JOURNAL OF FOOD AND DRUG ANALYSIS 23 (2015) 243–252

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.jfda-online.com

Original Article

Temperature-dependent studies on the total phenolics, flavonoids, antioxidant activities, and sugar content in six onion varieties

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ARTICLE INFO

Article history:
Received 3 June 2014
Received in revised form
19 September 2014
Accepted 2 October 2014
Available online 27 December 2014

Keywords:
antioxidant activity
onion powder
sugar content
total flavonoids
total phenolics

ABSTRACT

Heating effect on total phenol, flavonoids, antioxidant activity, and sugar content of six onion varieties has been quantitatively investigated to explore the effect of different temperatures. The onion varieties comprised one red-skinned variety, two white-skinned varieties, and three yellow-skinned varieties. The heating temperature was scanned at 80°C, 100°C, 120°C, and 150°C for 30 minutes each, and quantitative analysis was performed relative to the powdered onion at ambient temperature. Quercetin, glucosides and sugar content were analyzed using high-performance liquid chromatography. The total phenolic and antioxidant content increased in all six varieties. The total flavonoid levels showed a considerable change. On heating the onion samples at 120°C for 30 minutes, the red-skinned variety showed the highest level of total phenolic content [13712.67 ± 1034.85 μg of gallic acid equivalent/g dry weight (μg GAE/g DW)] and total flavonoids [3456.00 ± 185.82 μg of quercetin equivalents/g dry weight (μg Q/g DW)], whereas the content of total phenolics and total flavonoids were 13611.83 ± 341.61 μg GAE/g DW and 3482.87 ± 117.17 μg Q/g DW, respectively, for the yellow-skinned (Sunpower) variety. Quercetin and its glucoside contents increased up to 120°C and then decreased at 150°C, whereas the sugar content continuously decreased with heating. All cultivars showed the same pattern in the heating effect, and the predominant flavonoids were destroyed at higher temperatures. Therefore, it is improper to expose onion powder to a temperature higher than 120°C.

1. Introduction

Onion (*Allium cepa* L.) is one of the most cultivated vegetables in the world and is a good source of flavonoids. Flavonoids are bioactive components that possess a distinct flavor and aroma, and have potential health benefits [1]. Heating vegetables during the cooking process causes the loss of heat-sensitive compounds and reduces the nutritional quality.

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http://dx.doi.org/10.1016/j.jfda.2014.10.005

Heating is accountable for the oxidation, thermal degradation, and leaching of bioactive compounds from fresh vegetables [2]. Depending on the morphology and nutritional properties of vegetables, positive and negative effects of heating have been reported [3]. Different heating conditions (e.g., heating duration and temperatures) have different effects on the antioxidant properties of vegetables [4]. To obtain maximum health benefits, raw onion should be used or moderately cooked. In onion, quercetin aglycone accounts for up to 10% of the total flavonoids, and the remaining amount is in the form of glucosides. The compositional variations of quercetin and its glucosides exist in the yellow, white, and red onion varieties; and various other flavonoids, flavonols, anthocyanins, and dihydroflavonols exist in different cultivars [5]. Compared to red onions, yellow onions contain a high level of quercetin, and white onions have the lowest concentration [6]. More interest has recently been focused on the sweet and less pungent onion cultivars because of their appealing sweetness and lower pungency. The shelf life of the sweet onion is shorter than that of nonsweet onions, which can be attributed to the high water content [7]. Before being marketed to large food and trade companies, onions are typically cured, dried, and held in special long-term stores. Onions with a short shelf life are used within a short time period or they are processed as a sauce, fried chips, onion powder, etc. However, heating is the best method to increase the storage potential of sweet onion cultivars with a low shelf life [8].

Dehydrated onion has great commercial value because of its culinary and medicinal properties. For instance, the food industry sells onion powder as a nutraceutical or as a dietary supplement [9]. The processing of onion powder involves several steps such as storage, pretreatment, drying, and boiling. These steps affect the composition of the bioactive components of the onion. The fate of phytochemicals during processing and their bioavailability after consumption has been investigated in different vegetables [10–12]. The evaluation of the bioactive components of onion has practical importance and the stability of antioxidants during the sautéing, baking, boiling, and heat processing of fruits and vegetables has been discussed previously [4,13,14]. The beneficial health effects of antioxidants attract the interest of consumers and the food industries. Therefore, it is important to study the content of antioxidants in foods during heating at various temperatures. In this paper, we aim to analyze the chemical composition of powdered onions before and after heating at different temperatures that are generally applied during processing such as those used for making ketchup, sauces, soups, chips, meat products, and crackers. For this analysis, we selected six different onion varieties, which include red onion, yellow onion, and white (i.e., sweet) onion.

2. Materials and methods

2.1. Chemicals and standard solutions

All solvents used in this study were of high-performance liquid chromatography (HPLC) grade. Water was obtained from J. T. Baker (Phillipsburg, NJ, USA); methanol, from Dunstan (Seoul, Korea); and acetonitrile, from Daejung (Gyonggi-do, Korea). Trifluoroacetic acid (TFA; extrapure grade) was supplied by Alfa Aesar (Ward Hill, MA, USA). Quercetin-3,4′-O-diglucoside and quercetin-4′-O-monoglucoside were supplied by Polyphenols Laboratories AS (Sandnes, Norway). The purity of the flavonol standards was controlled by HPLC and was >99%. Gallic acid, 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (Trolox), 2,4,6-tris (1-pyridyl)-5-triazine (TPTZ), ferric chloride, and Folin–Ciocalteu reagent were purchased from Sigma-Aldrich (St. Louis, MO, USA), and 2,2-diphenyl-1-picrylhydrazyl was purchased from Wako Pure Chemicals (Osaka, Japan) and were used for antioxidant assays. The saccharide standards sucrose (>99.5%), D-glucose (>99.5%), and D-fructose (guaranteed reagent grade) were obtained from Fluka (Buchs, Switzerland), Sigma-Aldrich (Buchs, Switzerland), and Junsei Chemical Co. (Koshigaya, Saitama, Japan), respectively.

The stock solutions of quercetin (1 mg/mL) and quercetin glucosides (4 mg/mL) were prepared in 75% ethanol. All solutions were stored at −20°C. Calibration of standards was obtained by appropriate dilution of the stock solutions.

2.2. Sample preparation

Onions were grown at the Bioenergy Crop Research Center at the National Institute of Crop Science of the Rural Development Administration (Muan, Republic of Korea). Six onion varieties selected for this study were harvested from April to May 2013. The onions were cured in the field for 10 days and transported to the laboratory. The onion varieties were red-skinned (Colossal), yellow-skinned (Sunpower, Chairman, 110455), and white-skinned (110444, B-67); their dry matter contents are described in Table 1.

For each variety, replicate composite samples were prepared by mixing equal amounts of onion powder using 15 healthy onion bulbs in triplicate. To prepare the onion powder, approximately 800 g of onions were skinned, chopped, and freeze-dried. The resulting lyophilized onions were then ground into powder. The samples were stored in sealed plastic bottles at −20°C until analysis.

2.3. Dry matter percentage determination

The percentage of dry matter was determined before the sample was freeze-dried. For each variety, chopped samples of approximately 35 g were maintained in an oven with air circulation initially at 80°C for 24 hours, and then at 105°C for 2 hours. Each determination was performed in triplicate.

2.4. Heat treatment of the onion samples

Onion powder (10 g) was placed in a single layer in a Pyrex petri dish and heated in an oven at 80°C, 100°C, 120°C, and 150°C for 30 minutes each. After heating, the onion powder was allowed to cool at room temperature. After cooling a second time, the weight was measured to check the percentage of weight loss.

2.5. Extraction of phenolic compounds

The samples were extracted in triplicate, based on the method previously reported by Bonaccorsi et al [15], but