LWT - Food Science and Technology 64 (2015) 735–741

Contents lists available at ScienceDirect

LWT - Food Science and Technology

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

Are folates, carotenoids and vitamin C affected by cooking? Four domestic procedures are compared on a large diversity of frozen vegetables

Sylvie Bureau [a, b, *], Sonia Mouhoubi [a, b], Line Touloumet [a, b], Caroline Garcia [a, b], Florie Moreau [c], Valérie Bédouet [c], Catherine M.G.C. Renard [a, b]

[a] INRA, UMR408 Sécurité et Qualité des Produits d'Origine Végétale, F-84000 Avignon, France
[b] Université d'Avignon et des Pays de Vaucluse, UMR408 Sécurité et Qualité des Produits d'Origine Végétale, F-84000 Avignon, France
[c] Toupargel, 13, chemin des près secs, 69380 Civrieux d'Azergues, France

ARTICLE INFO

Article history:
Received 21 April 2015
Received in revised form
5 June 2015
Accepted 9 June 2015
Available online 25 June 2015

Keywords:
Domestic cooking
Reprocessing
Nutritional quality
Vegetables
Ascorbate

ABSTRACT

Four home procedures such as boiling in water, steaming, pressure steaming and microwave cooking were tested on 13 frozen vegetables. Folates, carotenoids and vitamin C were characterized on uncooked and cooked vegetables and illustrated a very large variability among the studied vegetables. The effect of cooking was significant but it varied according to vegetables and phytochemicals. The best method to preserve the nutritional quality could be alternatively steaming, microwaving or pressure cooking, whereas boiling was generally the less suitable method. On the fresh weight basis, boiling involved a high loss of total vitamin C (average of −51% on fresh matter) and folates (−68%) and a slight loss of lutein (−15%) and β-carotene (−9%). On the dry weight basis, it remained the less suitable for vitamin C (−44%) and folates (−65%) but not for carotenoids, as it allowed a better extractability of lutein (+9%) and β-carotene (+20%).

1. Introduction

Vegetables are a class of plant foods that are eaten as fresh, canned, frozen and cooked vegetables. Beyond its effect on texture and taste, cooking also changes the nutritional properties of vegetables. Main phytochemicals such as vitamin C, folates (vitamin B9) and provitamin A carotenoids (β, α and γ-carotene and β-cryptoxanthin) are present in vegetables. Among non-vitaminic compounds, lutein (Calvo, 2005) and lycopene (Singh & Goyal, 2008) are also mostly provided in the diet by green leafy vegetables and tomato, respectively. Lutein plays a major role against macula degeneration (Granado, Olmedilla, & Blanco, 2003), while lycopene has proven effects in prevention of prostate cancer (Bramley, 2000).

The effect of domestic cooking on phytochemicals (carotenoids non-vitamin C, polyphenols, chlorophylls) and on micronutrients (vitamins) and has been already studied on vegetables (Bernhardt & Schlich, 2006; Gebczynski & Lisiewska, 2006; Mazzeo et al., 2011; Miglio, Chiavaro, Visconti, Fogliano, & Pellegrini, 2008; Pellegrini et al., 2010; Sultana, Anwar, & Iqbal, 2008; Turkmen, Sari, & Velioglu, 2005; Volden, Borge, Hansen, Wicklund, & Bengtsson, 2009). Different procedures have been tested such as boiling, microwave cooking, steaming, pressure steaming, frying and stewing. Their effects have been observed on different families of phytochemicals i.e. total polyphenols, carotenoids, α-tocopherol, glucosinolates, vitamin C, anthocyanins and chlorophylls. A large diversity of vegetables has been concerned by these researches and it is encouraged to consume a large diversity of them to consume all nutrients and with a practical point of view to express the data on a dry weight basis to allow a good comparison taking into account the moisture change (Rickman et al., 2007a and b).

However data are fragmented because studies concern rarely all phytochemicals, usually on one or two vegetable species, and testing one or two of cooking methods, which makes difficult to have a good view of the effect of home cooking on the nutritional quality of vegetables. In addition, most of these studies have been focused on fresh vegetables, while modern lifestyles lead consumers to resort increasingly to processed vegetables (primarily

* Corresponding author. INRA, UMR408 Sécurité et Qualité des Produits d'Origine Végétale, Centre de Recherche PACA, 228 route de l'Aérodrome, CS 40509, Domaine Saint Paul – Site Agroparc, 84914 Avignon Cedex 9, France.
E-mail address: sylvie.bureau@avignon.inra.fr (S. Bureau).

http://dx.doi.org/10.1016/j.lwt.2015.06.016
0023-6438/

canned and frozen). Frozen vegetables are convenient and, after the original reduction caused by blanching and freezing, maintain nutritional qualities levels at −20 °C during storage for water soluble antioxidant activity in peas and spinach (Hunter & Fletcher, 2002). However, our recent studies (Delchier, Reich, & Renard, 2012) indicated that effects of cooking were exacerbated on frozen vegetables, mainly due to facilitated losses by leaching.

The aim of this work was to understand how an industrial processing (blanching and freezing) interacts with domestic cooking practices to impact the nutritional content of vegetables. Indeed, the effect of four common home cooking procedures, boiling in water, microwave cooking, steaming and pressure steaming, was studied on the micronutrient content of blanched and frozen vegetables. The representative micronutrients were hydrosoluble compounds such as vitamin C and folates, and phytochemicals such as carotenoids for lipidic compounds. As different effects were highlighted depending on the vegetables (Danesi & Bordoni, 2008), thirteen blanched and frozen vegetables, representative of a large diversity in composition and in shape, were characterized before and after cooking procedures.

2. Materials and methods

2.1. Materials

Thirteen vegetables were provided by a French company specialized in home delivery of frozen products (Toupargel, Civrieux d'Azergues). During their processing, vegetables were systematically blanched before freezing and then stored at −20 °C. The studied vegetables were: (1) green and (2) yellow French bean (*Phaseolus vulgaris* L.), (3) pea (*Pisum sativum* L.), (4) Brussels sprout (*Brassica oleracea* L. Gemmifera group), (5) broccoli (*B oleracea* L. Italica group) and (6) cauliflower (*B. oleracea* L. Botrytis group), (7) leek (*Allium porrum* L.), (8) zucchini (*Cucurbita pepo* L. *subsp. pepo*), (9) branch (whole leaves) and (10) hashed spinach (*Spinacia oleracea* L.), (11) mushroom, despite not being vegetables they are treated by most consumers similarly (*Agaricus bisporus* (J.E.Lange) Imbach), (12) carrot (*Daucus carota* L.) and (13) salsify (*Tragopogon porrifolius* L) were received in our laboratory in may 2012. For each, ten bags of 1 kg of the same batch were immediately stored at −20 °C until cooking.

2.2. Four tested methods of home cooking

Four home cooking methods were tested on 500 g of vegetables, following the recommendations indicated on the packaging by Toupargel, and following the instructions for use of the steamer (see § 2.2.3), of the pressure cooker, and of the microwave-oven. The frozen vegetables were ready to use, without thawing. For each method, three replications were performed on different portions of 500 g of vegetables but all portions were from the same batch of frozen vegetables. The cooking water was salted such as at home (around 10 g/L).

2.2.1. Boiling water (BW)

Each portion of frozen vegetables was immersed in boiling water in a pan at atmospheric pressure without lid. The volume of water and the time of cooking are given in Table 1. After boiling, vegetables were drained using a strainer, stabilized by freezing in liquid nitrogen and stored at −80 °C until analysis.

2.2.2. Pressure cooking (PC)

Each portion of frozen vegetables was placed in a sealed pressure cooker (nutricook®, SEB, Selongey, France) with 400 or 800 mL of water at the bottom of the cooker. Vegetables were kept out of the water during cooking. The time of cooking given in Table 1 corresponded to the time after the first issue of vapor. Just after cooking, vegetables were drained, chilled in an ice water bath during five minutes, drained, stabilized by freezing in liquid nitrogen and stored at −80 °C until analysis.

2.2.3. Steaming (ST)

As no recommendation was indicated on packaging, the cooking time was defined experimentally and collectively by 6 persons of the laboratory who tasted each vegetable after different cooking times. Each portion of frozen vegetables was steamed according to this defined time (Table 1). 1 L of water was used to generate the steam. Steaming was carried out using SEB "Vitacuisine Compact®" (SEB, Selongey, France). At the end of steaming, vegetables were directly stabilized by freezing in liquid nitrogen and stored at −80 °C until analysis.

2.2.4. Microwave cooking (MW)

In the microwave (Whirlpool, Family chef) no additional water was used. The vegetables were placed in a dish with a lid and were stirred at half of the cooking time (Table 1). Heating occurred with a power of 750 W, i.e. 1.5 W/g. Vegetables were then stabilized by freezing in liquid nitrogen and stored at −80 °C until analysis.

2.3. Samples preparation

Before analysis, the frozen samples were ground in liquid nitrogen to obtain a homogenised powder which was stored at −80 °C. In parallel to the cooking tests, three sets of 500 g of each uncooked vegetable, blanched and frozen, were directly taken in the marketed bags. They were ground in liquid nitrogen, stored at −80 °C until analyses. They corresponded to the 'control' samples identified by T0.

For each sample, the dry weight was determined on sample powder (the same as used for nutrient analyses to ensure consistency) in a convection oven at 70 °C until constant weight was reached (about 3 days). The determined dry weight was used to calculate the nutrient content in dry weight (DW) basis from the analytical results obtained in fresh weight (FW) basis.

2.4. Biochemical measurements

Nutrient analyses were made directly on homogenised powder, stored at −80 °C, without any defrosting.

2.4.1. Chemicals

Chemicals were the same that those already described by Delchier et al. (2013) for folates, by Page, Van Stratum, Degrou, and Renard (2012) for carotenoids and by Stevens, Buret, Garchery, Carretero, and Causse (2006) for vitamin C.

2.4.2. Folates

Folate extraction, deconjugation and derivatisation were carried out on frozen homogenised powder stored at −80 °C using the principle described by Delchier et al. (2012). Among the 13 vegetables, folates were characterized in all vegetables at T0 but only in 4 vegetables (green bean, broccoli, hashed spinach and cauliflower) after the four cooking procedures because their analysis is work-intensive and a number of vegetables had very low initial levels. Folate content was expressed as total folates in μg/kg of fresh weight (FW) and calculated in μg/kg of dry weight (DW).

2.4.3. Carotenoids

Carotenoid extraction was carried out on frozen homogenized powder stored at −80 °C using the micromethod described by