

Investigation of *Asparagus officinalis* Shoot Size and Drying Affecting to Herbal Tea Production

Nguyen Phuoc Minh^{1,*}, Le Thi Them², Nguyen Cao Dang³, Tran Phi Ho⁴, Nguyen Trung Hieu⁵, Lam Quang Luan⁶

¹Faculty of Chemical Engineering and Food Technology, Nguyen Tat Thanh University, Ho Chi Minh, Vietnam

²Faculty of Chemical Engineering and Food Technology, Nguyen Tat Thanh University, Ho Chi Minh, Vietnam

³Cuu Long University, Vinh Long Province, Vietnam

⁴Soc Trang Community College, Soc Trang Province, Vietnam

⁵Can Tho University, Can Tho City, Vietnam

⁶Dong Thap University, Dong Thap Province, Vietnam

Abstract.

Asparagus officinalis shoot is a spring vegetable by its unique texture and flavour. *Asparagus officinalis* is vegetable that offers multiple health benefits owing to containing flavonoids, phenolic compounds, alkaloids, saponins and tannins which possess strong antioxidant properties. Green asparagus is also an extremely perishable vegetable. Freshly harvested asparagus deteriorates rapidly which results in a short shelf life under normal postharvest handling at the room temperature. Drying is one of the most methods used for preservation. It maintains foodstuff stability by reducing water activity which hinders the growth and reproduction of microorganisms and also minimizes the moisture induced problems such as enzymatic activity. In order to increase its added value it is important to take advantage of the health benefits of asparagus by investigating some alternative processing methods. The present study aimed to investigate the effect of *asparagus officinalis* shoot size and drying to herbal tea production. Results revealed the blanching time (10s) and temperature (95°C); CaCl₂ concentration (3%) in blanching; *Asparagus officinalis* leaf size (2.0cm) in drying; drying temperature (30°C) by heat pump dryer; storage product under the PET/AL/PE (vaccum) bag at 4°C to maintain the antioxidant power for 6 months

Keywords: *Asparagus officinalis*, shoot, size, drying, herbal tea

I. INTRODUCTION

Asparagus is considered as a delicacy in the vegetable world. It is a good source of essential minerals, vitamins, amino acids, and dietary fibers maintaining a healthy digestive system. Green or white asparagus spears can be harvested in the spring months. White spears were more fibrous than green ones. Tip and middle sections of white spears were harder than equivalent sections of green spears. Sensory fibrousness was greater in white than in green spears and decreased from tip to base (Brovelli E.A. et al., 1998). Asparagus with reddish purple spears has attracted consumers. Purple asparagus is expected to possess higher antioxidant activity compared to the green or white varieties. Asparagose and fructans represent the greatest proportion of stored carbohydrates in asparagus plants (Ana Slatnar et al., 2018).

Asparagus officinalis contained steroid saponins including asparagosides A, B, D, F, G, H, I, the bitter steroid saponins, amino acids, caffeic acid, fructans (asparagose and asparagosine), lignan, polyphenol, ferulic acid, minerals, vitamins and flavonoids (Fukushi et al., 2000; Hafizur et al., 2012; Abbey Symes et al., 2018; Ana Slatnar et al., 2018). It reduces the risk of constipation, diarrhea, osteoporosis, obesity, cardiovascular disease, rheumatism and diabetes (Palfi, M. et al., 2017; Muhammad Iqbal et al. 2017). It also exerts anticancer, antimicrobial, antifungal, antioxidant, hypolipidemic, antidiabetic, anti-dysenteric, anti-inflammatory, and anti-abortifacient, anti-oxytoxic, antiulcer, hypertensive and anticoagulant effects (Arash Khorasani et al., 2010; Rahman Md. Hafizur et al., 2012; Rui Fan et al., 2015; Ali Esmail Al-Snafi, 2015; Hojatollah Karimi Jashni et al., 2016; Dipak Vora et al, 2017). The very short shelf life of asparagus is mainly related to its

high respiratory activity which continues after harvesting (Albanese D. et al., 2007). Dehydration, i.e. drying, of asparagus provides a long term conservation and marketability of this product (Jokic S. et al., 2009). Convective drying, mainly using tray driers, is also widely used, especially by small producers. This process can eliminate the disadvantages of the natural drying. Freeze-drying is a dehydration process during which water is removed by sublimation of ice from frozen materials.

There were several studies mentioned to asparagus *officinalis* production. Shear, moisture, and soluble solids values for either the all-green spears or those cut with a white butt portion are similar for either fresh or processed spears. Fresh asparagus spears cut all-green contain less ascorbic acid than spears cut with a white butt portion, but after processing no difference is evident. Small diameter spears are higher in ascorbic acid and shear values than large diameter spears. After processing, the shear values for the large diameter spears are higher than those for small diameter spears. Holding asparagus spears for extended periods of time results in decreased ascorbic acid and moisture content and increased shear values (Drake S. R. and Nelson J. W., 1979). Somogyi and Luh (1986) reported a study on the effect of drying methods on quality of dehydrated green asparagus in which it was observed that freeze-dried green asparagus with hot water blanching was faster in reconstitution and more tender in texture than the hot-air-dried product.

Sanchez-Pineda-Infantas M.T. et al. (1994) studied effects of three methods of blanching in conjunction with freezing, on texture of white asparagus as defined by three measures: maximum shear force, cutting energy, and total fiber content. They also assessed shelf life of asparagus kept in

frozen storage at -22°C . Methods of blanching were total immersion in hot water, progressive immersion in hot water and steam. An increase in total fiber content was found throughout frozen storage. This increase correlated with lignification of vascular bundles in the basal segment of spears, even during frozen storage. This was reflected in an increase in maximum shear force and cutting energy required. The shelf life of frozen asparagus was 12 months using total fiber content as a criterion. A study were to determine the optimum drying temperature, air velocity, and predrying blanching treatment and study the effects of those parameters on the drying curves for low-grade asparagus and the efficiency of the drying process (Strahm B.S., Flores R.A., 1994). The textural and green color degradation of asparagus was determined after heat treatments at temperatures between 70°C and 98°C for selected time intervals. Maximum shear stress required to cut through green asparagus and the hue angle of the spear surface color were selected to represent the textural and color changes in thermally treated asparagus (Lau M.H. et al., 2000).

A research is to evaluate drying methods that have the potential of adding value to green asparagus especially for use as ingredient in instant foods or as a nutraceutical product. Five drying methods were used: namely, tray drying (TD), spouted bed (SB) drying, combined microwave and spouted bed drying (MWSB), Refractance Window (RW) drying and freeze drying. Asparagus spears with diameters between 9 and 12 mm were blanched in 85°C water-bath for 3 min, sliced into 2–4 mm thickness (or pureed for RW drying), then dried to moisture content less than 0.1 db. MWSB drying produced asparagus particles with good rehydration and color characteristics, and was the fastest among the methods where heated air was used. When using MWSB drying, the power level of 2 W/g and 60°C heated air resulted in highest retention of total antioxidant activity (TAA). TAA of asparagus was enhanced after RW and freeze-drying, with the TAA values being significantly higher than for heated air-drying methods. In all cases, the tip portion of asparagus retained more TAA after drying than either middle or basal parts. The highest amount of ascorbic acid was retained in the product after RW drying, followed by freeze-drying, MWSB and SB drying. TD resulted in the least retention of ascorbic acid (Nindo C.I., 2003).

Postharvest life of asparagus (*Asparagus officinalis*) under warm conditions can be extended by controlled atmosphere or water feeding (Renquist A. R. et al., 2005). The content of antioxidative compounds was evaluated in frozen green asparagus produced with the traditional technology from the material blanched before freezing or with the modified technology from cooked asparagus (Piotr Gębczyński, 2007). Antioxidant activity and quality of asparagus affected by microwave-circulated water combination and conventional sterilization was examined (Ting Sun et al., 2007).

The influence of different drying procedures on the colour quality and rehydration capacity of wild asparagus (*Asparagus maritimus* L.) was examined. Asparagus samples were dried using convective (40°C , 50°C , 60°C ,

and 70°C at the airflow velocity of 2.75 m/s), natural, and freeze (-20°C and -40°C) drying procedures. Rehydration and colour characteristics were used as indicators of the quality of the dried asparagus samples. Convective drying of asparagus resulted in the smallest colour change of the fresh material, whereby drying at 60°C presented the optimum. The best rehydration ratio was achieved when the samples were freeze dried at -40°C . Naturally dried asparagus samples resulted in a very low rehydration ratio compared to the other procedures investigated. The rehydration and appearance of the dried asparagus are two important physical factors that need special attention when designing or selecting a drying procedure. Furthermore, the influence of drying on other quality characteristics of wild asparagus, such as the content of active ingredients or microbial count, should be investigated in further studies. The investigation of economic parameters of different drying procedures should be considered as well (Jokic S. et al., 2009).

The influence of UV-C and ozone postharvest treatments on biomechanical and biochemical textural related cell wall metabolism was investigated. UV-C-irradiation and washing with ozonated water resulted in a slight reduced respiration in white asparagus spears, but increase in spear tissue toughness. Total cell wall compounds were only tendentially reduced after 4 days of shelf-life at 20°C by application of aqueous ozone and UV-C (Huyskens-Keil S. et al., 2011).

Asparagus has a short shelf life. A temperature of $0-2^{\circ}\text{C}$ with a relative humidity of 95–100% is well known as the ideal storage environment for asparagus spears (Kana Nikaido et al., 2014).

Drying kinetics and activation energy of asparagus root (*asparagus racemosus* wild.) for different methods of drying was investigated. Fresh asparagus roots were pretreated in hot water at 80°C for 5 min. The methods of drying used for the study were tray drying, solar drying, vacuum drying and fluidized bed drying at four temperature levels 40, 50, 60 and 70°C . The complete drying of asparagus follow falling rate period only. The total time for drying decreases with increase in temperature of drying air from 40°C – 70°C . Fluidized bed dryer has a highest average drying rate as compare to tray dryer, solar dryer and vacuum dryer (Deepika Kohli et al, 2018).

The drying characteristics of asparagus roots of different shapes and sizes under blanched and nonblanched conditions using a hybrid solar dryer and mechanical tray dryer at three temperature levels of 50, 60, and 70°C was presented. The drying rate increases with the increase in drying air temperature, and blanching also increases the drying rate. The drying rate also depends on shape and size of the asparagus roots. The highest drying rate was found for sliced samples followed by split and whole root samples. The drying rate was extremely low for the whole asparagus roots. Cream color of asparagus roots remained almost unchanged after drying but the brightness increased. The quality change of the dried products in terms of color change was not significant in the temperature range of 50 to 70°C . Five thin-layer drying models were fitted to the experimental data of blanched and sliced asparagus roots

(Bala B. K. et al., 2018). A natural convection indirect solar cabinet dryer has been fabricated to study the drying behavior of *Asparagus officinalis* L.) in terms of its convective heat transfer coefficient and moisture removing rate (Fahim Ullah et al., 2018).

Respiration rate and transpiration in asparagus are high compared with those of other vegetables. Asparagus shoots are very active metabolically and highly perishable during handling and storage. The objective of the present study was to identify the effect of *asparagus officinalis* shoot size and drying to herbal tea production.

II. MATERIALS AND METHOD

2.1 Material

We collected *Asparagus officinalis* shoot in Buon Me Thuot city, Dak Lak province, Vietnam. They were cultivated following VietGAP to ensure food safety. After harvesting, it was conveyed to laboratory within 4 hours for experiments. This vegetable was washed thoroughly under turbulent washing to remove dirt, dust and adhered unwanted material. Beside *Asparagus officinalis* we also used other materials during the research such as CaCl₂, Lab utensils and equipments included heat pump dryer.



Figure 1. *Asparagus officinalis* shoot

2.2 Methods

2.2.1 Effect of blanching temperature and time

Different blanching time and temperature (100°C, 5 seconds; 95°C, 10 seconds; 90°C, 15 seconds; 85°C, 20 seconds) were examined *Asparagus officinalis* shoot. Then they were dried by heat pump at 60°C until 6.5% moisture. All samples were analyzed vitamin C (mg/100g), the ferric reducing antioxidant power (FRAP, μmol TE/g fw) and DPPH (μmol TE/g fw) radical scavenging assays, color (sensory score) to validate the appropriate blanching condition.

2.2.2 Effect of CaCl₂ concentration in blanching

Raw *Asparagus officinalis* shoots were blanched in water solution with different CaCl₂ concentration (1.0%, 2.0%, 3.0%, 4.0%, 5.0%) at 95°C, 10 seconds. Then they were dried by heat pump at 60°C until 6.5% moisture. All samples were analyzed vitamin C (mg/100g), the ferric reducing antioxidant power (FRAP, μmol TE/g fw) and DPPH (μmol TE/g fw) radical scavenging assays, color (sensory score) to validate the appropriate blanching condition.

2.2.3 Effect of *Asparagus officinalis* shoot size in drying

Raw *Asparagus officinalis* shoots were blanched in water solution with 4% CaCl₂ at 95°C, 10 seconds. Then they were dried at different size (0.5 cm, 1.0 cm, 1.5 cm, 2.0 cm, 2.5 cm) by heat pump at 60°C until 6.5% moisture. All samples were analyzed vitamin C (mg/100g), the ferric reducing antioxidant power (FRAP, μmol TE/g fw) and

DPPH (μmol TE/g fw) radical scavenging assays, color (sensory score) to validate the appropriate blanching condition.

2.2.4 Effect of drying temperature

Raw *Asparagus officinalis* shoots were blanched in water solution with 4% CaCl₂ at 95°C in 10 seconds. Then these samples would be dried in 1.0 cm of size under heat pump dryer at different temperature (10°C, 20°C, 30°C, 40°C, 50°C, 60°C) until 6.5% moisture. All samples were analyzed vitamin C (mg/100g), the ferric reducing antioxidant power (FRAP, μmol TE/g fw) and DPPH (μmol TE/g fw) radical scavenging assays, color (sensory score) to validate the appropriate drying temperature.

2.2.5 Effect of storage condition

After completion of drying treatment, the dried *Asparagus officinalis* shoots were subjected to storage. They were kept in PET/AL/PE (vacuum) bag at different 4°C, 28°C. The ferric reducing antioxidant power (FRAP, μmol TE/g fw) and DPPH (μmol TE/g fw) radical scavenging assays will be analyzed in 1 week interval for 6 weeks.

2.3 Physico-chemical and biological analysis

The vitamin C (mg/100g) content of the *Asparagus officinalis* shoots was determined by redox titration using iodate solution. The ferric reducing antioxidant power (FRAP, μmol TE/g fw) and DPPH (μmol TE/g fw) radical scavenging assays was determined with reference to the method of Benzie and Strain (1996); Brand-Williams *et al.*, (1995). Total phenolic (TP, μg GAE/g fw) contents were measured according to the method of Singleton and Rossi (1965) with slight modifications. Color (sensory score) of *Asparagus officinalis* shoots was assessed by a group of panelist. They were required to evaluate the odour, colour, taste, sweetness and overall acceptance using the 9-point hedonic scale (1 = dislike extremely, 9 = like extremely).

The ferric reducing antioxidant power (FRAP) method was conducted according to Benzie and Strain (1996). To conduct the assay, a 2.97-ml aliquot of FRAP reagent, a mixture of 0.1 mol/l acetate buffer, 10 mmol/l 2,4,6-Tris(2-pyridyl)-s-triazine (TPTZ) and 20 mmol/l ferric chloride (10:1:1 v/v/v) was combined with 30 μl of the extract. After incubation for 10 min, the absorbance of each solution was determined at 593 nm. The DPPH radical scavenging capacity was measured using the method of Brand-Williams *et al.* (1995). The radical solution was prepared by dissolving DPPH (40 mg/l) in methanol. For the assay, a 2.97-ml aliquot of 2,2-diphenyl-1-picrylhydrazyl (DPPH) solution and 30 μl samples were mixed. After 10 min, the reaction absorbance was measured at 515 nm. To determine the antioxidant capacity of samples by both procedures, absorbance values were compared with those obtained from standard curves of trolox (10–100 μmol/l). Antioxidant capacity values were expressed as trolox equivalents (TE)/g fw.

2.4 Statistical analysis

The Methods were run in triplicate with three different lots of samples. Data were subjected to analysis of variance (ANOVA) and mean comparison was carried out using Duncan's multiple range test (DMRT). Statistical analysis was performed by the Statgraphics Centurion XVII.

III. RESULTS & DISCUSSION

3.1 Phytochemical composition in *Asparagus officinalis* shoot

Phytochemical composition in *Asparagus officinalis* shoot was primarily analyzed. Results were elaborated in table 1. From table 1, we clearly noticed that *Asparagus officinalis* shoot had good antioxidant capacity which was suitable for herbal tea production. These results were similar to finding by Yang Gyu Ku et al., (2017).

3.2 Effect of blanching temperature and time

Different blanching time and temperature (100°C, 5 seconds; 95°C, 10 seconds; 90°C, 15 seconds; 85°C, 20 seconds) were examined on *Asparagus officinalis* shoot. Then they were dried by heat pump at 60°C until 6.5% moisture. All samples were analyzed vitamin C (mg/100g), the ferric reducing antioxidant power (FRAP, µmol TE/g fw) and DPPH (µmol TE/g fw) radical scavenging assays, color (sensory score) to validate the appropriate blanching condition. From table 2, the optimal blanching time and temperature should be conducted at 95°C, 10 seconds.

Sanchez-Pineda-Infantas M.T. et al. (1994) studied effects of three methods of blanching in conjunction with freezing, on texture of white asparagus as defined by three measures: maximum shear force, cutting energy, and total fiber content. They also assessed shelf life of asparagus kept in frozen storage at -22°C. Methods of blanching were total immersion in hot water, progressive immersion in hot water and steam. An increase in total fiber content was found throughout frozen storage. This increase correlated with lignification of vascular bundles in the basal segment of spears, even during frozen storage. This was reflected in an

increase in maximum shear force and cutting energy required. The shelf life of frozen asparagus was 12 months using total fiber content as a criterion. A study were to determine the optimum drying temperature, air velocity, and predrying blanching treatment and study the effects of those parameters on the drying curves for low-grade asparagus and the efficiency of the drying process (Strahm B.S., Flores R.A., 1994). The textural and green color degradation of asparagus was determined after heat treatments at temperatures between 70°C and 98°C for selected time intervals. Maximum shear stress required to cut through green asparagus and the hue angle of the spear surface color were selected to represent the textural and color changes in thermally treated asparagus (Lau M.H. et al., 2000).

3.3 Effect of CaCl₂ concentration in blanching

Raw *Asparagus officinalis* shoots were blanched in water solution with different CaCl₂ concentration (1.0%, 2.0%, 3.0%, 4.0%, 5.0%) at 95°C, 10 seconds. Then they were dried by heat pump at 60°C until 6.5% moisture. All samples were analyzed vitamin C (mg/100g), the ferric reducing antioxidant power (FRAP, µmol TE/g fw) and DPPH (µmol TE/g fw) radical scavenging assays, color (sensory score) to validate the appropriate blanching condition.

Dominika Guzek et al., (2012) proved that soaking in 1% calcium chloride solution prior to low-temperature blanching resulted in obtaining a colour more attractive for consumers, compared to the use of conventional technology. According to our results, the optimal CaCl₂ concentration should be 3%.

Table 1. Phytochemical composition in *Asparagus officinalis* shoot

Parameter	Vitamin C (mg/100g)	FRAP (µmol TE/g fw)	DPPH (µmol TE/g fw)	Total phenolic (TP, mg GAE/g fw)
Value	45.19±0.03	22.57±0.02	13.35±0.01	17.42±0.02

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 3%).

Table 2. Effect of blanching temperature and time

Blanching condition	Vitamin C (mg/100g)	FRAP (µmol TE/g fw)	DPPH (µmol TE/g fw)	Sensory score
100°C, 5 second	41.04±0.01 ^b	20.24±0.01 ^b	12.01±0.02 ^b	6.45±0.01 ^b
95°C, 10 seconds	43.19±0.02 ^a	21.08±0.00 ^a	12.34±0.01 ^a	7.23±0.00 ^a
90°C, 15 seconds	40.28±0.00 ^c	19.37±0.02 ^c	11.48±0.00 ^c	6.02±0.02 ^c
85°C, 20 seconds	38.11±0.03 ^d	19.02±0.02 ^d	11.26±0.03 ^d	5.67±0.03 ^d

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 3%).

Table 3. Effect of CaCl₂ concentration in blanching

CaCl ₂ in blanching	Vitamin C (mg/100g)	FRAP (µmol TE/g fw)	DPPH (µmol TE/g fw)	Sensory score
1%	42.04±0.01 ^c	19.89±0.02 ^c	11.78±0.00 ^c	6.49±0.01 ^c
2%	42.79±0.00 ^b	20.24±0.01 ^b	12.01±0.02 ^b	7.01±0.03 ^b
3%	43.19±0.02 ^a	21.08±0.00 ^a	12.34±0.01 ^{ab}	7.23±0.00 ^{ab}
4%	43.20±0.00 ^a	21.11±0.02 ^a	12.37±0.03 ^a	7.29±0.02 ^{ab}
5%	43.22±0.01 ^a	21.13±0.03 ^a	12.40±0.02 ^a	7.30±0.01 ^a

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 3%).

Table 4. Effect of *Asparagus officinalis* leaf size during drying

<i>Asparagus officinalis</i> leaf size	Vitamin C (mg/100g)	FRAP (µmol TE/g fw)	DPPH (µmol TE/g fw)	Sensory score
0.5 cm	41.37±0.00 ^d	19.48±0.01 ^d	10.20±0.02 ^d	5.13±0.03 ^d
1.0 cm	42.20±0.01 ^c	20.14±0.02 ^d	11.39±0.00 ^c	6.55±0.01 ^c
1.5 cm	42.49±0.03 ^b	20.67±0.01 ^b	12.01±0.03 ^b	6.90±0.02 ^b
2.0 cm	43.19±0.02 ^a	21.08±0.00 ^a	12.34±0.01 ^a	7.23±0.00 ^a
2.5 cm	43.23±0.01 ^a	21.10±0.03 ^a	12.39±0.02 ^a	7.29±0.01 ^a

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 3%).

Table 5. Effect of drying temperature

Drying temperature	Vitamin C (mg/100g)	FRAP (μmol TE/g fw)	DPPH (μmol TE/g fw)	Sensory score
10°C	43.32±0.00 ^a	21.29±0.01 ^a	12.52±0.00 ^a	8.51±0.01 ^a
20°C	43.30±0.01 ^{ab}	21.24±0.01 ^{ab}	12.46±0.01 ^{ab}	8.29±0.02 ^{ab}
30°C	43.27±0.00 ^{ab}	21.22±0.02 ^{ab}	12.43±0.00 ^{ab}	8.13±0.01 ^{cb}
40°C	43.24±0.03 ^{ab}	21.17±0.03 ^{ab}	12.40±0.02 ^b	7.90±0.03 ^b
50°C	43.22±0.01 ^{ab}	21.13±0.01 ^{ab}	12.39±0.03 ^{bc}	7.67±0.02 ^{bc}
60°C	43.19±0.02 ^b	21.08±0.00 ^b	12.34±0.01 ^c	7.23±0.00 ^c

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 3%).

Table 6. Effect of storage condition

Storage duration (week)	Storage temperature 4°C		Storage temperature 28°C	
	FRAP (μmol TE/g fw)	DPPH (μmol TE/g fw)	FRAP (μmol TE/g fw)	DPPH (μmol TE/g fw)
0	21.22±0.02 ^a	12.43±0.00 ^a	21.22±0.02 ^a	12.43±0.00 ^a
1	21.20±0.01 ^{ab}	12.40±0.02 ^{ab}	21.17±0.02 ^{ab}	12.38±0.02 ^{ab}
2	21.11±0.00 ^{ab}	12.35±0.02 ^{ab}	21.03±0.01 ^b	12.27±0.01 ^{ab}
3	21.02±0.01 ^b	12.29±0.01 ^b	20.79±0.03 ^{bc}	12.18±0.03 ^b
4	20.88±0.02 ^{bc}	12.17±0.03 ^{bc}	20.50±0.00 ^c	12.02±0.02 ^{bc}
5	20.53±0.03 ^{bc}	12.01±0.01 ^{bc}	20.28±0.00 ^{cd}	11.87±0.01 ^{bc}
6	20.24±0.01 ^c	11.94±0.00 ^c	20.04±0.01 ^d	11.65±0.02 ^c

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 3%).

3.4 Effect of *Asparagus officinalis* shoot size in drying

Raw *Asparagus officinalis* shoots were blanched in water solution with 4% CaCl₂ at 95°C, 10 seconds. Then they were dried at different size (0.5 cm, 1.0 cm, 1.5 cm, 2.0 cm, 2.5 cm) by heat pump at 60°C until 6.5% moisture. All samples were analyzed vitamin C (mg/100g), the ferric reducing antioxidant power (FRAP, μmol TE/g fw) and DPPH (μmol TE/g fw) radical scavenging assays, color (sensory score) to validate the appropriate blanching condition. From table 4, the leaf size should be 2.0cm in drying.

Fresh asparagus spears cut all-green contain less ascorbic acid than spears cut with a white butt portion, but after processing no difference is evident. Small diameter spears are higher in ascorbic acid and shear values than large diameter spears. After processing, the shear values for the large diameter spears are higher than those for small diameter spears. Holding asparagus spears for extended periods of time results in decreased ascorbic acid and moisture content and increased shear values (Drake S. R. and Nelson J. W., 1979).

3.5 Effect of drying temperature

Raw *Asparagus officinalis* shoots were blanched in water solution with 4% CaCl₂ at 95°C in 10 seconds. Then these samples would be dried in 1.0 cm of size under heat pump dryer at different temperature (10°C, 20°C, 30°C, 40°C, 50°C, 60°C) until 6.5% moisture. All samples were analyzed vitamin C (mg/100g), the ferric reducing antioxidant power (FRAP, μmol TE/g fw) and DPPH (μmol TE/g fw) radical scavenging assays, color (sensory score) to validate the appropriate drying temperature. From the table 5, the drying temperature should be conducted at 30°C in order to saving the phytochemical elements as well as reducing the drying time.

A research is to evaluate drying methods that have the potential of adding value to green asparagus especially for use as ingredient in instant foods or as a nutraceutical product. Five drying methods were used: namely, tray drying (TD), spouted bed (SB) drying, combined

microwave and spouted bed drying (MWSB), refractance window (RW) drying and freeze drying. *Asparagus* spears with diameters between 9 and 12 mm were blanched in 85C water-bath for 3 min, sliced into 2–4 mm thickness (or pureed for RW drying), then dried to moisture content less than 0.1 db. MWSB drying produced asparagus particles with good rehydration and color characteristics, and was the fastest among the methods where heated air was used. When using MWSB drying, the power level of 2 W/g and 60C heated air resulted in highest retention of total antioxidant activity (TAA). TAA of asparagus was enhanced after RW and freeze-drying, with the TAA values being significantly higher than for heated air-drying methods. In all cases, the tip portion of asparagus retained more TAA after drying than either middle or basal parts. The highest amount of ascorbic acid was retained in the product after RW drying, followed by freeze-drying, MWSB and SB drying. TD resulted in the least retention of ascorbic acid (Nindo C.I., 2003).

3.6 Effect of storage condition

After completion of drying treatment, the dried *Asparagus officinalis* shoots were subjected to storage. They were kept in PET/AL/PE (vaccum) bag at different 4°C, 28°C. The ferric reducing antioxidant power (FRAP, μmol TE/g fw) and DPPH (μmol TE/g fw) radical scavenging assays will be analyzed in 1 week interval for 6 weeks.

Asparagus officinalis shoots contain saponin as the main active constituent, which is very hygroscopic. Therefore, a suitable method of drying and storage of powder of *Asparagus officinalis* shoots is needed in which the degradation of saponin is minimal. From table 6, the dried *Asparagus officinalis* shoots still have the antioxidant power under the PET/AL/PE (vaccum) bag at 4°C after 6 months of preservation.

IV. CONCLUSION

Asparagus is a plant with high nutritional, pharmaceutical, and industrial values. *Asparagus officinalis* offers various health benefits because of valuable ingredients like

alkaloids, saponins and tannins that help in improving fertility and vitality. Green asparagus (*Asparagus officinalis* L.), also perishable vegetable, is processed after harvest to minimize the deterioration of its physical and chemical quality. The present study has successfully investigated the effect of *asparagus officinalis* shoot size and drying to herbal tea production.

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