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Effect of ultrasound and blanching pretreatments on polyacetylene and carotenoid content of hot air and freeze dried carrot discs

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ABSTRACT

The effect of ultrasound and blanching pretreatments on polyacetylene (falcarinol, falcarindiol and falcarindiol-3-acetate) and carotenoid compounds of hot air and freeze dried carrot discs was investigated. Ultrasound pretreatment followed by hot air drying (UPHD) at the highest amplitude and treatment time investigated resulted in higher retention of polyacetylenes and carotenoids in dried carrot discs than blanching followed by hot air drying. Freeze dried samples had a higher retention of polyacetylene and carotenoid compounds compared to hot air dried samples. Color parameters were strongly correlated with carotenoids ($p < 0.05$). This study shows that ultrasound pretreatment is a potential alternative to conventional blanching treatment in the drying of carrots.

1. Introduction

The health-promoting properties of fruit and vegetables are strongly related to their processing history [1]. For example, conditions during storage, processing and preparation have been shown to have significant effects on the content of bioactive compounds [2,3]. Drying is one of the oldest methods of food preservation [4]. Dehydrated carrots are used as an ingredient in many prepared foods such as instant soups and are an excellent ingredient for developing healthy snack foods [5]. The health promoting properties of fruit and vegetables may be related to the presence of non-nutritional compounds known as phytochemicals. Carrots are a particularly good source of two groups of phytochemicals namely polyacetylenes and carotenoids. A number of recent studies have reported that a group of C_{17} polyacetylenes present in members of the Apiaceae family have cytotoxicity against cancer cells [6,7]. Carrots (*Daucus carota* L., Apiaceae) also contain 3 polyacetylenes of the falcarinol type, namely falcarinol, falcarindiol and falcarindiol-3-acetate [6]. These compounds prevent fungal infections in the plant (root). They also possess antibacterial, anti-inflammatory and anti-platelet-aggregatory effects in humans [7]. In terms of cytotoxicity against cancer cell lines (human gastric adenocarcinoma cells), falcarinol is the most active compound [8–10]. Carrots are also a well known source of carotenoids, in particular β-carotene (precursor of vitamin A) which has been shown to have health promoting function in humans [2].

Drying can be carried out by many methods including hot air drying and freeze drying. Hot air-drying involves exposure of the product to be dried to a continuously flowing hot air stream. Hot air drying produces dehydrated products that can have an extended shelf life of up to a year, but the quality of conventionally dried products is usually much less than that of the original foodstuff [11]. Hot air drying leads to considerable product shrinkage caused by cell collapse following moisture loss and may also lead to poor rehydration characteristics of the dried product as well as unfavorable changes in color, texture, flavor and nutrients. In contrast, vacuum freeze-drying is a better method of water removal resulting in products of a higher quality compared to other methods of drying [12,13]. Freeze-drying is based on dehydration by sublimation of water from a frozen product. Due to the absence of liquid water and the low temperatures required for freeze drying, most of the deterioration and microbiological reactions are retarded resulting in a final product of high quality. Freeze drying is used in the processing of pharmaceutical products and the drying of medicinal and/or aromatic herbs, as it minimises the loss of bioactivity and flavor [14,15]. Freeze-drying protects the primary structure and the shape of a product with minimal reduction of volume. Despite the

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obvious advantages of freeze drying, there has been poor industry uptake mainly due to the high energy costs associated with the process.

The quality of a dehydrated product depends not only on the drying conditions but also on the pretreatments employed before drying [16]. For example, blanching involves heating a product to a high temperature for a short period and is normally carried out prior to dehydration to inactivate enzymes which may otherwise lead to formation of unacceptable color and flavors [17,18]. Blanching pre-treatments are also used to improve the final texture and color after rehydration [19]. Blanching has also been reported to reduce drying times, though thermal degradation of the product may occur as a result of the relatively high temperatures used. In common with other thermal processes, blanching has been shown to affect the concentration of some bioactive compounds in vegetables including polyacetylenes [20]. However these studies have been far less extensive for polyacetylenes than for other bioactive compounds (i.e. antioxidants) from vegetables and have often formed part of larger studies assessing other effects such as variety and agronomic factors. In addition, conflicting results have been reported by Czepa and others [21,22].

Given the possible detrimental effect of blanching on the nutritional quality of some products, there is a need to develop alternative pretreatment methods that have minimal impact on the nutritional and organoleptic properties of food [23]. Power ultrasound is an emerging and promising alternative technology for food processing applications [24] which has been identified as a possible pretreatment to replace blanching.

While some work on ultrasound assisted drying of vegetables such as mushrooms, brussels sprouts, cauliflower and carrots has been reported [25,26], no study has been carried out on the effect of ultrasound assisted drying on polyacetylene content. The present study investigated the effect of ultrasound and blanching pretreatments on color, polyacetylene and carotenoid compounds in hot air and freeze dried carrot samples.

2. Material and methods

2.1. Chemicals

HPLC grade acetonitrile (ACN), ethyl acetate and water were obtained from Sigma Aldrich (UK). Diatomaceous earth was obtained from Dionex (Surrey, UK).

2.2. Sample preparation

Raw unprocessed carrots (*Daucus carota*, cv. Nerac) were obtained from a local wholesaler (Seaview, Dublin, Ireland) and stored at 4 °C for a maximum of 24 h prior to analysis. Carrots with no visible damage and root length of 15.5 ± 1.5 cm were selected for the experiment. After hand-peeling, carrots were vertically sliced into disks (5 mm thickness), using a Berkel 800 meat slicer (Berkel company, Indiana, USA).

2.3. Sample pretreatments

2.3.1. Ultrasound and blanching pretreatment

Carrot discs samples of 150 g were placed in a 400 ml beaker and 200 ml of distilled water at 25 °C was added. A 1.5 kW ultrasonic processor (VC 1500, Sonics and Materials Inc., Newtown, USA) operating at 20 kHz with a 19 m diameter probe was used for sonication. The energy input was controlled by setting the amplitude of the sonicator probe. Extrinsic parameters of amplitude (24.4, 42.7 and 61.0 μm) and processing time (3 and 10 min) were varied with pulse durations of 5 s on and 5 s off. The ultrasound probe was submerged to a depth of 25 mm in the sample as shown in Fig. 1. All treatments were carried out in triplicate. Treatments for 3 and 10 min were selected after preliminary studies. The acoustic energy density (AED) employed in this experiment was in range of 0.39–0.95 W/ml, as measured by calorimetry. AED was calculated at a particular amplitude level, with temperature T recorded as a function of time under adiabatic

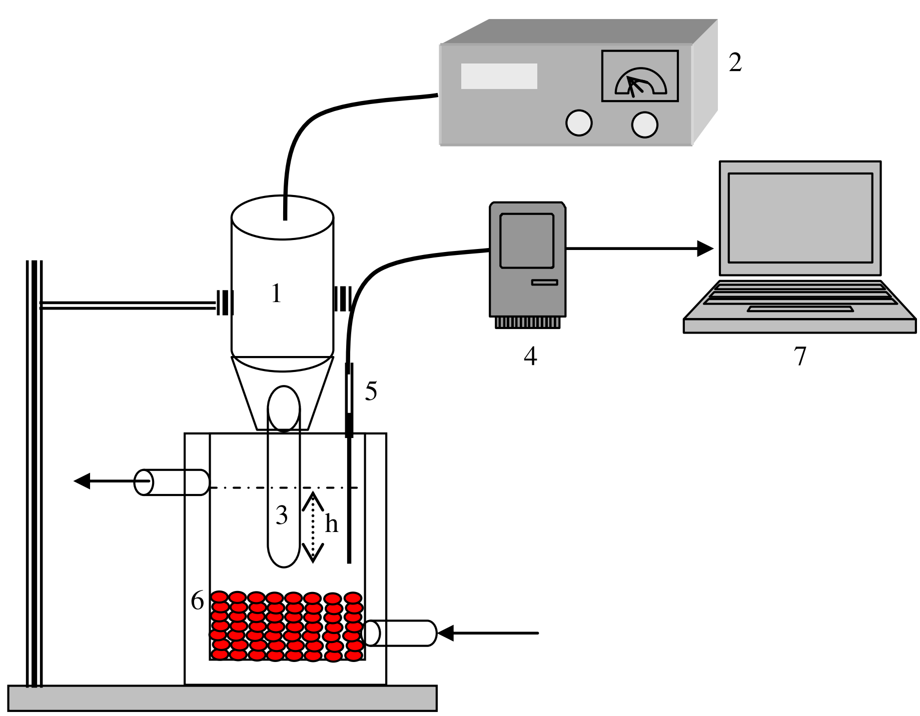

Fig. 1. Experimental set-up: (1) ultrasound transducer, (2) ultrasonic generator, (3) ultrasound probe (19 mm), (4) data logger, (5) temperature probe, (6) jacketed glass beaker, (7) computer and (h) depth of probe into the water (2.5 cm).