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Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2020 17(2):941-947. **OPEN ACCESS**

Various variables in production of dried Roselle (*Hibiscus sabdariffa* L.) Calyx herbal tea

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Roselle *(Hibiscus sabdariffa*L.) calyx has a special attention due to its nutritional composition, bioactive constituents and therapeutic applications. Fresh Roselle *(Hibiscus sabdariffa* L.) calyx has short shelf life due to its high moisture content. In order to extend its shelf life, as well as create one new kind of therapeutic herbal tea, we examined various parameters of blanching, vacuum drying, roasting to the total phenolic, total flavonoid content and sensory characteristics in the dried herbal tea. Our results proved that steaming at 115^{o}C in 30 seconds, vacuum drying at 35^{o}C under pressure -0.6 bar, roasting at 135^{o}C in 9 minutes were adequate to produce one kind of herbal tea having good overall acceptance while preserving the highest ascorbic, total phenolic and flavonoid content. Our results supported available evident for manufacturers in processing of this fragrant calyx into functional herbal tea containing a great source of phytochemical constituents.

Keywords: *Hibiscus sabdariffa L*. calyx, herbal tea, steaming, vacuum drying, roasting, phenolic, flavonoid, overall acceptance

INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.) is an ideal crop for developing countries. Rain or high humidity during the harvest time and drying process can downgrade the quality of the calyces and reduce the yield. It can be used as food and fibre (Inês Da-Costa-Rocha et al., 2014). Roselle contains protein, fat, carbohydrate, fiber, and mineral, vitamin (Adanlawo y Ajibade, 2006). It is normally utilized in the traditional medicine by its phytochemical constituents such as polyphenols especially anthocyanins, polysaccharides and organic acids contributing to different modern therapeutic applications (Ajiboye et al., 2011). Fresh or dried calyces of *Hibiscus sabdariffa* L. are utilized to convert into herbal tea, hot and cold beverage, fermented drink, soft drink, wine, jam, jellied confectionary, sauce, marmalade, ice cream, chocolate, flavouring agent, pudding and cake (Bako et al., 2009; Bolade et al., 2009; Ismail et al., 2008; Okoro, 2007; Tsai et al., 2002; Bahaeldeen et al., 2012; Ochoa-Velasco et al., 2017; Thongam ChanuAnel et al., 2016). Aqueous extracts of roselle (*Hibiscus sabdariffa* L.) calyces have characteristic intense red coloration due to the presence of anthocyanins which could be utilized as coloring agent in pharmaceutical products (Grace Frimpong et al., 2014). It has been utilized to cure different degenerative diseases like hypertension, hyperlipidemia, cancer and other inflammatory diseases of liver and kidney (Ghazala, Rajni Chopra, 2018). It's also proven to treat cardiac, diuretic, sore throat and cough, cholerectic, febrifugal and hypotensive effect, liver disorder, decrease the viscosity of the blood, induce lactation and stimulate intestinal peristalsis (Salleh et al., 2002; Ali-Bradeldin et al., 2005; Gaya et al., 2009).

The consumption of roselle calyx tea has been reported to promote health benefits, which mainly functions as an antioxidant (Lin et al.,

2011). There was little research mentioned to drying of *Hibiscus sabdariffa L.* calyx into herbal tea. Roselle drying time and drying quality were optimized (Hahn et al., 2011). Freshly harvested roselle calyces of dark and light red varieties were sundried and oven dried and evaluated for proximate composition and moisture sorption (Ashaye, 2011). A continuous production roselle (*Hibiscus sabdariffa* L.) dryer using solar energy was conducted (Alejandro et al., 2014). Effects of different drying methods on proximate composition of three accessions of roselle (*Hibiscus sabdariffa*) calyces were studied (Amoasah et al., 2018). One research studied the efficacy of air temperature and relative humidity on the kinetics and product quality during drying of roselle extract foamed with ovalbumin and glycerol monostearate (Mohamad et al., 2018). One study conducted to determine the influence of oven, solar and sun drying methods on the mineral content of rosella (Amoasah et al., 2019). The effectiveness of drying temperature on the retention of total phenolic content and antioxidant capacity of the dried roselle was investigated (Nguyen and Chuyen, 2020). Purpose of our research verified various parameters of steaming, vacuum drying, roasting to the ascorbic, total phenolic, total flavonoid content and organoleptic attribute in the dried functional herbal tea.

MATERIALS AND METHODS

Material

Roselle (*Hibiscus sabdariffa*L.) calyxs were collected from gardens in SocTrang province, Vietnam. Only fully bloomed, disease free, and undamaged healthy calyxs were selected. After collecting, they must be conveyed to laboratory as soon as possible for experiments. They were cleaned by air blowing to remove foreign matters. The raw samples were quickly sanitized by peracetic acid 25ppm and left drain. These calyxs were steamed and dried by vacuum dryer. After drying, they were set in cool temperature for 30 minutes before subjecting to the roasting step. Dried samples were roasted under various values. Besides *Hibiscus sabdariffa L.*, other materials were used like Folin–Ciocalteu reagent, sodium carbonate, $NaNO_2$, $AlCl_3{\cdot}6H_2O$, NaOH. Lab utensils and equipments were also utilized including the steaming oven, vacuum drier, roasting oven, spectrophotometer, vortex mixer, test tube, erlenmeyer flask, beaker, cylinder.

Researching procedure

Effect of steaming to ascorbic acid, total phenolic, total flavonoid and overall acceptancce of steamed Hibiscus sabdariffa L. calyx

Fresh roselle(*Hibiscus sabdariffa*L.) calyx samples were steamed in various values (125^{o}C in 10 seconds, 120^{o}C in 20 seconds, 115^{o}C in 30 seconds, 110^{o}C in 40 seconds, 105^{o}C in 50 seconds). After steaming, they were set at ambient temperature before drying at 25^{o}C under -1.0 bar. The dried sample would be evaluated chemical and sensory attributes. For each steaming duration, 600 g of fresh sample was used (in triplicate).

Effect of drying to ascorbic acid, total phenolic, total flavonoid and overall acceptancce of dried Hibiscus sabdariffa L. calyx

Steamed *Hibiscus sabdariffa L.* calyx samples were subjected to vacuum drying with different conditions (25^{o}C in -1.0 bars; 30^{o}C in -0.8 bar; 35^{o}C in -0.6 bar; 40^{o}C in -0.4 bar; 45^{o}C in -0.2 bar). Drying duration was set for 4 hours. After drying, these samples were set to cool at ambient temperature before analysis. For each drying method, 600 g of steamed sample was used (in triplicate).

Effect of roasting to ascorbic acid, total phenolic, total flavonoid and overall acceptancce of dry-roasted Hibiscus sabdariffa L. tea calyx

After drying, dried calyxs were set in cool place for 30 minutes before subjecting to the roasting step. Dried samples were roasted under different conditions (125^{o}C in 15 minutes, 130^{o}C in 12 minutes, 135^{o}C in 9 minutes, 140^{o}C in 6 minutes, 145^{o}C in 3 minutes). For each roasting method, 100 g of dried sample was used (in triplicate).

Chemical, sensory and statistical analysis

Ascorbic acid (mg/100g) was determined by iodometric titration technique (Emanuel Peter et al., 2014). Total phenolic content (mg GAE/g) was evaluated using Folin–Ciocalteu assay (Meda et al., 2005; Nizar et al., 2014). Total flavonoid content (mg GE/g) was avaluated by the aluminium calorimetric method (Quettier-Deleu et al., 2000; Formagio et al., 2015). Overall acceptance was estimated by a group of panelist using 9 point-Hedonic scale. The experiments

were run in triplicate with three different lots of samples. Statistical analysis was performed by the Stat graphics Centurion XVI.

RESULTSAND DISCUSSION

Effect of steaming to ascorbic acid,total phenolic, total flavonoid and overall acceptancce of steamed roselle(*Hibiscus sabdariffa*L.) calyx

Steaming is normally performed in advance of drying to decrease the bulkiness, support packaging, inactivate enzymes, eliminate air trapped in the cell, modify texture, maintain the nutritional value, preserve the color and flavour (Manpreet et al., 2000; Bahceci et al., 2004; Barrett et al., 1995; Elisabeth et al., 2001). In our research, fresh *Hibiscus sabdariffa L.* calyx samples were steamed in various values (125^{o}C in 10 seconds, 120^{o}C in 20 seconds, 115^{o}C in 30 seconds, 110^{o}C in 40 seconds, 105^{o}C in 50 seconds). Our results showed that steaming at 115^{o}C in 30 seconds was adequate to preserve the most ascorbic acid,total phenolic, flavonoid content as well as overall acceptance (see table 1). Calyx of roselle had a good source of dietary antioxidants and ascorbic acid (Kekungu et al., 2017). Ascorbic acid varied dramatically between fresh (6.7–14 mg/100 g) and dried (260–280 mg/100 g) *Hibiscus sabdariffa L.* calyx (Ismail et al., 2008). According to Emanuel Peter et al., (2014) the amount of L-ascorbic acid extracted was 83.1 mg/100g. *Hibiscus sabdariffa L.* calyx contained polyphenols of the flavonol and flavanol type in simple or polymerised form (McKay, 2009). Extracts of dried calyces were able to decrease low-density lipoprotein cholesterol, triglyceride, total cholesterol and lipid peroxidaxion (Ochani D'Mello, 2009; Yang et al., 2010; Farombi and Ige, 2007). According to Nizar et al., (2014), the total phenolic content was found to be 41.07 mg GAE/g. According to Jeny Hinojosa-Gómez et al. (2018) roselle had total phenols 29.178 mg/kg. Meanwhile, flavonoid was observed in calyx extracts 148.35 mg/g (Formagio et al., 2015). Increase in the steaming time caused a significant reduction in total phenolic content, antioxidant activities (Oluwaseun et al., 2017). This reduction might be owing to the decomposition of phenolic substances by thermal. Disruption of the cell wall of the plant may occur leading to leaching out of the soluble phenolic substances. In one report, effect of steam blanching on total soluble solids, pH, titratable acidity and color of green roselle pickle was examined (Nasution et al., 2012).

Effect of drying to ascorbic acid,total phenolic, total flavonoid and overall acceptance of dried roselle (*Hibiscus sabdariffa*L.) calyx

Polyphenols in roselle included delphinidin and cyanidin having antioxidant activities beneficial for human body (Borrás-Linares et al., 2015; Jabeur et al., 2017; Wang et al., 2011). Aqueous extracts of roselle (*Hibiscus sabdariffa* L.) calyces have characteristic intense red colouration due to the presence of anthocyanins, which are flavonoids are water-soluble natural pigments (Shruthi et al., 2016). Vacuum drying technology is an important process for drying highly heat-sensitive materials. The water evaporation proceeds more rapidly at low pressures (Bazyma and Kutovoy, 2005). The drying process eliminates the water or humidity content of the calyxes but must maintain the nutritional properties, specifically the ascorbic acid content (Meza et al., 2008). In our current study, Steamed *Hibiscus sabdariffa L.* calyx samples were subjected to vacuum drying with different conditions (25^{o}C in -1.0 bar; 30^{o}C in -0.8 bar; 35^{o}C in -0.6 bar; 40^{o}C in -0.4 bar; 45^{o}C in -0.2 bar). Our results revealed that vacuum drying at 35^{o}C under -0.6 bar was adequate for drying of this herb (see table 2). In one report, foam mat drying increased the drying rate significantly and retained the antioxidant activity and colour of roselle calyces extract. Shorter drying time was achieved when higher air temperature and/or lower relative humidity was used. Foam mat drying produced dried brilliant red roselle calyces extract with better antioxidant activity and colour qualities when compared with non-foam mat drying (Mohamad et al., 2018). Oven-drying at 60^{o}C resulted in calyces with significantly lower moisture content (6.97%), but higher fat (2.88%), ash (5.80%) and carbohydrate (62.46%) compared to sun at 34.9°C, solar at 56.5°C (Amoasah et al., 2018). In another report, the drying at 80◦C produced the dried roselle with the highest retention of total phenolic, antioxidant capacity, and the highest sensory quality (Quang and Hoang, 2020).

Effect of roasting to ascorbic acid,total phenolic, total flavonoid and overall acceptance of dry roasted roselle(*Hibiscus sabdariffa*L.*)* tea calyx

Roasting was widely used in herb-processing to prevent exaggerated pharmacological actions, alleviate side effects, modify energy properties, mask disagree Normally there are three degrees of roasting evaluated by the color in appearance

and/or odor of a specific herb: roasting till yellow, till charred, and till carbonized (Xu et al., 2018).

Table 1: Effect of steaming to the ascorbic acid,total phenolic, total flavonoid and overall acceptance in the steamed roselle(*Hibiscus sabdariffa*L.) calyx

Steaming	125ºC in 10 seconds	120ºC in 20 seconds	115ºC in 30 seconds	110ºC in 40 seconds	105ºC in 50 seconds
Ascorbic acid (mg/100g)	9.35±0.02^{c}	9.85±0.00^{b}	10.42±0.01^{a}	10.05±0.03^{ab}	9.61±0.02^{bc}
Total phenolic (mg GAE/g)	40.37±0.03^{bc}	45.21±0.02^{ab}	48.63±0.03^{a}	43.15±0.00^{b}	38.59±0.01^{c}
Total flavonoid (mg GE/g)	14.01±0.01^{bc}	14.92±0.03^{ab}	15.48±0.02^{a}	14.27±0.01^{b}	13.89±0.03^{c}
Overall acceptance	5.92±0.00^{bc}	6.11±0.01^{ab}	6.25±0.00^{a}	6.03±0.02^{b}	5.79±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 = 5%).

Table 2: Effect of vacuum drying to the ascorbic acid,total phenolic, total flavonoid and overall acceptance in dried *Hibiscussabdariffa L.* calyx

Vacuum drying	25ºC, -1.0 bar	30ºC, -0.8 bar	35ºC, -0.6 bar	40ºC, -0.4 bar	45ºC, -0.2 bar
Ascorbic acid (mg/100g)	10.42±0.01^{c}	10.73±0.03^{b}	11.19±0.02^{a}	10.98±0.01^{ab}	10.64±0.02^{bc}
Total phenolic (mg GAE/g)	48.63±0.03^{c}	49.05±0.00^{bc}	49.69±0.03^{a}	49.24±0.02^{ab}	49.12±0.03^{b}
Total flavonoid (mg GE/g)	15.48±0.02^{c}	15.63±0.02^{bc}	16.06±0.01^{a}	15.95±0.00^{ab}	15.87±0.00^{b}
Overall acceptance	6.25±0.00^{c}	6.49±0.01^{bc}	7.46±0.00^{a}	7.19±0.01^{ab}	6.93±0.02^{b}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 3: Effect of roasting to total phenolic, total flavonoid and overall acceptance of dry-roasted roselle herbal tea calyx

Roasting condition	125 ºC, 15 min	130 ºC, 12 min	135 ºC, 9 min	140 ºC, 6 min	145 ºC, 3 min
Ascorbic acid (mg/100g)	8.25±0.01^{c}	8.86±0.01^{b}	9.21±0.03^{a}	9.03±0.00^{ab}	8.57±0.02^{bc}
Total phenolic (mg GAE/g)	41.27±0.02^{d}	42.56±0.00^{b}	43.83±0.01^{a}	42.19±0.03^{bc}	42.04±0.00^{c}
Total flavonoid (mg GE/g)	12.49±0.00^{d}	13.75±0.03^{b}	15.28±0.02^{a}	13.31±0.01^{bc}	13.05±0.02^{c}
Overall acceptance	7.85±0.03^{bc}	8.13±0.02^{ab}	8.47±0.00^{a}	8.06±0.02^{b}	7.49±0.01^{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 = 5%).

In our research, dried samples were roasted under different conditions (125ºC in 15 minutes, 130ºC in 12 minutes, 135ºC in 9 minutes, 140ºC in 6 mintutes, 145ºC in 3 minutes). Our results noted that the optimal roasting condition for this herb was recorded at 140ºC in 6 mintutes (see table 3). The roselle calyces were dry processed and packaged in tea bags under conditions (Anthony and Gideon, 2015).

CONCLUSION

The roselle (*Hibiscus sabdariffa* L.) calyx is brilliant red in color due to the existence of anthocyanins. It has been used as food and herbal medicine owing to various phytochemical constituents contributing to pharmacological, nutraceutical, cosmetological and therapeutic effects. We have successfully proven different variables in the steaming, drying and roasting affecting to herbal tea production from *Hibiscus sabdariffa L.* calyx. The highest valuable ascorbic acid, phenolic and flavonoid content as well as overall acceptance in this herbal tea could be maintained effectively. *Hibiscus sabdariffa* could be a good source of active dietary constituents.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT

We acknowledge the financial support for the

publication provided by Ho Chi Minh City Open University, Vietnam

AUTHOR CONTRIBUTIONS

Minh Phuoc Nguyen arranged the experiments and also wrote the manuscript.

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