Food Chemistry 193 (2016) 102–105

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Analytical Methods

Inulin content of fortified food products in Thailand ☆

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ARTICLE INFO

Article history:
Available online 3 November 2014

Keywords:
Inulin
Food products
Fortified food

ABSTRACT

This study examined inulin content in 266 samples. They were 126 dried, 105 liquid and 27 semi-solid of twelve commercial inulin fortified food products and 8 samples of natural dried sunchoke. For dried food products, inulin content ranged from 3.0 ± 0.8 g/100 g fresh weight (FW) in milk powder to 83.7 ± 17.8 g/100 g FW in inulin powder. The levels in a descending order are the powder of inulin, weight control diet, coffee mixed, instant beverage, supplemented food products for pregnant and milk. For liquid fortified foods, inulin at the level of 0.3 ± 0.1 g/100 mL FW was found in UHT milk, and up to 13.5 ± 4.1 g/100 mL FW in weight control diet beverage. The level of 2.0–2.3 g/100 g FW of inulin was found in beverage with different flavours, soybean milk and fruit juice. For semi-solid food, cream yoghurt, inulin at 3.9 ± 1.1 g/100 g FW was found. A serving of most products contributes inulin at 11–33% of the recommended daily intake of dietary fibre.

1. Introduction

Inulin is found in many plants as a storage carbohydrate and has been part of the human daily diet for several centuries. It presents in foods such as onion, garlic, chicory, and sunchoke (or Jerusalem artichoke) (Judprasong, Tanjor, Puwastien, & Sungpuag, 2011; Van Loo, Coussement, DeLeenheer, Hoebregs, & Smits, 1995). Inulin and fructooligosaccharides in foods fulfil the two major functions of soluble dietary fibre and prebiotic. An extra benefit of inulin as a potential source of dietary fibre in many manufactured food products is that it cannot be digested by the enzymes of the human small intestine. The most effective human intake level of inulin for reducing serum triglyceride, cholesterol and LDL-cholesterol concentrations in the blood was found to be 8–10 g per day (Abrams et al., 2005, 2007; Canzi, Brighenti, Casiraghi, Del Puppo, & Ferrari, 1995; Hidaka, Tashiro, & Eida, 1991; Jackson, Taylor, Clohessy, & Williams, 1999; Williams, 1999). Inulin at 15–20 g per day was found by Gibson, Beatty, Wang, and Cummings (1995), Hond, Geypens, and Ghoos (2000), Kleessen, Svkura, Zunft, and Blaut (1997) to be effective in relieving constipation. Microorganism fermentation of inulin has produced short chain fatty acids and lactate while bifidobacteria increased from 20% to 71% and bacteroids decreased from 65% to 26% (Gibson et al., 1995).

Owing to its nutritional and physiological properties, inulin has increasingly been used as a versatile ingredient in processed functional foods such as fat and sugar replacements or fibre supplements (Roberfroid, 2007). Inulin and fructooligosaccharides have numerous beneficial characteristics as functional ingredients that offer a unique combination of interesting nutritional properties and important technological benefits. They can improve taste, texture, and moisture in many foods. Inulin has gelling characteristics that can be used to make low fat cheeses, sauces, soups and table spreads. Its melting properties allow for easy processing of frozen desserts. Binding characteristics allow for inulin to be used in cereal bars. Consequently, fat and carbohydrate replacement with inulin offers the advantage of not having to compromise on taste or texture, while delivering further nutritional benefits. Hence, inulin represents a key ingredient that offers new opportunities to a food industry that is constantly seeking well balanced, yet better tasting, products of the future.

In view of the lack of readily available information on inulin and its growing importance in food products in Thailand, this study was performed to examine inulin content in different food products. Amount of inulin (as dietary fibre) in a serving of each product as per cent of the recommended daily intake (RDI) and the USA was also evaluated.

2. Materials and methods

2.1. Food sampling and sample preparation

The Institute of Nutrition, Mahidol University (INMU) is the only institute in Thailand who could analyse inulin content in

☆ Presented at the Tenth International Food Data Conference (10th IFDC), Granada, Spain, September 12–14, 2013.

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http://dx.doi.org/10.1016/j.foodchem.2014.10.140
0308-8146/

foods. The food manufacturers were advised to collect at least three representative samples of their products and submitted to INMU for analysis. During 2008 to 2013, two hundred and fifty-eight commercial inulin fortified food products which could classified into twelve food groups were analysed, together with eight samples of natural dried sunchoke. The distribution of the number of determined inulin fortified samples, in a descending order, was milk powder ($n = 57$), drinking yoghurt ($n = 39$), cream yoghurt ($n = 27$), weight control diet powder ($n = 22$), beverage with different flavours ($n = 22$), instant beverage powder ($n = 21$), fruit juice ($n = 17$), UHT milk ($n = 16$), 3 in 1 instant coffee mix powder ($n = 15$), inulin powder ($n = 11$), soybean milk ($n = 6$) and supplemented food powder for pregnant women ($n = 5$). Only the edible part of each sample was homogenised using an appropriate food mixer. Dry samples were mixed in a big plastic bag or in a food processor depending on the quantity of the sample. Each sample was immediately analysed for moisture before being stored, in an acid-washed screw-capped plastic bottle, at 4 °C for dried samples and at −20 °C for semi-solid and liquid samples until analysis.

2.2. Reagents

Four level of standard sugar (fructose, glucose and sucrose, Fluka, USA) in the range 0.2–0.8 mg/mL and 0.2 mg/mL of rhamnose (Sigma, USA) as an internal standard, were prepared. The used deionised water (resistivity 18.2 MΩ/cm) was obtained using a Millipore water purification system (Millipore RiOs-DITM134, Bedford, MA, USA).

2.3. Moisture determination

Moisture in fresh samples was determined according to the AOAC method No. 990.19 (AOAC, 2005) in which 1–2 g of homogenised sample was dried in an oven at 100 ± 2 °C until constant weight. Moisture content, as g/100 g sample, was then calculated from the weight loss.

2.4. Inulin determination

Following the AOAC method No. 997.08 (AOAC, 2005), inulin was extracted from each sample with hot water. Inulin-type fructans in a portion of the hot water extract were hydrolysed by inulinase (Sigma–Aldrich®, USA, I2017 inulinase from *Aspergillus niger*, CAS Number 9025-67-6 which has enzyme activity of 1740 inu/g). Both hot water extracted and enzyme hydrolysed fractions were derivatised into volatile oxime-trimethylsilyl derivatives. Each individual sugar, both before and after enzyme hydrolysis, was then determined by high temperature gas chromatography (Joye & Hoebregs, 2000) and total inulin in each sample was calculated. Details of inulin analysis have been described elsewhere (Judprasong et al., 2011). The amount of inulin was presented as mean ± standard deviation and expressed as g/100 g edible portion on fresh weight basis (FW).

2.5. Analytical quality control

Two commercial products, namely, a mixture of inulin and oligofructose (Orafti® P95, Beneo, Belgium) and granulated inulin powder (Orafti® GR, Beneo Belgium), were used as reference materials for checking accuracy, while inulin fortified milk powder (Protection 1+, Nestle®) was used as a laboratory quality control sample for checking precision in inulin analysis. These materials were analysed in each run along with the unknown samples. Results obtained were evaluated using the values of inulin in the reference materials and the assigned value of inulin in the quality control sample.

3. Results and discussion

3.1. Quality control system for inulin and sugar analysis

Inulin analysis using reference materials, a quality control sample and the unknown food samples was performed in triplicate. Table 1 shows accuracy and precision performance for inulin analysis. Recovery of inulin in the reference materials (Orafti® P95 and Orafti® GR) was 98–102% which fell within the accepted range (AOAC, 2012) indicating good accuracy performance. Results obtained from analysis of the quality control sample fell within the mean ± 2SD of the assigned value (Table 1). This indicated good performance of laboratory precision. The obtained relative standard deviation from intralaboratory reproducibility (%RSD_r = 7.1), triplicate analysis, was in the range of 0.3–1.3 of the relative standard deviation between laboratories ($pRSD_R$) at inulin level of 4.6 g/100 g (%RSD_R = 11.1) as derived from interlaboratory study using AOAC method No. 997.08 (AOAC, 2005). This evidence indicated good intermediate precision performance for the analyst.

3.2. Inulin content in food products

Moisture and inulin content (presented in descending order) in commercial inulin fortified dried products, together with non-fortified sunchoke powder (*Helianthus tuberosus* L.) and in liquid food products, are shown in Table 2. For dried food products, inulin content ranged from 3.0 ± 0.8 g/100 g FW (mean ± SD) in milk powder (the most popular fortified food product) to 83.7 ± 17.8 g/100 g in inulin powder. For weight control diet powder, it was found that they were fortified at two levels of inulin, 32.8 ± 7.2 and 76.9 ± 9.8 g/100 g FW, respectively. Sunchoke powder, a non-fortified commercial product sold in the form of ready-to-eat powder, contained inulin level of 53.5 ± 11.8 g/100 g FW (or 59.6 ± 13.1 g/100 g dry weight). The inulin level on a dry weight basis in the sunchoke

Table 1
Accuracy and precision performance in inulin analysis.[a]

Food matrices	Fructans (g/100 g)		Recovery (%)
	Reference values/assigned values	Values from this study	
Accuracy performance			
Mixtures of inulin + fructooligosaccharides (Orafti® P95, Beneo Belgium)	90	90.6 ± 1.6 (CV = 1.8%)	100.7 ± 1.8
Granulated inulin powder (Orafti® GR, Beneo Belgium)	87	87.9 ± 1.7 (CV = 1.9%)	100.5 ± 1.7
Precision performance			
Inulin fortified milk powder (Protection 1+, Nestle®)	2.9 ± 0.1 ($n = 20$, %CV = 3.4)	2.8 ± 0.2 (%CV = 7.1)	–

[a] Number of analytical sets which include reference materials and quality control samples.