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ORIGINAL PAPER

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THE NUTRIENT, COLOR AND ANTIOXIDANT CAPACITY OF ASPARAGUS (*ASPARAGUS OFFICINALIS* L.) ROOT TEA AFTER BLANCHING

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ABSTRACT

Background. Green asparagus (*Asparagus officinalis* L.) roots were used as raw materials for herbal tea because of their antioxidant, anti-inflammatory, antimicrobial, antiviral, and antiproliferative properties through the bioactive sources. This research focused on analyzing the effects of blanching parameters on the quality of a tea product made from green asparagus roots. This evaluation used an analysis of chemical and bioactive compounds.
Materials and methods. The investigated temperature and time of blanching were in the range of 80, 85, 90, and 95°C for 0, 2, 4 and 6 minutes. The results were observed and presented through the physicochemical including color, the content of saccharose, vitamin C, phenolic, flavonoid, saponin and antioxidant capability.
Results. The asparagus roots treated at 85°C for 2 minutes were able to maintain an acceptable amount of vitamin C and saccharose contents; the loss of bioactive compounds including phenolic, flavonoid and saponin was not significant. The contents of saccharose, vitamin C, phenolic, flavonoid, saponin, DPPH and FRAP (calculated per 100 g of dry matter) were 2.860 g, 4.010 g, 0.440 g TAE, 0.567 g QE, 5.472 g SE, 54.320% and 11.911 M $FeSO_4$, respectively. At the same time, the sensory test was evaluated highly.
Conclusion. The material blanched at 85°C for 2 minutes was recommended as the optimal conditions for the pretreatment for making tea product from green asparagus roots.

Keywords: blanching temperature, blanching time, bioactive compounds, herbal teas, pretreatment

INTRODUCTION

Asparagus (*Asparagus officinalis* L.) has been ranked in the list of the world's top 20 valuable vegetable crops due to its excellent nutritional properties and flavor/fragrance, which is attributed to a set of volatile components including pyrazines and sulfur-containing compounds (Pegiou et al., 2019). Studies on the chemical compounds of asparagus have shown a rich mixture, including saponins, flavonoids, vitamins, and other polysaccharides, dietary fiber, and oligosaccharides (Fuentes-Alventosa et al., 2013; Zhang et al., 2019).

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These compositions exhibit anti-cancer, anti-tumor, antioxidant, immunomodulatory, hypoglycemic, antihypertensive and anti-epileptic effects and contribute to enhancing the value of this crop (Pegiou et al., 2019; Guo et al., 2020). However, fewer applications exist for the roots as a by-product that have been researched and developed. Therefore, the asparagus roots (Fig. 1a) are still the potential raw material for creating added-value products, which contribute to enhancing the crop value and utilizing this by-product.

Blanching is a preliminary treatment in the food processing industry, which is applied before drying, freezing or canning in order to remove tissue gases, with the aim of shrinking the material to conserve space in packing and boiling and the inactivation of the undesirable enzymes present in the material and reducing the microbial load (Ravindra et al, 2021; Cumming et al., 2007). There are several popular blanching techniques that have been reported, such as using hot water, steaming and fluidized bed blanching with a steam-hot air mixture (Nath and Purandar, 2017). Vegetables are the most common material for blanching in product processing, which aims to inactivate the enzymes along with the destruction of surface micro flora (Severini et al., 2016). Blanching also contributes to aid reconstitution and textural improvement in product (Nath and Purandar, 2017). However, blanching also has deteriorative effects, particularly on the water-soluble components. In addition, prolonged hot water blanching resulted in significant loss of macro and micronutrients including carbohydrates, proteins, and minerals. Therefore, it is necessary to minimize the blanching time or investigate the proper blanching parameters in order to prevent the high solid loss and keep the good properties of the products (Nath and Purandar, 2017; Severini et al., 2016).

Nowadays, herbal teas are recognized for their health-promoting activities including anti-cancer, antibacterial, anti-diabetic, anti-inflammatory and antioxidant properties, representing the presence of mainly biological and antioxidant activities such as polyphenolic compounds, vitamins, and carotenoids (Jasenka et al., 2013; Topuz et al., 2023). Furthermore, plant composition, preparation and processing methods, and raw material storage conditions influence the concentration of bioactive compounds and antioxidant capacity of herbal teas. This study focused on investigating the effects of blanching parameters to create dried asparagus root tea, which is efficient in nutrition and meets sensory and safety requirements for consumers (Poswal et al., 2019) (Fig. 1b and 1c). A 2-level factorial design was applied to evaluate the effects of the blanching process on physicochemical components including color, total sugar and total acid content, biologically active compounds, as well as the ability to inhibit free radical scavenging (DPPH) and ferric-reducing antioxidant power (FRAP) of the target product.

MATERIALS AND METHODS

Materials

Green asparagus roots in good condition, which were fresh, undamaged and free from pests, were collected at My Thoi Ward, Long Xuyen city, An Giang

(a) (b) (c)

Fig. 1. Green asparagus roots (a), green asparagus roots after blanching (b), and asparagus roots tea (c)

province, Vietnam. The material was treated within 1 hour of being transported to the laboratory.

Experimental design

Green asparagus roots were washed and drained carefully, for each treatment using 2 kg of raw materials. The fresh asparagus root was cut into 1–1.5 cm pieces and then blanched in hot water at the temperature and time investigated. The experiment was conducted at 80, 85, 90 and 95°C in 0, 2, 4 and 6 minutes; these treatments were designed randomly with tri-replicates. After blanching, the samples were drained and arranged on the baking tray (40 × 60 cm^2) in order to dry in the forced convection cabinet dryer ESCO (OFA–110–8, Indonesia) (Airflow velocity was 1 m/s) at 80°C until the sample reached a moisture content of less than 10% by observing the moisture content in every 30 minutes. For the analysis of the nutrients in asparagus tea, a 5 g dried sample of each treatment was soaked in 50 mL ethanol 70% v/v (at 30°C) in 24 hours (See et al., 2016). The color (through *L*, *a*, *b* values) and the sensory characteristics were investigated using the extracted solution obtained from 5 g asparagus tea soaked in 50 mL of hot water at 80°C for 5 minutes.

Analysis methods

Determination of color

Color analysis with *L*, *a*, *b* values of the extracted solution used a colorimeter (Konica Minolta CR400, Japan).

Determination of saccharose content

Saccharose content (g/100 g of dry matter) was measured by the Dinitro Salicylic Acid (DNS) method. This method is based on the oxidation of the C = O group by 3,5-Dinitrosalicylic acid from yellow color to orange-red in an alkaline medium (Nielsen, 2010). In brief, 5 g of dried asparagus root tea was hydrolyzed with 5 mL of concentrated HCl at 68–70°C for 7 minutes. The mixture was neutralized to pH 7.0 with 30% NaOH. Then, 7 mL of 30% $Pb(CH_3COO)_2$ was added to precipitate impurities, and 18–20 mL of saturated Na_2SO_4 was added to remove excess $Pb(CH_3COO)_2$; transferred the mixture to a 100 mL volumetric flask and filter. An aliquot (1 mL) of the sample was put in a test tube and then 2 mL of reagent DNS was added. Tubes of a blank solution of standard glucose and samples were put into boiling water for 10 minutes. Next, 7 mL distilled water was added. The solution was analyzed at an absorption of 575 nm using a UV-visible spectrophotometer (V730, Jasco, Japan). The concentration of total sugar was based on a standard curve of glucose, $y = 23885x + 0.126$ ($R^2 = 0.9999$), where y is the absorbance and x is the concentration of the solution in the tube.

Determination of vitamin C content

Vitamin C content (g/100 g of dry matter) was determined based on the 2,4-dinitrophenyl hydrazine colorimetric method described by Sharaa and Mussa (2019) with some modifications. Approximately 1 g of the sample with 5 mL of a solution containing 3% metaphosphoric acid (w/v) and 8% glacial acetic acid (v/v) were taken in a 15 mL centrifuge tube. The centrifuge tube was placed on the Reciprocating shaker (Stuart, UK) for 1 hour. 1 mL of supernatant after centrifugation was mixed with 0.5 mL of 3% bromine, 0.25 mL of 10% thiourea and 0.25 mL of 2,4-dinitrophenyl hydrazine. The mixture was incubated for 3 hours at 37°C. After that, 10 mL of 85% H_2SO_4 was added to the tube to form a red complex. The solution was cooled to room temperature and analyzed with an absorption at 520 nm, using a UV-visible spectrophotometer (V730, Jasco, Japan). The vitamin C concentration was calculated with a standard ascorbic acid graph, $y = 0.2253x + 0.0024$ ($R^2 = 0.9999$), where y is the absorbance and x is the concentration of the solution in the tube.

Determination of phenolic content

Phenolic content (g TAE/100 g of dry matter) was indicated by the Folin-Ciocalteu reagent (Sumaiyah et al., 2015) with some modifications. In brief, 0.15 mL of the sample was mixed with 1.2 mL of distilled water and 0.45 mL of 5% (w/v) Na_2CO_3 in a test tube. The mixture was added to 0.1 mL of Folin-Ciocalteu reagent and left at room temperature for 90 min for the reaction. Phenolic in the extract reacts with Folin-Ciocalteu to form a phosphomolybdenum complex with a blue color in the alkaline medium. The concentration of total phenolics was calculated equally to the standard tannic acid graph (TAE), $y = 0.0021x + 0.0064$ ($R^2 = 0.9999$), where y is the absorbance and x is the concentration of the solution in the tube.

Determination of flavonoid content

This assay was performed using the aluminum chloride colorimetric method described by Sumaiyah et al. (2015) with some modifications. The principle related to $AlCl_3$ creating a stable acid complex with the C-4 keto groups and the hydroxyl C-3 or C-5 group of the flavon and flavonol. 100 µL of the sample was added to 1200 µL of distilled water and 30 µL of 5% (w/v) $NaNO_2$. The mixture was mixed with 10% (w/v) $AlCl_3H_2O$ (60 µL); 200 µL of 1 M NaOH and 110 µL of water. The solution was measured at 510 nm, using a UV-visible spectrophotometer (V730, Jasco, Japan). The concentration of total flavonoids was calculated as equal to the standard quercetin graph (QE), $y = 8.2634x + 0.0182$ ($R^2 = 0.9999$), where y is the absorbance and x is the concentration of solution in the tube.

Determination of saponin content

The saponin content was determined using the vanillin-sulfuric acid method (Le et al., 2018). The basic principle is related to the oxidation of triterpene saponins by sulfuric acid and vanillin, producing a distinctive red-violet color. Approximately 0.25 mL of the sample was placed in the test tube and 0.25 mL of 8% (w/v) vanillin in ethanol 96% and 2.5 mL of 72% H_2SO_4 were added. The mixture was incubated at 60°C for 30 mins and then cooled to room temperature. The solution was measured at 560 nm, using a UV-visible spectrophotometer (V730, Jasco, Japan). The concentration of saponin was calculated as equal to the standard saponin graph (SE), $y = 0.1348x + 0.0075$ ($R^2 = 0.9999$), where y is the absorbance and x is the concentration of the solution in the tube.

Determination of DPPH (2,2-diphenyl-1-picrylhydrazyl) scavenging activity

A DPPH assay was measured using the method described by Molyneux (2004) with some modifications. 1.5 mL of the sample was mixed with 1.5 mL of DPPH solution. This assay was based on the electron transfer that produces a purple solution in ethanol and was analyzed at 517 nm using a UV-visible spectrophotometer (V730, Jasco, Japan). Inhibition of DPPH free radicals was calculated using equation 1:

$$\text{Inhibition of DPPH radical (\%)} = = 100 \times (A_c - A_s)/A_c \quad (1)$$

where A_c is the absorbance of the control and A_s is the absorbance of the sample.

Determination of ferric reducing antioxidant power (FRAP) assay

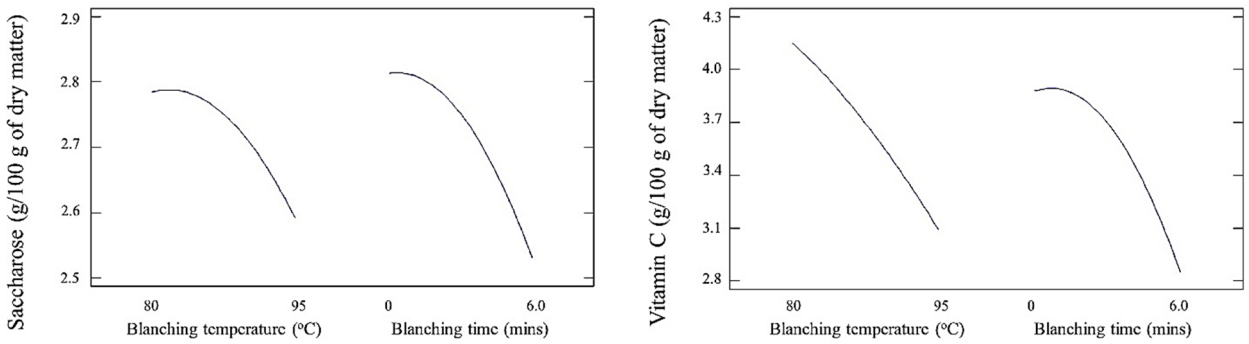
FRAP assay (mM of $FeSO_4$/g dry matter) was measured by Sudha et al. (2012) with some modifications. This method is based on the reduction of tripyridyltriazine complex Fe $(TPTZ)^{3+}$ to blue-colored Fe $(TPTZ)^{2+}$ by antioxidants in an acidic medium. The FRAP reagent contained 100 mL of 200 mM acetate buffer (pH 3.6), 10 mL of 20 mM $FeCl_3.6H_2O$ and 10 mL of a 10 mM TPTZ in 40 mM HCl. 0.05 mL of the sample was added to 1.5 mL of the FRAP reagent and 0.15 mL of distilled water. The mixture was incubated at 37°C for 8 mins. It was later analyzed at an absorption of 593 nm, using a UV-visible spectrophotometer (V730, Jasco, Japan).

Data analysis

Statistical analysis of the data was performed using STATGRAPHICS Centurion 16.1 software. Multiple-way analysis of variance (ANOVA) was used. Tukey's multiple comparison test was applied to determine significant differences in treatment means at $p < 0.05$. Microsoft Excel software was used for calculating and graphing.

RESULTS AND DISCUSSION

Blanching is a short heat treatment, which is applied in order to improve both safety and quality properties, such as destruction of surface microorganism, enhancement of color, texture, etc. However, the blanching products are significantly dependent on the blanching temperature and time (Severini et al., 2016; Nath and Mandal, 2017). The results in Figure 2 show that the blanching temperature and time affected the chemical compositions of the asparagus tea. Vitamin C and total sugar content decreased with the increase in blanching temperature from 80°C to 95°C. Specifically, when the temperature changed from 80°C to 95°C, vitamin C content decreased from 11.86 g to 8.92 g/100 g of dry matter, respectively; total sugar content tended to decrease from 2.74 g to 2.55 g/100 g of dry matter, respectively, whilst there was no significant difference in the vitamin C and total



a. Saccharose

b. Vitamin C

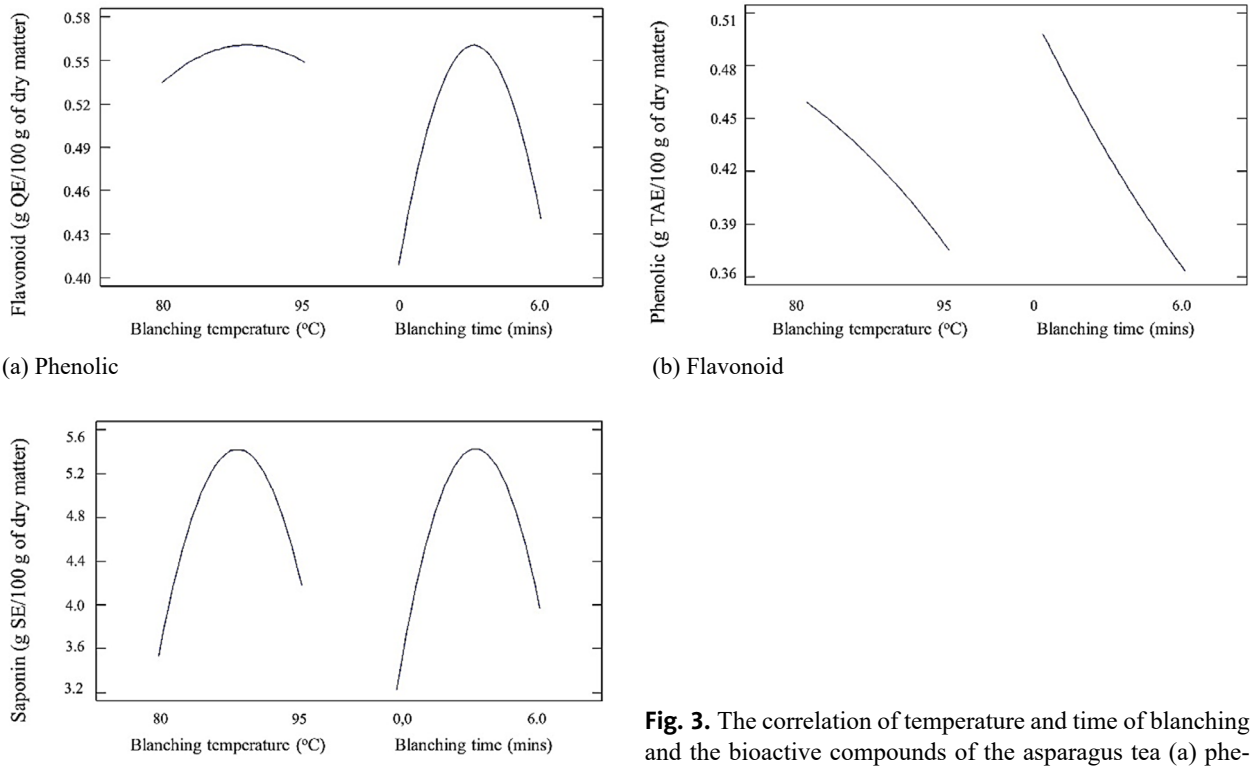
Fig. 2. The correlation of temperature and time of blanching and the chemical compositions of the asparagus tea (a) saccharose and (b) vitamin C

sugar content at 80°C and 85°C ($p > 0.05$). After 2 minutes of blanching, the total sugar content increased from 26.95 to 30.77%, but after 6 minutes, the total sugar loss increased from 30.11 to 43.12%. These results were similar in terms of the loss of vitamin C and the reduction enhanced from 31.64–49.87% after 6 minutes of blanching. The loss of nutrients during blanching with hot water is due to the filtration or diffusion of water-soluble nutrients such as sugars, vitamins, minerals, and flavors that can leak from the plant cells into the blanching water (Xiao et al., 2017). Previous research showed that most of the sugars like glucose, fructose and sucrose in the raw materials were reduced during blanching with hot water (Song et al., 2003; Villamiel et al., 2006; Pimpaporn et al., 2007; Jabbar et al., 2014). Research by Badwaik et al. (2015) showed that blanching asparagus in water at 95°C for 20–30 minutes significantly reduced carbohydrate and sugar content from 4.08 to 2.25 g/100g and from 1.33 to 0.87 g/100 g of dry matter. In addition, vitamin C is soluble in water; it is easily transformed to be oxidized and degraded during heat treatment (Gupta et al., 2008; Jeney et al., 2008; Xiao et al., 2017). During blanching at a high temperature, the L-ascorbic acid (vitamin C) in green asparagus was converted to dehydroascorbic acid (Munyaka et al., 2010) and resulted in the loss of vitamin C. Similar results were obtained as described by El-Ishaq and Obirinakem (2015) for making pineapple and tomato juice using heat treatment.

The effects of each factor, blanching temperature and blanching time, on the bioactive compounds of the dried asparagus tea are shown in Figure 3. Figure 3a shows that the phenolic content decreased with an increase in both blanching temperature and time from 80°C to 95°C and from 0 to 6 minutes, respectively. The lowest reduction in phenolic content was observed when blanching the asparagus root at 80°C for 2 minutes (1.15%). In addition, the loss of phenolic compounds increased significantly (10.08–27.25%) when increasing the blanching temperature from 80°C to 85°C, 90°C and 95°C for 2 minutes. Similarly, at the same blanching temperature, a reduction in phenolic content increased in the range of 19.90–24.36% was observed at blanching temperatures of 80°C and 85°C, while a loss of phenolic compounds was enhanced from 31.68–39.52% at the temperatures 90°C and 95°C for 6 minutes.

The changes of flavonoids and saponins during blanching (Fig. 3b and 3c) showed that flavonoid, and saponin content increased to the highest value, then gradually decreased with the increase in blanching temperature and time. Specifically, the flavonoid and saponin content (calculated per 100 g of dry matter) from 0.51 g QE and 0.28 g SE when blanched at 80°C increased to 0.52 g QE and 4.94 g SE, respectively, at 85°C. However, samples blanched at a higher temperature, which slowly increased to 95°C, and the flavonoid and saponin content decreased by 0.52 g TAE/100g and 3.62 g SE/100g of dry matter, respectively.

Phenolic content was lost in vegetables during blanching and this loss could be due to phenolic



(a) Phenolic

(b) Flavonoid

(c) Saponin

Fig. 3. The correlation of temperature and time of blanching and the bioactive compounds of the asparagus tea (a) phenolic, (b) flavonoid and (c) saponin

oxidation or water solubility (Sikora et al., 2008; Korus and Lisiewska, 2011; Jaiswal et al., 2012; Xiao et al., 2017). In addition, phenolic compounds are found in soluble form and in collaborative form with cellular components of plants (Francisco et al., 2010). Heat treatment causes the degradation of phenolics, especially under high temperature conditions (Teh et al., 2016). Furthermore, the higher the temperature, the more swollen and movable the components are in the material. Previous studies had also found flavonoid and saponin compounds that were easily movable from the cell wall after heat treatment, which caused an increase in the content of these substances (Jeong et al., 2004). However, when the temperature continued to increase, flavonoids and saponins were degraded by hydrolysis, intrinsic oxidation, and polymerization (Liyana and Shahidi, 2005; Sarkar et al., 2021). Ha and Nguyen (2020) stated that a prolonged period of heat treatment causes a reduction in bioactive compounds.

Data analyzed by Pareto charts are illustrated in Figure 4. These results show the influence of the independent variables (A: blanching temperature and B: blanching time) as well as the interactions between them (AA, BB and AB) affecting on the chemical compositions and bioactive compounds of dried asparagus tea. These results found that the prolonged treatment time affected the bioactive contents of asparagus tea more than the effect of heat treatment, except for vitamin C content.

The antioxidant activity, as an additional function in food products, had a positive correlation with the content of bioactive compounds in the material. For example, phenolics improved the quality and nutritional value of foods because hydroxyl groups of phenolics had scavenging capacity (Nithya et al., 2016) or flavonoids were a powerful antioxidant, as well as free radical scavenger and iron chelators (Jaiswal et al., 2012) or saponins that had pharmacological effects and were resistant to pathogens (Nithya et al., 2016). The study also determined the antioxidant activity of dried asparagus after treating at different temperature ranges and blanching times through the DPPH and FRAP analysis (Fig. 5). The results showed that the DPPH inhibitory percentage reached a high value

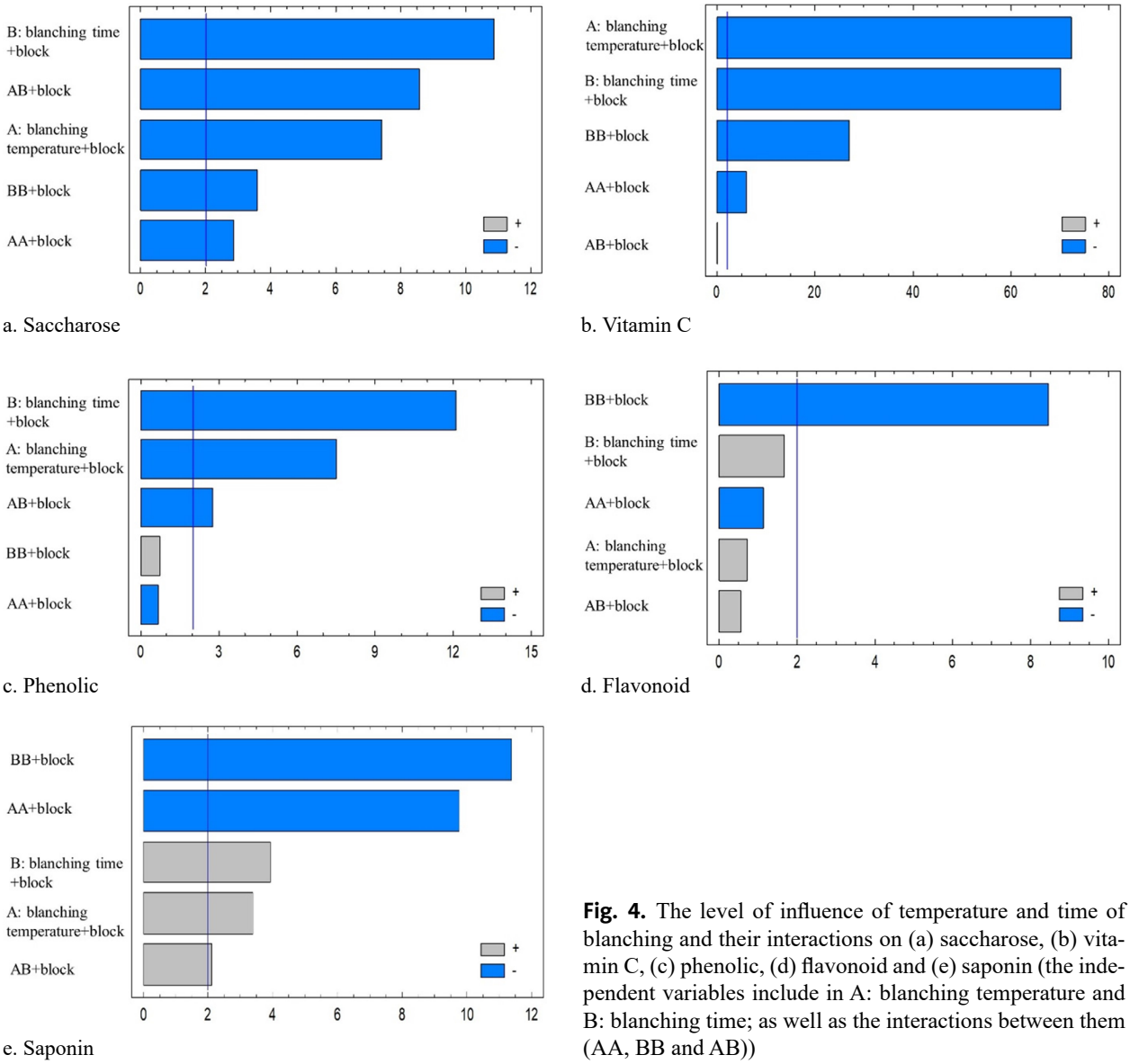
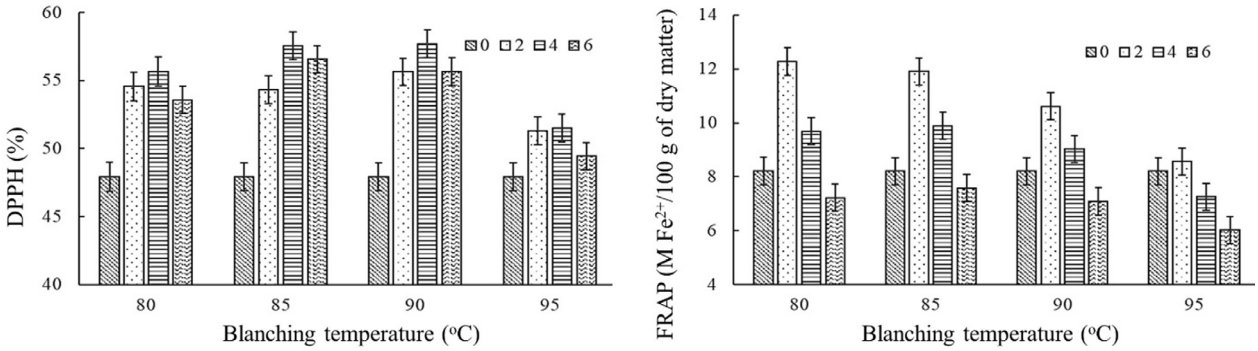


Fig. 4. The level of influence of temperature and time of blanching and their interactions on (a) saccharose, (b) vitamin C, (c) phenolic, (d) flavonoid and (e) saponin (the independent variables include in A: blanching temperature and B: blanching time; as well as the interactions between them (AA, BB and AB))

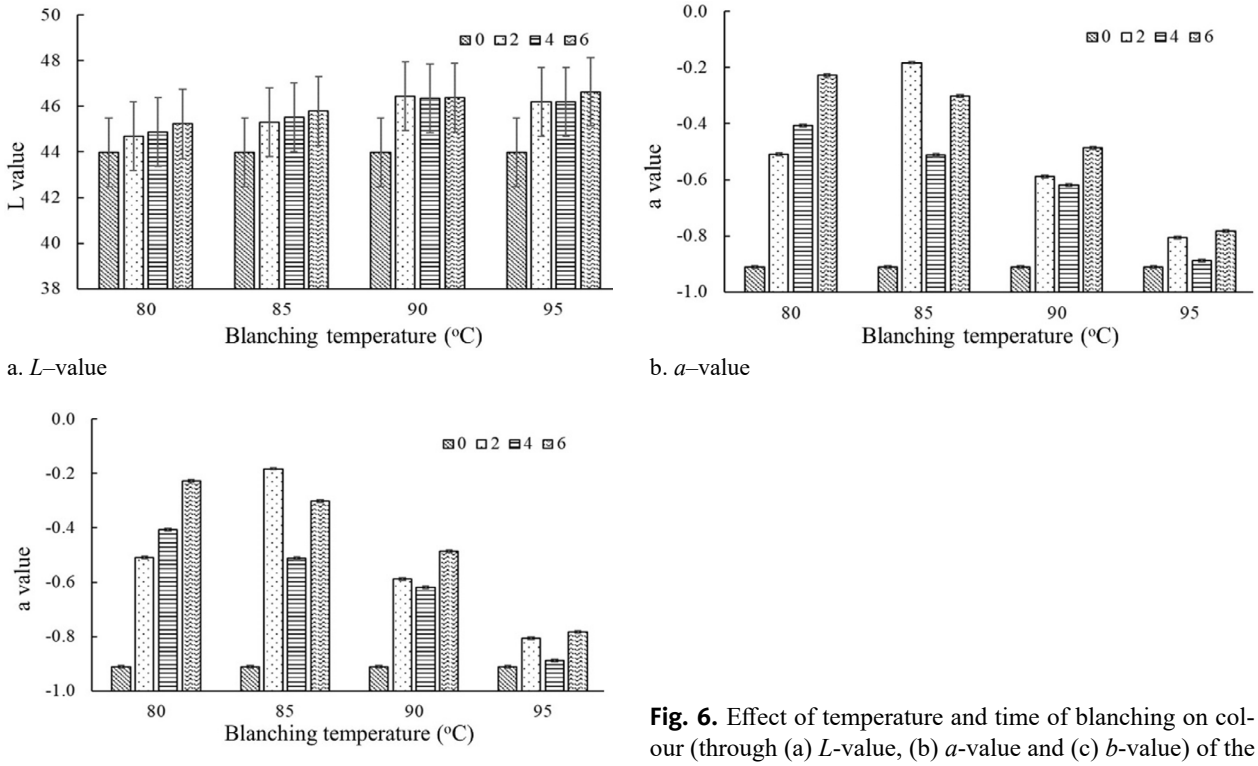
when blanching asparagus root at 85°C and 90°C for 4 minutes and there was no significant difference at 5% level. The ferric reducing antioxidant power (FRAP) of asparagus tea reached a value of 10.78–10.91 when blanching at 80°C and 85°C (the difference was not statistically significant at 5%) and when the blanching time was increased, the reduction in ferric ion tended to decrease. Most bioactive substances were sensitive to temperature and the increase or decrease in phenolic, flavonoid and saponin compounds when increasing temperature and blanching time could lead to an increase or decrease in antioxidant activity of asparagus tea (Sumaiyah et al., 2015; Nithya et al., 2016). Furthermore, the study of Chantaro et al. (2008) also confirmed that there is a correlation between the loss of phenolic content and antioxidant activity of carrot peel materials. According to Jaiswal et al. (2012), the treated temperatures range from 80–90°C, DPPH free radical scavenging activity decreases by 60–65% when blanching time exceeds 6 minutes.



a. DPPH b. FRAP

Fig. 5. Effect of temperature and time of blanching on antioxidant activities of asparagus tea (a) DPPH and (b) FRAP

Color is one of the important quality attributes of food, and blanching temperature and time also affect the color of asparagus tea after extraction (via *L*, *a*, *b* values). Figure 6 shows that the *L*-value increased, proving that the color of the extract becomes brighter as temperature and blanching time increase, and reached the highest value when blanching at 90–95°C for 4–6 minutes ($p > 0.05$). The results were similar for *b* values, and the higher the *b*-value, the more yellow the solution was. The negative numbers of a value indicated the greenness of the tea solution after extraction and the higher the blanching temperature and the longer the time, the more positive the value was. Lespinard et al. (2009) studied the effects of blanching



a. *L*–value b. *a*–value

c. *b*–value

Fig. 6. Effect of temperature and time of blanching on colour (through (a) *L*-value, (b) *a*-value and (c) *b*-value) of the extract from asparagus tea

on the color of Brussels sprouts and mushrooms and showed that the reduction in green color (through *a*-value) could be due to chlorophyll degradation and the dissolving of color compounds in the blanching water. This decomposition is also temperature-dependent (Koca et al., 2007). In addition, blanching can inactivate the enzyme polyphenol oxidase, making the color of the tea solution brighter (Jaiswal et al., 2012; Xiao et al., 2017). Therefore, blanching at 85°C for 2 minutes was chosen as the appropriate parameter for further experiments.

CONCLUSION

This study investigated the appropriate parameter of blanching in the tea-making process, with the aim of maintaining adequate bioactive compounds. Both temperature and time factors of the blanching process significantly affected the quality of the extracted solution from the dried asparagus tea, especially affecting the bioactive compounds. The asparagus root treated at 85°C for 2 minutes retained the investigated parameters at an acceptable level in terms of vitamin C and saccharose contents; the loss of bioactive compounds including phenolic, flavonoid and saponin was not significant. This research recommends further studies with similar purposes in making the good-quality tea products.

DECLARATIONS

Data statement
All data supporting this study has been included in this manuscript.

Ethical Approval
Not applicable.

Competing Interests
The authors declare that they have no conflicts of interest.

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