

Effect of Pretreatment Method on the Content of Phenolic Compounds, Vitamin C and Antioxidant Activity of Dried Dill

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Abstract—Dill contains range of phytochemicals, such as vitamin C and polyphenols, which significantly contribute to their total antioxidant activity. The aim of the current research was to determine the best blanching method for processing of dill prior to microwave vacuum drying based on the content of phenolic compounds, vitamin C and free radical scavenging activity. Two blanching mediums were used – water and steam, and for part of the samples microwave pretreatment was additionally used. Evaluation of vitamin C, phenolic contents and scavenging of DPPH[•] radical in dried dill was performed. Blanching had an effect on all tested parameters and the blanching conditions are very important. After evaluation of the results, as the best method for dill pretreatment was established blanching at 90 °C for 30 seconds.

Keywords—blanching, microwave vacuum drying, TPC, vitamin C.

I. INTRODUCTION

DILL (*Anethum graveolens* L.), a biennial or annual herb of the parsley family (*Apiaceae* or *Umbelliferae*), is mostly grown outdoors and harvested seasonally. Dill contains range of phytochemicals, such as vitamin C and polyphenols, which significantly contribute to their total antioxidant activity [1]. The leafy tops of dill are used in cottage cheese, potato salad, soups, sauces and salads [2], [3]. Drying is one of the oldest methods of food preservation that is used for extending dill availability throughout the year. Dehydration of herbs can be performed using different methods. Microwave drying is an efficient method for rapid dehydration and is used for aromatic plants such as dill leaves [2], [4], parsley [2], rosemary [5] etc. Our previous investigations showed that microwave vacuum drying is one of the best methods to preserve vitamin C [6] and phenolic compounds [7] in dill.

Pre-treatment is common in most processing operations to improve product safety, quality or process efficiency [8], [9]. Blanching is a thermal process designed to clean vegetable surface, reduce microbial load, slow or stop the enzyme activity, enhance the color and texture, produce structural alterations (swelling of cell walls, disruption of membranes, shrinkage of intercellular spaces, etc.), which could affect mass transport phenomena during the following processing steps [10]–[13].

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The quality of blanched product depends significantly on the time and temperature of blanching and also on the physical and chemical properties of vegetable to be blanched. Industrial blanching processes involve treating with steam or hot water for 1–10 min at temperatures ranging from 70 to 95 °C [14], [15]. Olivera et al. [16], Zheng and Lu [17] reported that microwaves may be an effective pre-treatment process for use prior to water blanching to reduce the degradation of ascorbic acid and to accelerate the inactivation of peroxidase catalyses and thus maintain produce quality. Also in Brussels sprouts microwave pretreatment showed the higher increase in radical scavenging activity with respect to the control and an elevated level of ascorbic acid content [18].

However, since blanching is a heat treatment, changes associated with thermal processing can be expected. These include degrading and leaching of nutritive components, for example, sugars, minerals and vitamins, color change, loss of turgor in cells, due to thermal destruction of membrane integrity and partial degradation of cell wall polymers [10]. Significant reductions in the texture, color, polyphenols and antioxidant capacity were observed due to blanching of York cabbage [19]. Many authors reported significant losses in the content of vitamin C and polyphenols and decreases in antioxidative activity in vegetables after blanching [9], [20]–[22]. Selman [23] showed that the loss of vitamin C in blanched vegetables varied from 20 to 70%, while Puupponen-Pimiä et al. [24] reported 20–30% losses in brassica vegetables. Blanching reduces antioxidative activity in different vegetables; the amount of decrease depends on the length of exposure to high temperatures, the cultivar and the species. Amin and Wee Yee [25] showed that when blanching brassica vegetables for 15 min, the decrease in activity compared with the raw material was 40% in Chinese cabbage but only 4% in red cabbage.

According to Jaiswal et al. [19] minimal heat treatment in cooking practices, for example blanching, is recommended to prevent major loss of antioxidant activity and various phytochemicals. Volden et al. [26] showed the effects of blanching of red cabbage on the levels of glucosinolates, polyphenols and anthocyanins, as well as for the antioxidant potential by the ferric reducing ability power (FRAP) and oxygen radical absorbance capacity (ORAC) assays. Important changes in physicochemical and structural properties can take place in vegetable tissues after blanching, which will affect food behaviour during the final preservation stage and its storage [27].

According to Korus [9] in spite of losses in antioxidant content caused by blanching at the preliminary stage of processing, drying blanched kale leaves resulted in lower antioxidant loss. Similarly, the loss of polyphenols and vitamin C and the decrease in Trolox equivalent antioxidant

activity occurring during storage was greater in non-blanching dried leaves than in blanching kale leaves. Data on the effect of blanching on physicochemical properties of dill is scarce [3].

The aim of current research was to determine the best blanching method for processing of dill prior to microwave vacuum drying based on content of phenolic compounds, vitamin C and free radical scavenging activity.

II. MATERIALS AND METHODS

A. Raw materials

Dill variety 'Superdukat' was grown in the test fields of the Latvia University of Agriculture and harvested at the height of 30–35 cm. After harvest dills were washed and separated in two fractions: leaves and stems. For further analyses dill leaves were used.

B. Pretreatment process

Dill leaves were water blanched at:

- 90 °C temperature for 30 seconds;
- 70 °C temperature for 60 seconds.

Dill was treated in steam at 95 ± 1 °C for 30 seconds.

For microwave (MW) pretreatment 70 g of dill leaves were placed on the plate (20-cm diameter) and positioned on the turntable of the microwave variable power oven (model EMS 28405, Electrolux, Sweden). Power level 900 W was used at treatment duration 30 s. After microwave pretreatment dill was subjected to blanching in hot water or steam.

All treatments were carried out in triplicate.

The following abbreviations for the samples in this work are used, according to the method of pretreatment applied:

UB – unblanched dill;

SB – steam blanched dill;

SB_MW – steam blanched dill pretreated with microwaves;

WB_70 – water blanched dill at 70 °C temperature for 60 seconds;

WB_70_MW – water blanched dill at 70 °C temperature for 60 seconds pretreated with microwaves;

WB_90 – water blanched dill at 90 °C temperature for 30 seconds;

WB_90_MW – 90 °C temperature for 30 seconds pretreated with microwaves.

C. Drying

After blanching dill leaves were cut in slices 0.4 ± 0.1 cm and dried using a microwave-vacuum drier „Musson-1” (OOO „Ingredient”, St. Petersburg, Russia). Characteristic parameters of the drying program are presented in Table 1.

D. Analytical methods

Dried dill (0.5 g) was extracted with 50 ml 80% ethanol solution (v/v) in water. After 2 hour extraction using magnetic stirring, samples were filtered (paper No. 89). Extracts were prepared in triplicate.

The total phenol content (TPC) of the dill extract was determined according to the Folin-Ciocalteu spectrophotometric method [28] with some modifications. To 0.5 ml of diluted extract 2.5 ml of Folin-Ciocalteu reagent (diluted 10 times with water) was added and, after 3 minutes 2 ml of

Na_2CO_3 (75 g/L) was added. The sample was mixed. The control sample contained all the reaction reagents except the extract. After 30 minutes of incubation at room temperature, the absorbance was measured at 765 nm using a spectrophotometer JENWAY 6300 (Baroworld Scientific Ltd., UK). Total phenols were expressed as gallic acid equivalents (GAE).

TABLE I
CHARACTERIZATION OF MICROWAVE VACUUM
DRYING PROGRAM FOR DILL LEAVES

Parameters	Units	Values
Number of magnetrons	-	4-3-2
Pressure	kPa	12.00–14.63
Drum rotation speed	rpm	6
Drying time	min	17
Product mass	kg	1

Antioxidant activity of the plant extracts was measured on the basis of scavenging activities of the stable 2,2-diphenyl-1-picrylhydrazyl (DPPH[•]) radical as outlined by Yu et al. [29]. The antioxidant reaction was initiated by transferring 0.5 ml of plant extract into a sample cavity containing 3.5 ml of freshly prepared DPPH[•] methanol solution (0.004 g DPPH[•] to 100 ml methanol). After 30 min of incubation in the dark at room temperature, the absorbance was measured at 517 nm using a spectrophotometer JENWAY 6300.

Inhibition of DPPH[•] in percent (DPPH[•], %) of each extract sample was calculated from the decrease of absorbance according to relationship:

$$\text{DPPH}^{\bullet}, \% = \frac{A_{\text{blank}} - A_{\text{sample}}}{A_{\text{blank}}} \times 100,$$

where

A_{blank} - absorbance of control reaction (methanol–water with DPPH[•]);

A_{sample} - absorbance of the tested samples.

Lower absorbance of the reaction mixture indicates higher free radical scavenging activity [30].

Vitamin C was determined in dill leaves using iodometric titration method and moisture content was determined by standard method (ISO 6496:1999). All results are expressed to dry matter.

III. RESULTS AND DISCUSSION

A. Effect on vitamin C

The content of vitamin C in dried dill blanched by various methods differed significantly ($p < 0.05$) (Fig. 1). Blanching helped to maintain vitamin C, except, in the samples blanched at 70 °C. In the study of Martinez et al. [31] also in blanched sweet pepper retention of vitamin C comparing to unblanched samples increased. It can be concluded that longer blanching time at lower temperature increase the losses of vitamin C (Fig. 1). Other authors also reported that blanching duration significantly influenced content of ascorbic acid during steam blanching and the reason is thermal degradation of ascorbic acid [32]. As vitamin C is a highly soluble substance, it is readily lost through leaching [33]. Our results show that content of vitamin C in dill after steam blanching and drying is

lower comparing to water blanching at 90 °C in water, and leaching is not the most important factor that influences vitamin C content. In the current research treatment in steam at 95±1 °C for 30 seconds was used and the results correspond to the study on blanching of Swiss chard with steam at atmospheric pressure for 30 s which was sufficient to inactivate its enzymatic systems, longer blanching would result in greater losses of ascorbic acid [32]. Red peppers did not differ significantly from control sample but in the samples blanched at higher temperatures retention of vitamin C was even lower [34], but our results showed that the highest content was detected in the sample blanched at 90 °C. Although literature data showed that microwaves may be an effective pre-treatment process for use prior to water blanching to reduce the degradation of ascorbic acid [17], our results showed that only for sample blanched at 70 °C for 60 seconds beneficial effect was observed.

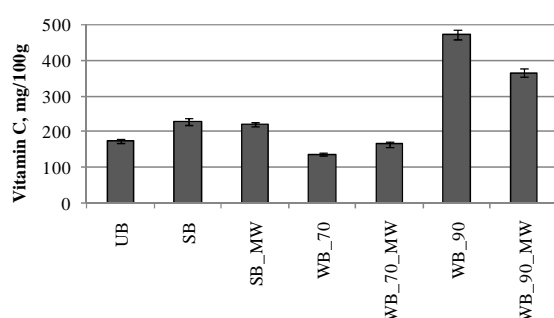


Fig. 1 Effect of pretreatment on content of vitamin C content of dried dill

In fresh dill the content of vitamin C was 581 mg/100 g. Comparison of vitamin C content in fresh and dried dill, show a decrease ranged from 19–76%, with the smallest reduction for the sample blanched in water at 90 °C. Decrease of vitamin C during microwave vacuum drying depends on program used and varies from 8% till 90% [7].

B. Effect on total phenols

Pretreatment method altered TPC in dried dill under the experimental conditions (Fig. 2).

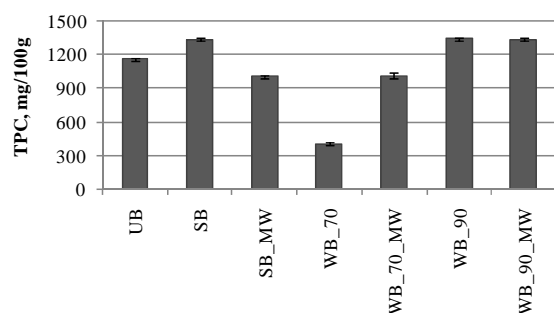


Fig. 2 Effect of pretreatment on total phenol content of dried dill

Blanching helped to maintain TPC in dill blanched in steam and in water at 90 °C temperature for 30 seconds with and without additional microwave pretreatment.

Microwave pre-treatment process influenced TPC in dried dill and it is possible to identify several contradictory trends:

- combined pretreatment of microwave and steam blanching reduced TPC in dill;
- microwave pretreatment combined with water blanching at 90 °C temperature did not influence TPC in dill;
- TPC in dill increased if water blanching at 70 °C temperature was preceded by microwave treatment.

In fresh dill TPC was 3452 mg/100 g. When compared TPC of fresh and dried dill, decrease ranged from 61 to 88%, with the smallest reduction for dill blanched in water at 90 °C both with and without microwave treatment and dill blanched in steam. Amin et al. [20] reported significant decreases in the level of polyphenols in spinach (up to 51%) after blanching. Great losses of polyphenols in vegetables during aquathermal processing are due to the dilution of these compounds in water. The dissolution of polyphenols into water depends on time of processing and size of vegetables [35].

C. Effect on DPPH' free radical scavenging activity

Blanching has not beneficial effect on the DPPH' free radical scavenging activity, but also significant differences between unblanched and blanched samples were not detected ($p > 0.05$), except dill blanched at 70 °C, where activity was significantly lower (Fig. 3).

Olivera et al. [16] reported that microwave pretreatment before water blanching of Brussel sprouts increased antiradical activity.

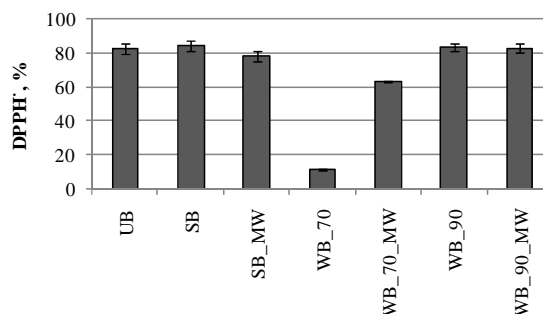


Fig. 3 Effect of pretreatment on DPPH' free radical scavenging activity of dried dill

Amin et al. [20] reported that less intensive aquathermal processing of leafy vegetables, such as blanching, causes a decrease of 50% in antioxidant activity, while boiling for 15 min causes as much as 82% of antioxidant compounds, including polyphenols, to escape into the water.

D. Correlation between quality parameters of dried dill

To investigate the influence of the TPC and vitamin C on the DPPH' free radical scavenging activity in dried dill, correlation between these parameters were determined. Results showed that there is a significant relationship between DPPH' scavenging capacity and TPC ($r = 0.95$) (Fig. 4.)

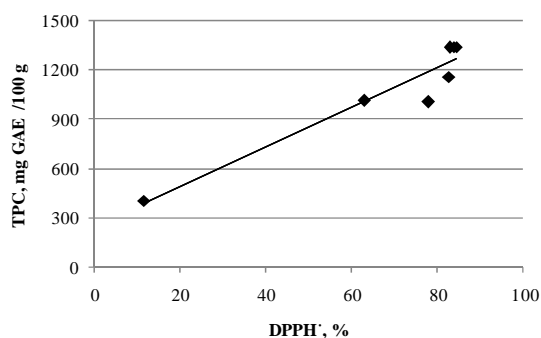


Fig. 4 Correlation between DPPH· free radical scavenging activity and total phenol content in dried dill

Research results of Hossain et al. [36] show importance of phenolic compounds in formation of herb antioxidant properties. In *Actinidia* fruits also DPPH· free radical scavenging activity highly correlated with TPC [37]. In literature contrasting data exists and in the study of Hinneburg [38] correlation between TPC and DPPH· scavenging as well as between TPS and iron reducing was not established.

Du et al. [37] reported that vitamin C and DPPH· scavenging activity exhibited strong correlation ($r = 0.83$), but experimental results of dried dill in the current study showed medium correlation ($r = 0.52$) (Fig. 5).

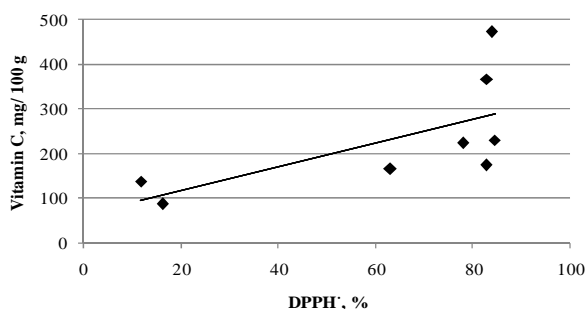


Fig. 5 Correlation between DPPH· free radical scavenging activity and vitamin C content in dried dill

Also Ramful [39] reported that vitamin C content of citrus fruit pulps has moderate or weak correlation with antioxidant activity measured by different methods.

To investigate the tendency of influence of blanching method on the maintaining TPC and vitamin C content in dried dill the correlation between these parameters was determined (Fig. 6).

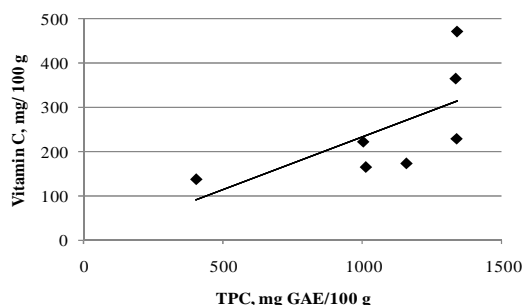


Fig. 6 Correlation between total phenol content and vitamin C content in dried dill

Medium correlation ($r = 0.65$) was observed meaning that blanching method has effect on the content of vitamin C and TPC in microwave vacuum dried dill.

IV. CONCLUSION

The present study confirms that blanching has an effect on the content of vitamin C, phenolic and scavenging of DPPH· radical of dried dill. Blanching is recommended to prevent the major loss of nutrients but the conditions of blanching are very important. After evaluation of TPC, vitamin C content and antiradical activity, as the best method for dill pretreatment was established blanching at 90 °C for 30 seconds. Future experiments will mainly cover the optimization of microwave pre-treatment to reduce phytochemical losses from dill in its processing.

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