Annex 9

Inulin and oligofructose: safe use as a nutritive ingredient

Annex 9.1.

Inulin and oligofructose: safe use as a nutritive ingredient

Executive summary

1. Use as safe ingredients

1.1. Historical

Inulin was first identified and isolated in 1804 by a German scientist Rose, who termed it “a peculiar substance from plant origin”. It was first named “inulin” by Thomson in 1818.

Inulin is a non-digestible storage carbohydrate. It is the main fructans, which can be found in significant portions in over 36,000 plant species (Carpita et al., 1989), and as such is, after starch, the most abundant non-structural polysaccharides in nature (Franck et al., 2002).

Inulin and oligofructose (FOS), through their natural sources, have been part of the daily diet for many centuries. Our ancestors, including the Aborigines in Australia (Leach et al., 2006) have been eaten inulin for tens of thousands of years, some in quantities of up to 50 g per day (Leach, 2006).

1.2. Today

Modern diets continue to contain moderate amounts of inulin and oligofructose. Estimates of intake from natural sources range between 2 – 12 g in Europe (Van Loo et al., 1995) to between 1 – 4 g for Americans (Van Loo et al., 1995; Moshfegh et al., 1999).

Inulin contains approximately 30% oligofructose (FOS). Pure oligofructose can be obtained from sugar, or through a partial enzymatic hydrolysis of inulin (Norman et al., 1989). Partial enzymatic hydrolysis of inulin occurs naturally in the chicory plant towards the season (Van den Ende et al., 1996) and is similar to the Orafti process used to derive inulin.

Inulin and oligofructose have been approved for use and/or have been used historically as food ingredients for more than a decade in Australia and New Zealand, and for almost 2 decades in Europe. Orafti products are being used as general food ingredients in generally available manufactured foods in more than 75 countries today. General safety evaluations include:

- A self affirmation GRAS Evaluation of the Food Safety Aspect of Inulin and Oligofructose conducted by an independent panel of experts: Kolbey A.; Blumenthal H.; Bowman B.; Byrne J.; Carr C.; Kirschman J.; Roberfroid M.; Weinberger M.; 1992.
- GRAS confirmation GRN No. 118 and resulting "FDA no objection letter" (2002) for inulin, including baby food.
- GRAS confirmation GRN No. 44 and resulting "FDA no objection letter" (2000) for oligofructose (FOS) from sugar, including baby food.
- Health Canada (letter dated. September 28, 1994) stating: "We have completed a review on the information you have provided to date. On the basis of that information, we would have no objection to the use of inulin and oligofructose as food ingredients."
- After a lengthy review process, by Health Canada (letter dated 3 March, 2006): "Based on the above data, we have determined that inulin from chicory root does not fall within the definition of "novel fibre" as per Healthy Canada Guideline No. 9, 1988 (revised November, 1994). Therefore, we would have no objection to the classification of inulin as dietary fibre for labelling purposes in Canada."

2. Use as nutritive ingredients: dietary fibre

2.1. History, consumption & recommendation

Although first used by Hipsley in 1953, the first proper definition of dietary fibre (DF) was proposed by Trowell in 1972 as "the skeletal remains of plant cells that are resistant to digestion by enzymes of man". The same author, together with Southgate, Wollever and Jenkins (Trowell et all), acknowledged in 1976, that the above definition was inadequate, since it excluded storage polysaccharides, having the same essential properties as the ones originating from plant cell walls. As a result DF was redefined as "plant polysaccharides and lignin which are resistant to hydrolysis by the digestive enzymes of man."

Inulin is the most abundant storage DF in nature.

The average daily consumption of DF across countries ranges between 12 – 29 g, worldwide recommendations range between 20 – 40 g. In Australia, recommendations for adult DF intake are 25 g and 30 g for women and men respectively (National Health and Medical Research Council, 2005), and 30 – 35 g by Nutrition Australia. Average daily intakes are estimated between 20 (f) and 26 g (m) per day (National Health and Medical Research Council, 2003).

2.2. Definition of DF and relevance to inulin & oligofructose

The main use of inulin and oligofructose as nutritive ingredients in Australia and New Zealand is for their dietary fibre (DF) properties and classification. The inclusion of inulin and oligofructose within the different proposed DF definitions worldwide has been evaluated and confirmed on numerous occasions, and by worldwide recognised experts and institutes, including the following (a non-exhaustive selection). Inulin and oligofructose comply with each and every definition:

- Codex Alimentarius Commission - CCNFSDU

In Appendix III of Alinorm 06/29/26, the following definition and properties of dietary fibre were proposed at step 7 of the 8-step approval procedure.

"Dietary fibre means carbohydrate polymers with a degree of polymerisation (DP) not lower than 3, which are neither digested nor absorbed in the small intestine. A degree of polymerisation not lower than 3 is intended to exclude mono- and disaccharides. It is not intended to reflect the average DP of a mixture. Dietary fibre consists of one or more of:

- Edible carbohydrates naturally occurring in the food as consumed,
- Carbohydrate polymers, which have been obtained from food raw materials by physical, enzymatic or chemical means,
- Synthetic carbohydrate polymers.

Dietary fibre generally has properties such as:

- Decrease intestinal transit time and increase stools bulk,
- Fermentable by colonic microflora,
- Reduce blood total and/or LDL cholesterol levels,
- Reduce post-prandial blood glucose and/or insulin levels."

In the list of "Methods of Analysis for Dietary Fibre", methods AOAC 997.03 and AOAC 999.03 are both included as dedicated methods to measure inulin and oligofructose.

Inulin and oligofructose are also in compliance with the previous Codex definition, as stated in the Codex guidelines on nutrition labelling; CAC/GL2 – 1985 (Rev. 1 – 1993):

“Dietary fibre means edible plant and animal material not hydrolysed by the endogenous enzymes of the human digestive tract as determined by the agreed upon method.”

- European Food Safety Authority

“Statement of the Scientific Panel on Dietetic Products, Nutrition and Allergies on a request from the Commission related to dietary fibre”

Request No. EFSA-Q-2007-121, expressed on 6 July 2007 at its 17th plenary meeting.

“The definition of dietary fibre should include all carbohydrate components occurring in foods that are non-digestible in the human intestine. This includes non-starch polysaccharides, resistant starch, resistant oligosaccharides with three or more monomeric units, and other non-digestible, but quantitatively minor components when naturally associated with dietary fibre polysaccharides, especially lignin.”

- International Life Science Institute – ILSI

“Dietary fibre”; ILSI Europe Concise Monograph Series; Gray, 2006.

The ILSI publications emphasises the importance of a physiological definition.

“Physiological properties of dietary fibre determine the importance in the human body and its requirement in the human diet. Therefore; most scientists now agree that the definition of dietary fibre should be physiologically based.”

Inulin and oligofructose are specifically mentioned in the composition and types of dietary fibre components.

- World Health Organisation – WHO

“Diet, Nutrition and the Prevention of Chronic Diseases”; Report of a joint WHO/FAO Expert Consultation; 2003

“NSP (dietary fibre): Dietary fibre is a heterogeneous mixture of polysaccharides and lignin that cannot be degraded by the endogenous enzymes of vertebrate animals.”

- Food and Agriculture Organisation of the United Nations – FAO (and WHO)

"Carbohydrates in human nutrition"; Report from a Joint FAO/WHO Expert Consultation, Rome, 14-18 April 1997; FAO, 1998.

"Dietary fibre occurring in foods and food products can be considered to consist of cellulose, hemicellulose, pectic substances, hydrocolloids (gums and mucilages), resistant starches, and resistant oligosaccharides."

Table 9 includes data on the "Colonic fermentability of dietary fibres in humans". Inulin and oligosaccharides are included as fully fermented (if they are not in excess).

- American Association of Cereal Chemists – AACC

"The Definition of Dietary Fiber: Report of the Dietary Fibre Committee to the Board of Directors"; 2001. (Cereal Foods World, Vol. 46, No. 3.)

"Dietary Fibre is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary fibre includes polysaccharides, oligosaccharides, lignin and associated plant substances. Dietary fibres promote beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or glucose attenuation."

It states further: "The updated definition includes the same food components as the historical working definition used for almost 30 years (a very important point, considering that most of the research of the past 30 years delineating the positive health effects of dietary fibre are based on that working definition)"

In the list of constituents of dietary fibre, inulin and oligofructose are explicitly mentioned.

- Institute of Medicine – IOM (USA)

"Dietary Reference Intakes for Energy, Carbohydrates, Fiber, Fat, Protein and Amino Acids (Macronutrients)"; 2002; National Academy of Sciences (NAS)

Chapter 7: Dietary, Functional and Total Fiber

"Dietary fiber consists of nondigestible carbohydrates and lignin that are intrinsic and intact in plants. Functional fiber consists of isolated, nondigestible carbohydrates that have beneficial physiological effects in humans. Total fibre is the sum of Dietary Fiber and Functional Fiber."

The document further states: “Inulin and oligofructose are naturally occurring in a variety of plants…. With respect to the definitions outlined in this chapter, the naturally occurring fructans that are found in plants such as chicory, onions, and Jerusalem artichoke, would be classified as Dietary Fiber, whereas the synthesised or extracted fructans could be classified as Functional Fibers when there are sufficient data to show positive physiological effects in humans.

- Agence Française de Sécurité Sanitaire des Aliments – AFSSA (French Authorities)
”Dietary fibre: definitions, analysis and nutrition claims”; Report of the Specialist Expert Committee on Human Nutrition, 2002.

“Dietary fibre consists of:
carbohydrate polymers (Polymerisation degree (PD) ≥ 3) of plant origin, which may or may not be associated in the plant with lignin or other non-carbohydrate components (polyphenols, waxes, saponins, cutin, phytates, phytosterols, etc.).
or
Carbohydrate polymers (PD ≥ 3) processed (by physical, enzymatic or chemical means) or synthetic, included in the attached list whose components may change on the basis of AFSSA recommendations.

In addition dietary fibre is neither digested nor absorbed in the small intestine. It has at least one of the following properties:

- Increase stools production
- Stimulate colonic fermentation
- Reduce post-prandial cholesterol levels
- Reduce post-prandial blood sugar and/or insulin levels.”

- British Nutrition Foundation
“Carbohydrates and dietary fibre”; Lunn and Buttriss, 2007; Nutrition Bulletin, 32, 21-64.

The British Nutrition Foundation recognises that DF is not an entity, but a collective term for a complex mixture of substances. It recognises that“a workable definition should clarify the constituent makeup of dietary fibre, and recognise that a primary characteristic is resistance to digestion and absorption in the small intestine and fermentation in the large intestine.”

Inulin and oligofructose are referred to on several occasions throughout the document as being part of the DF complex.

In addition, several experts have reviewed the DF definition and published their opinion:

- De Vries et al., 2005; Journal of AOAC International; Vol. 88; No. 5. “Historical perspective as a guide for identifying and developing applicable methods for dietary fibre”

This publication refers to the definition of Trowell et al. from 1981, which evolved to the following: “Dietary fibre consists of the remnants of edible plant cells, polysaccharides, lignin, and associated substances resistant to (hydrolysis) digestion by the alimentary enzymes of humans…. The Trowell et al. definition has served health research and regulatory communities well over 30 years.”

The publication further states that as a result of these consensus activities on DF, 4 additional Official Methods of Analysis were developed and adopted, one being AOAC 997.08, to analyse the polyfructose content (inulin and fructooligosaccharides) of foods.

- Cho et al., 1997; AOAC International; “Dietary fibre analysis and applications”; ISBN 0-935584-62-5.

This publication states that fructans (inulin and oligofructose) fall into a similar (DF) category because they are essentially undigestible in the small intestine. It further states that a recently published paper provided a method to determine inulin and resistant oligosaccharides in food products. By integrating this procedure into the current AOAC method, total dietary fibre is measured.

Prosky; 1999; Journal of AOAC International; “Inulin and oligofructose are part of the dietary fibre complex”; Vol. 82, No. 2.

Leon Prosky, the developer of the standard TDF official reference method AOAC 985.29, refers to the definition of dietary fibre as “the remnants of plant cells resistant to hydrolysis by human alimentary enzymes.”

He further states: “After discussions at the FDA in 1995 regarding the oligosaccharides that do not precipitate with 78% ethanol, FDA officials told the General Referee for Dietary Fiber and Complex Carbohydrates and the Chairman of the Official Methods Board of AOAC International that they would consider inulin and oligofructose as dietary fibre if the method for their determination could pass the scrutiny of an AOAC collaborative study.”

“On the basis of these findings, the natural occurrence of these oligosaccharides (fructans) in vegetables and fruits, and the physiological effects associated with inulin and oligofructose, I, as General Referee for Dietary Fiber and Complex Carbohydrates of AOAC International, conclude that inulin and oligofructose are indeed part of the dietary fibre complex.”

- Ha et al.; 2000; European Journal of Clinical Nutrition; “Review: A definition of dietary fibre”; 54; 861-864.

The article makes the following statement:

“The framework definition and the classification within this framework are based on recent advances, not only in the discipline of human nutrition but also in the disciplines of animal nutrition and cell-wall science.

Our proposed definition is:

Any dietary component that reaches the colon without being absorbed in a healthy gut. The framework definition is similar to Trowell’s original concept, but has been enlarged to include substances other than cell-wall material.”

Flamm et al.; 2001; Critical Reviews in Food Science and Nutrition; “Inulin and oligofructose as dietary fibre: a review of the evidence”; 41 (5); 353-362.

With Dr. Joanne Slavin (Food Science and Nutrition, University of Minnesota) as the referee, the authors concluded:

“After reviewing their chemistry, origin, and physiological effects, it is the opinion of the authors that inulin and oligofructose are dietary fibre. They share the basic common characteristics of dietary fibres, that is, saccharides of plant origin, resistance to digestion and absorption in the small intestine, and fermentation in the colon to produce short-chain fatty acids that are absorbed and metabolised in various parts of the body.

Definitions by National Authorities

Since an international definition of DF is lacking, several national authorities have included a definition in their national legislation.

- Canada; 1985:
"Dietary fibre is the endogenous components of plant material in the diet which are resistant to digestion by enzymes produced by humans. They are predominantly non-starch polysaccharides and lignin and may include, in addition, associated substances."

- Germany; 1989:
"Dietary fibre is substances of plant origin, that cannot be broken down to resorbable components by the body's own enzymes in the small intestine. Included are essentially soluble and insoluble non-starch polysaccharides (cellulose, pectin, hydrocolloids) and lignin and resistant starch. Substances like some sugar substitutes, organic acids, chitin and so on, which either are not completely absorbed in the small intestine, are not included."

- Belgium; 1992:
"Dietary fibre is the components of food that are not normally broken down by the body's own enzymes of humans."

- Italy; 1993:
"Dietary fibre is the edible substance of vegetable origin which normally is not hydrolysed by the enzymes secreted by the human digestive system."

- China; 1995:
"Dietary fibre is the sum of food components that are not digested by intestinal enzymes and absorbed by the body."

- Denmark; 1995:

“Dietary fibre is the material isolated by AOAC methods 985.29 and 997.08” (the Fructan method).

- Finland; 1998:
“Dietary fibre is the part of the carbohydrate obtained when using AOAC methods 985.29 and 997.08” (the Fructan method).

- Norway; 1998:
“Dietary fibre is the material isolated by AOAC method 985.29 and inulin and oligofructose.”

- Sweden; 1999:
“Dietary fibre is the edible material that cannot be broken down by human endogenous enzymes. Dietary fibre is determined with AOAC 985.29. In addition, the fructan method AOAC 997.08 may be used.”

- ANZFA (Australia & New Zealand):
“Dietary fibre means that fraction of the edible part of plants or their extracts, or synthetic analogous, that are resistant to digestion and absorption in the human small intestine, usually with complete or partial fermentation in the large intestine, and promote one of the following physiological effects:
- laxation, and
- reduction in blood cholesterol, and
- modulation of blood glucose.

and includes polysaccharides, oligosaccharides (DP>2), and lignins.”

- Health Council of the Netherlands; 2006:
“Dietary fibre is the collective term for substances that are not digested or absorbed in the human small intestine, and which have the chemical structure of carbohydrates, compounds analogous to carbohydrates, and lignin and related substances.”

Confirmation of the DF status of inulin and/or oligofructose in writing from competent national authorities:

As a result of separate submissions, the status of inulin and oligofructose as DF for food labelling has been confirmed in the following countries:

Austria

Australia

Brazil

Canada

Belgium

Czech Republic

Denmark

Finland

France

Germany

Greece

Ireland

Italy

Japan

Malaysia

Mexico

Netherlands

Norway

Poland

Portugal

Singapore

South-Africa

South-Korea

Sweden

Switzerland

Thailand

United Kingdom

3. Food Applications

Inulin and oligofructose are used as food ingredients for two reasons: for their DF and technical properties. These ingredients offer a double benefit, namely an improved organoleptic quality and a better balanced nutritional composition. The potential uses include a wide range of different food categories. Examples of intendedi use categories and use levels have been published by Leatherhead in "LFRA Ingredients Handbook: Prebiotics and Probiotics", 2000. The relevant pages are included in Annex 9.2.

4. Stability

The stability of the ingredients includes ingredient shelf life, process and acid stability.

In powder form, tests have demonstrated that during shelf life in their original packaging, the ingredients remains within specification for at least 3.5 years.
In acid and high temperature conditions, a partial hydrolysis of the ingredients may occur. In the a result, however, the only by-products that are formed are fructose, and to a minor extent glucose. The available data on stability in food matrix-type conditions include:

- storage stability in liquids at several pH conditions;
- process stability under typical food processing steps, including sterilisation, pasteurisation, UHT.

This data is available in the Application File "Acid and Thermal Stability" (see Annex 9.3).

5. Analytical methodology

Several methods have been developed and published to quantify inulin and oligofructose in standard food matrices. These include two AOAC Reference methods to quantify inulin (AOAC 999.03) and inulin and oligofructose (AOAC 997.08). In addition, two methods have been published by AOAC International, to determine oligofructose (Joye et al., 2000) and to determine inulin and oligofructose (Steegmans et al., 2004).

Both AOAC reference methods AOAC 997.08 (for inulin and oligofructose) and AOAC 999.03 (for inulin) are included in FSANZ Food Code Standard 1.2.8 on Nutrition Information Requirements.

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Annex 9.2.

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Leatherhead Food RA
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LFRA
INGREDIENTS HANDBOOK

PREBIOTICS AND PROBIOTICS

Edited by
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Fiona Angus

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TABLE III
Food applications for inulin and oligofructose

Application	Functionality	Dosage level inulin (% w/w)	Dosage level oligofructose (% w/w)
Dairy products (yoghurts, cheeses, desserts, drinks)	Sugar replacement (OF) Synergy with intense sweeteners (OF) Fat replacement (IN) Body and mouthfeel (IN, OF) Foam stability (IN) Fibre and prebiotic (IN, OF)	2-10	2-10
Frozen desserts	Fat replacement (IN) Texture (IN) Sugar replacement (OF) Synergy with intense sweeteners (OF) Melting behaviour (IN, OF) Low caloric value (IN, OF) Fibre and prebiotic (IN, OF)	2-10	5-12
Table spreads and butter products	Fat replacement (IN) Texture and spreadability (IN) Emulsion stability (IN) Replacement of gelatin (IN) Fibre and prebiotic (IN)	2-10	-
Baked goods and breads	Fibre and prebiotic (IN, OF) Moisture retention (IN, OF) Sugar replacement OF)	2-15	2-25
Breakfast cereals and extruded snacks	Fibre and prebiotic (IN, OF) Crispiness and expansion (IN, OF) Low caloric value (IN, OF)	2-25	2-15
Fillings	Fat replacement (IN) Sugar replacement (OF) Texture (IN)	2-30	2-50
Fruit preparations	Sugar replacement (OF) Synergy with intense sweeteners (OF) Body and mouthfeel (IN, OF) Low caloric value (IN, OF) Fibre and prebiotic (IN, OF)	2-10	5-50
Salad dressings	Fat replacement (IN) Mouthfeel and body (IN)	2-10	-
Meat products	Fat replacement (IN) Texture and stability (IN) Fibre and prebiotic (IN)	2-10	-
Dietetic products and meal replacers	Fat replacement (IN) Sugar replacement (OF) Low caloric value (IN, OF) Synergy with intense sweeteners (OF) Body and mouthfeel (IN) Fibre and prebiotic (IN, OF)	2-15	2-20
Chocolate	Sugar replacement (IN) Fibre and prebiotic (IN) Heat resistance (IN)	5-30	-
Tablets	Sugar replacement (IN, OF) Fibre and prebiotic (IN)	5-100	2-10

IN = inulin; OF = oligofructose

Annex 9.3.

Application File
Acid and Thermal Stability

Application File

Acid and Thermal Stability

ORAFTI
ACTIVE FOOD INGREDIENTS

BENEO

CONTENT

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1. Description

In acid and (high) temperature conditions oligofructose and inulin can be hydrolysed in shorter chains and fructose (see fig.1). This results in a partial (or total) loss of the nutritional properties and in some cases an increase in sweetness. The hydrolysis depends on pH, water activity, temperature and time. It can often be estimated or predicted since a lot of data are already available. Only in a few specific cases hydrolysis can limit the development of new products e.g., acid products with a long shelf-life and with a "sugar free" claim. In most cases of hydrolysis a small overdosing can be sufficient to obtain the necessary result, e.g. the right amount of fibre at the end of the shelf-life.

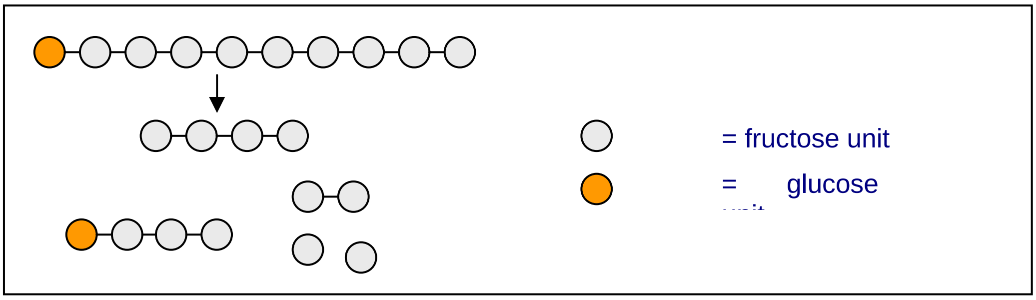

Fig 1. Hydrolysis of inulin : formation of shorter chains (GF_n, F_n), fructose and a limited amount of glucose. The shorter fructan chains have the same nutritional properties as the longer ones.

The hydrolysis grade is determined by :

$$\%\text{hydrolysis} = \frac{\text{inulin or oligofructose content } (T_0) - \text{inulin or oligofructose content } (T_1)}{\text{inulin or oligofructose content } (T_0)}$$

So, the hydrolysis level is expressed in percent as the difference between the inulin/oligofructose content measured at T_0 (initial) and at T_1 (final).

2. Consequences

2.1. Sweetness increase

The effect on sweet taste depends on the initial amount of inulin or oligofructose applied in the product and the hydrolysis. In most cases where rather small quantities are incorporated e.g. 2% and where e.g. 10 - 20% hydrolysis occurs a sweetness increase equivalent to 0.2 - 0.4% fructose is obtained which is not significant from the sensorial point of view.

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2.2. Partial loss of nutritional benefits

When hydrolysis takes place fructose is formed from inulin or oligofructose, the nutritional properties are therefore partially lost. This can in most cases be solved by adding an extra amount of inulin or oligofructose to compensate for this loss. An example :

Acid milk drink, pH 4.0, shelf-life 6 months, 1 g fibre per 100 g product

- fibre source : Beneo™ST
- expected hydrolysis : 15% after 6 months
- calculation :

goal at $T(_1)$ which is the end of the shelf-life : 1g fibre/100 g

to be added initially at $T(_0)$: 1.18% inulin = 1.32% Beneo™ST*

* Beneo™ST : contains 97% dry solids, 92% inulin on d.s.

3. Process stability of Beneo™ inulin and Beneo™ oligofructose

3.1. Process stability of Beneo™ oligofructose

The table hereunder shows the hydrolysis grade of oligofructose after different heat treatments. It depends on pH, dry substance (water activity), temperature and time. In identical conditions Beneo™ oligofructose is more sensitive to hydrolysis compared to Beneo™ inulin due to its lower degree of polymerisation.

Remark : All hydrolysis grades are expressed as % of the initial amount of inulin or oligofructose in the sample (see paragraph 1).

3.1.1. Pasteurisation

Beneo™P95 or Beneo™L95, addition level : 20% dry substance

% hydrolysis	pH = 6.0	pH = 4.0	pH = 3.5
85°C 2’	0	< 1	5
85°C 5’	0	< 1	6
90°C 5’	0	< 1	10
95°C 2’	0	1	10
95°C 5’	0	1	16

In this table the effect of pH and temperature is clearly demonstrated. If pH is equal or higher than 4.0 hydrolysis is fairly limited in all temperature conditions. At lower pH levels temperature is more

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important, e.g. at 95°C during 5’ already 16% hydrolysis occurs.

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Beneo™L95 or Beneo™P95, addition level : 40% dry substance

% hydrolysis	pH = 6.0	pH = 4.0	pH = 3.5
85°C 2'	0	< 1	4
85°C 5'	0	< 2	5
90°C 5'	0		9
95°C 2'	0	< 1	10
95°C 5'	0		15

At a 40% dry solids level a slightly better stability is noticed but this is not highly significant. An identical effect of pH and temperature is noticed as at 20% dry solids level.

3.1.2. UHT process

Beneo™L95 or Beneo™P95, addition level : 20% dry substance

% hydrolysis	pH = 6.0	pH = 3.5
140°C, 10" direct *	1	22
140°C, 10" indirect**	0	5
120°C, 5" indirect	1	
120°C, 120" indirect	4	

* direct steam injection : direct contact between the steam and the product
** indirect system : no direct contact

As illustrated in the table above UHT treatment of products which have a neutral pH does not induce hydrolysis. This means that Beneo™ can be applied in e.g. UHT milk or UHT desserts without any risk of loss of its technological and nutritional properties. When acid products are produced, the UHT system will determine the rate of hydrolysis. In an indirect system only a limited hydrolysis occurs whereas in a direct system a significant loss can be noticed.

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3.1.3. Sterilisation

Tests were done in a typical sterilisation tower with 5 different stages :

stage 1 : 15 minutes at 64°C
stage 2 : 15 minutes at 85°C
stage 3 : 11 minutes at 114-118°C
stage 4 : 15 minutes at 85°C
stage 5 : 15 minutes at 40°C

This is a rather severe thermal treatment which results in more hydrolysis at lower pH levels compared to other thermal treatments. At 15% dry solids level and pH of about 5.7 no hydrolysis takes place.

When pH is about 3.5 a significant hydrolysis of the oligofructose (Beneo™L95 or Beneo™P95) happens : up to 50%. At higher dry solids level such as e.g. 60% we notice a reduction of the hydrolysis grade down to 24%.

3.2. Process stability of Beneo™ inulin

The table hereunder shows the hydrolysis grade of inulin after different heat treatments. In acid and high temperature conditions inulin can be hydrolysed in shorter chains with as a consequence the formation of fructose and an increase in sweetness. A clear difference between oligofructose and inulin can be noticed : inulin is less sensitive due to its longer chains. Therefore Beneo™HP is also less sensitive compared to standard inulin (Beneo™ST ,GR, ST-Gel).

Generally the hydrolysis rate of Beneo™ST is twice the one of Beneo™HP.

3.2.1. Pasteurisation

Beneo™ST-Gel, addition level : 10% dry substance

% hydrolysis	pH = 6.5	pH = 4.0	pH = 3.5	pH = 3.0
70°C 5’	**0**	**< 1**		**1**
15’	**0**	**< 1**		**5**
30’	**0**	**< 1**		**7**
60’	**0**	**2**		**13**
90°C 5’	**0**		**3**	

In this table the effect of pH and temperature is clearly demonstrated. If pH is equal or higher than 4.0 the total hydrolysis is fairly limited in all temperature conditions. At lower pH levels such as 3.0 temperature is more important e.g. at 70°C during 60’ already 13% hydrolysis occurs.

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3.2.2. UHT process

Beneo™ST-Gel, addition level : 15% dry substance

% hydrolysis	pH = 5.0
direct : 145°C, 10"	0
indirect : 140°C, 10"	0

3.2.3. Sterilisation

The applied sterilisation process is described in Fig 2. At neutral pH values no hydrolysis occurs. In acid conditions e.g. pH 3.5, 15% dry solids, 13% hydrolysis is found. At a higher dry solids level e.g. 60% no hydrolysis takes place.

4. Storage stability of Beneo™ inulin and Beneo™ oligofructose

4.1. Storage stability of Beneo™ oligofructose

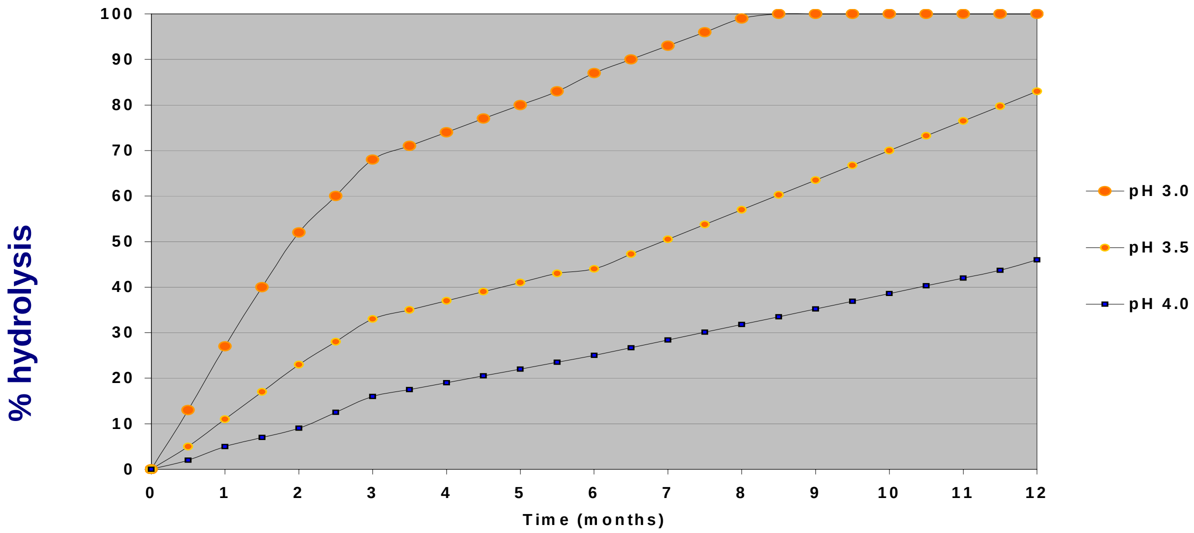

Fig. 3: the hydrolysis of Beneo™P95 is shown when stored at different pH levels and at 20°C. The test product was an acid drink at 14°Bx.

Fig. 3 illustrates that significant hydrolysis rates should be taken into account. For a product with a 6 month shelf-life and a pH of 4.0, an overdosing of 20% must be applied to compensate for the acid

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hydrolysis.

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4.2. Storage stability of Beneo™ inulin

Due to the reduced sensitivity to hydrolysis compared to oligofructose, inulin is more suitable as a nutritional ingredient in acid drinks. Beneo™ST and Beneo™HP can easily be used. In Fig. 4 the hydrolysis grade of Beneo™ST is shown.

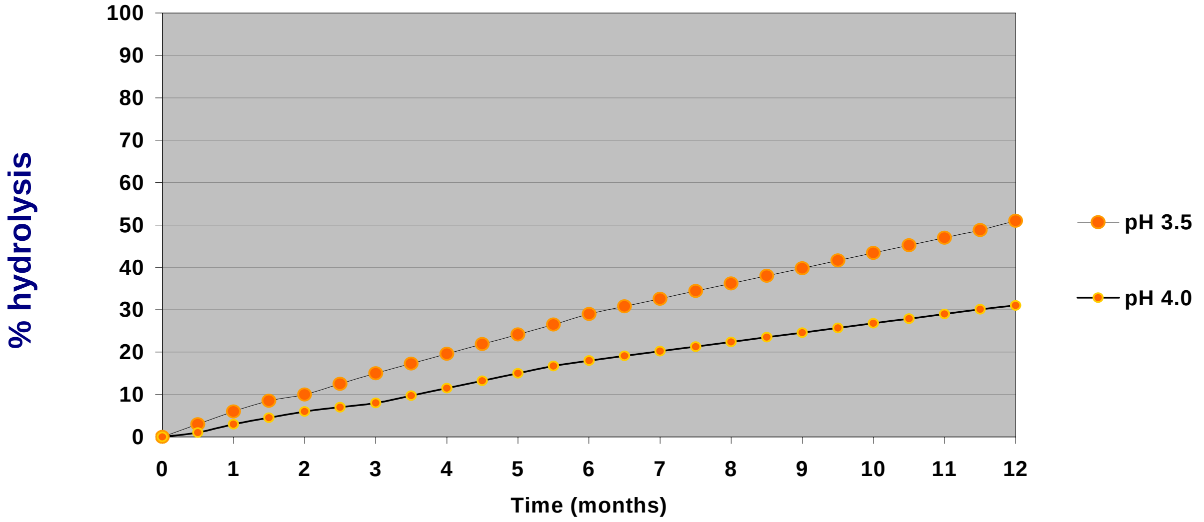

Fig. 4 : Hydrolysis of Beneo™ST stored for 12 months at room temperature and different pH levels.

This illustrates that inulin is a more suitable ingredient as e.g. fibre for acid drinks with a long shelf-life. For instance at a pH = 4.0 an hydrolysis of about 15% is measured after 6 months which can easily be compensated by overdosing about 15% inulin. This allows to guarantee the claimed fibre content after 6 months storage. The hydrolysis products don't cause sensorial differences because of the rather low concentration of inulin used in such applications (max. 2%).

Another option is the use of Beneo™HP and Beneo™HP-Gel which are less sensitive than Beneo™ST. Their solubility is however limited to about 1% at room temperature. Nevertheless in most cases 1% fibre is sufficient and therefore Beneo™HP is a suitable option. Fig. 5 gives a simulation of the hydrolysis rate of Beneo™HP.

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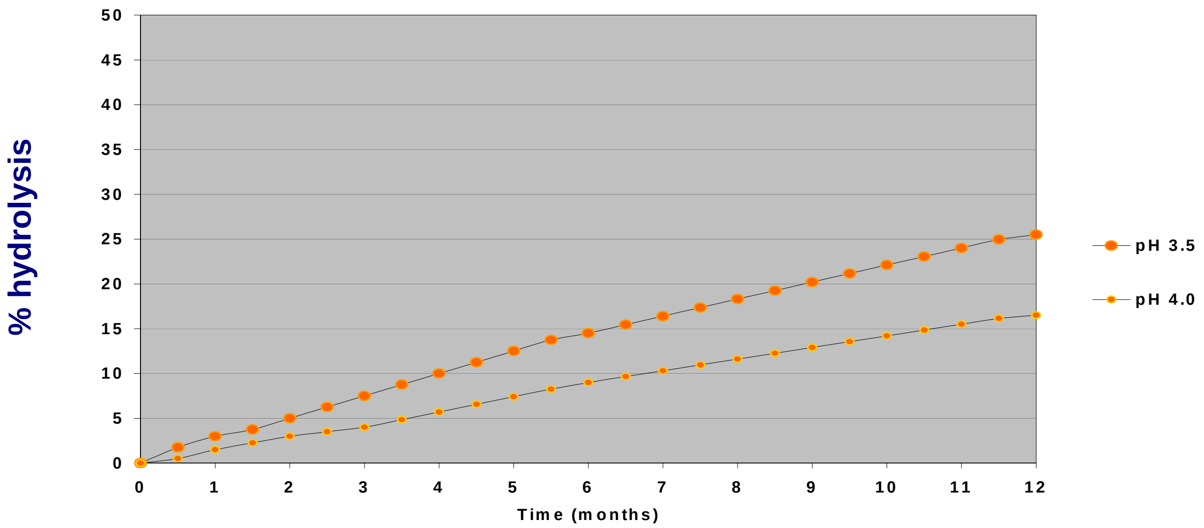

Fig. 5 :	*Hydrolysis of Beneo™HP stored for 12 months at room temperature and different pH levels.*

Fig. 5 illustrates that Beneo™HP is the most suitable Beneo™ type at low dosages e.g. as a fibre for acid drinks with a long shelf-life. Even at a pH = 3.5 a hydrolysis of less than 15% is measured after 6 months which can easily be compensated by overdosing of about 15% inulin.

5. Conclusions

From a technological point of view Beneo™ inulin and Beneo™ oligofructose can usually be applied, e.g. for their nutritional benefits, in most food applications, including acid formulations. Only in case of specific severe conditions, their use can be limited. In most other cases, a slight overdosing can solve the hydrolysis problem.

6. Nutritional properties of Beneo™ oligofructose and Beneo™ inulin

See our specific document <<Nutritional Properties>>.

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7. Notes

Remark : Analytical Method for inulin/oligofructose (dietary fibre analysis).

To measure inulin or oligofructose, the standard AOAC-Total Dietary Fibre methods or the Englyst method cannot be used. A specific AOAC method, the <<Fructan Method>> officially published by AOAC under number 997.08., must be used.

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