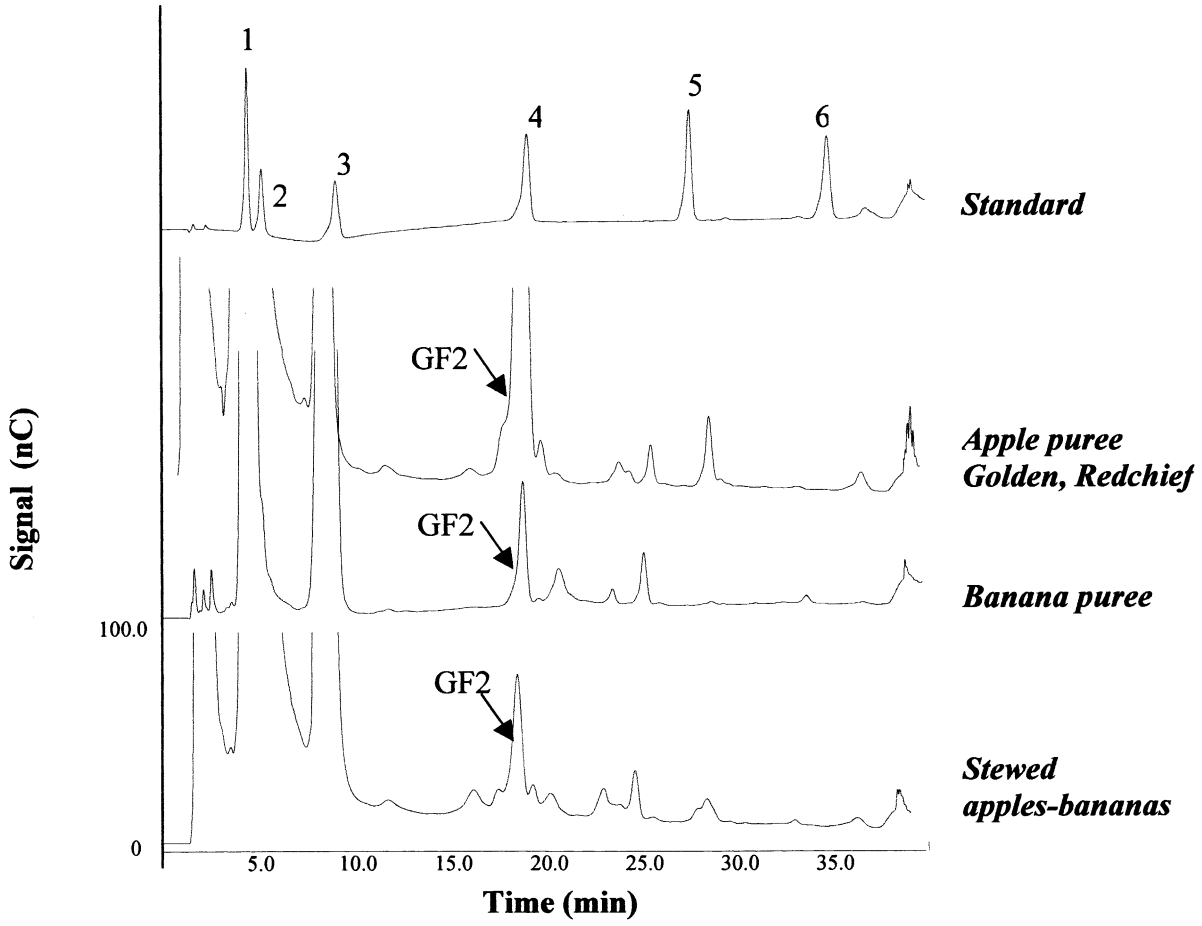

Fig. 2. Chromatographic profiles of extracts of a three apple dessert (finished product, diluted to the 1/5), concentrated juice of apples (raw material, diluted to the 1/100) and of apple puree (raw material, not diluted), provided by the company Charles Faraud, obtained by HPLC (Dionex) as well as standards (50 μM). The peaks correspond to glucose (1), fructose (2), saccharose (3), 1-kestose (4 or GF2), nystose (5) and fructofuranosylnystose (6).

Table 1
Fructan level of a fruit dessert, a stewed fruit and the raw material used for their manufacturing

	Composition (%)		GF2 (μg/g of LM)
Three apples dessert			
Raw material	87	Apple puree (Golden, Braeburn, Jonagold)	753±46
		Apple juice concentrate	2839[a]±178
Finished product		Three apple dessert	2248±148
Stewed apples–bananas			
Raw material	72	Apple puree (Golden, Redchief)	6933±277
	16	Banana Puree	6832±360
Finished product		Stewed apples–bananas	1006±109

LM, lyophilized matter.
[a] μg/g of fresh matter.

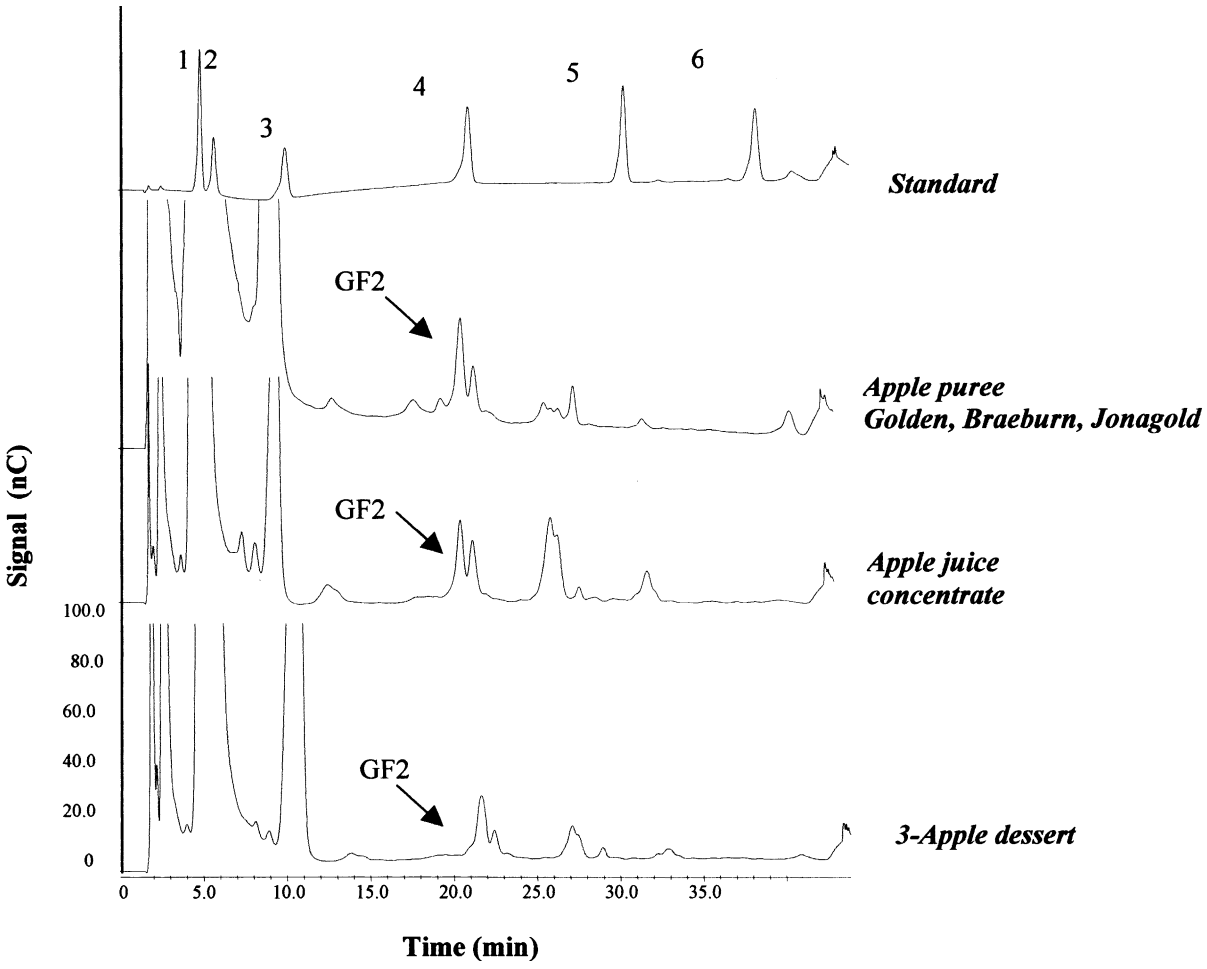

Fig. 3. Chromatographic profiles of extracts of a stewed apples–bananas (finished product, not diluted), bananas puree (raw material, diluted to the 1/10) and of apple puree (raw material, not diluted), provided by the company Charles Faraud, obtained by HPLC (Dionex) as well as standards (50 μM). The peaks correspond to glucose (1), fructose (2), saccharose (3), 1-kestose (4 or GF2), nystose (5) and fructofuranosylnystose (6).

standards. Fructans were quantified by measuring peak areas and comparing them to a standard curve, generated by plotting area counts against concentration of standards (0–50 μM). The fructan level (μg/g dry matter) was estimated using the following formula:

$$\text{Fructan } (\mu g/g\ DM) = C \times D \times V \times M/LM \times 1000$$

where C was the fructan concentration in the extracted sample (μM), estimated from calibration curve, D the dilution used throughout the experiment, V the volume of extract (50 ml), M the molecular weight of the compound and LM (g) the lyophilized weight of the analysed product.

The elution was performed at a constant flow rate of 1ml/min, at room temperature, using a 20 min linear gradient from 0 to 40% of a 80 mM NaOH–500 mM sodium acetate in 80 mM NaOH–5 mM sodium acetate. Both eluents were prepared with ultra pure water and degased by nitrogen bubbling. The injection volume was 10 μl. Each time point was determined in triplicate. Peak identification was realized using commercials standards.

3. Results and discussion

The presence of FOS in processed food has already been reported by Campbell et al. (1997), Hogarth et al. (2000), L'homme et al. (2001).

Our objective in this study was to analyse the FOS content in raw materials and finished products. This is in order to assay the consequences of the preparation process on the content of 1-kestose. Fig. 1 illustrates the stewed fruits and dessert process in the Charles Faraud firm. These products are prepared from either apple puree only, or a mixture of apple puree and another fruit. They are sweetened by addition of crystalline sugar or an apple juice concentrate. We have thus analysed the three apple dessert and the stewed apples–bananas products as well as the ingredients used for their fabrication (purees and/or juice).

Fig. 2 shows chromatographic profiles of extracts of a three apple dessert (finished products), apple juice concentrates (raw material, diluted to the 1/100) and of apple puree (raw material, not diluted), provided by the company Charles Faraud, obtained by HPAEC–PAD (Dionex).

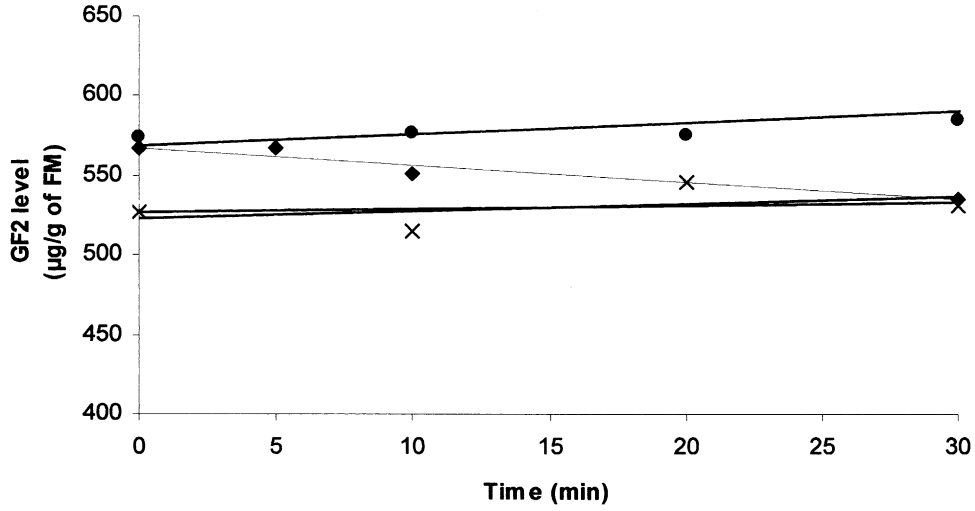

Fig. 4. Degradation of banana puree at 80 °C (◆), 90 °C (●), 100 °C (□) and 110 °C (×). FM: fresh matter.

Fig. 3 gives chromatographic profiles of extracts of a stewed apples–bananas (finished product), bananas puree (raw material) and of apple puree (raw material).

In the both finished products (and their ingredients), only 1-kestose has been identified. Table 1 gives the 1-kestose content of a fruit dessert, a stewed fruit and the raw material used for their manufacturing. It appears that there is a loss in 1-kestose content which can result from the food-processing conditions as already pointed out by Hogarth, Hunter, Jacobs, Garleb, and Wolf (2000).

L'homme et al. (in press) and Blecker, Fougnies, Van Herck, Chevalier, and Paquot (2002) have shown that FOS as well as inulin and oligofructose can be hydrolysed in acidic media. We then investigated the stability of a banana puree upon cooking (Fig. 4). It appears that the raw material incubated for 30 min over a range of temperature, between 80 and 110 °C, is stable. This indicates that cooking or pasteurization (which is a shorter process) are not responsible of the fructooligosaccharide loss, but rather it is the formulation; in apple products the degradation was extensive whereas in the apple–banana mixture the degradation was increased although the oligosaccharides in the banana alone were relatively stable to heat.

4. Conclusion

Cooking of raw fruits does not alter the 1-kestose contents, while fabrication process can be responsible of such a modification.

Acknowledgements

We are grateful to the Conseil Régional PACA and the Société de Conserverie Alimentaire Charles FARAUD in Monteux (France) for fellowship (C. L'homme recipient) and financial support. Our thanks are also to C. Villard for technical assistance (HPAEC–PAD system) and H. Attoui for reviewing the English.

References

Blecker, C., Fougnies, C., Van Herck, J.-C., Chevalier, J.-P., & Paquot, M. (2002). Kinetic study of the acid hydrolysis of various oligofructose samples. *Journal of Agricultural and Food Chemistry*, *50*, 1602–1607.

Campbell, J. M., Bauer, L.L, Fahey, G. C. Jr., Hogarth, A. J. C. L., Wolf, B. W., & Hunter, D. E. (1997). Selected fructooligosaccharide (1-kestose, nystose, and 1^F-β-fructofuranosylnystose) composition of foods and feeds. *Journal of Agricultural and Food Chemistry*, *45*, 3076–3082.

Hidaka, H., Eida, T., Takizawa, T., Tokunaga, T., & Tashiro, Y. (1986). Effects of fructooligo saccharides on intestinal flora and human health. *Bifidobacteria Microflora*, *5*, 37–50.

Hogarth, A. J. C. L., Hunter, D. E., Jacobs, W. A., Garleb, K. A., & Wolf, B. W. (2000). Ion chromatographic determination of three fructooligosaccharide oligomers in prepared and preserved foods. *Journal of Agricultural and Food Chemistry*, *48*, 5326–5330.

Lewis, D. H. (1993). Nomenclature and diagrammatic representation of oligomeric fructans. A paper for discussion. *New Phytologist*, *124*, 583–594.

L'homme, C., Arbelot, M., Puigserver, A., & Biagini, A. (2002). Kinetics of hydrolysis of fructooligosaccharides in mineral buffered aqueous solutions: influence of pH and temperature. *Journal of Agricultural and Food Chemistry* (in press).

L'homme, C., Peschet, J. L., Puigserver, A., & Biagini, A. (2001). Evaluation of fructans in various fresh and stewed fruits by high-performance anion-exchange chromatography with pulsed amperometric detection. *Journal of Chromatography A*, *920*, 291–297.

Yun, J. W. (1996). Fructooligosaccharides-occurence, preparation, and application. *Enzyme and Microbial Technology*, *19*, 107–117.

Yun, J. W., & Song, S. K. (1993). The production of high-content fructooligosaccharides from sucrose by the mixed-enzyme system of fructosyltransferase and glucose oxidase. *Biotechnology Letters*, *15*, 573–576.