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Efficacy of Blanching and Infrared Dehydration on Phytochemical and Antioxidant Properties of the Dried *Vernonia amygdalina* Bitter Leaf Tea

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ABSTRACT

Vernonia amygdalina is a versatile plant that possesses several prophylactic and therapeutic potential with significant free radical scavenging and antioxidant activities. It's necessary to dry fresh *Vernonia amygdalina* bitter leaf into dehydrated form to extend its shelf-life for long storage. Objective of this study penetrated on the effectiveness of various processing variables such as blanching duration; infrared drying power, temperature and air velocity on total phenolic content (TPC), flavonoid content (FC), radical scavenging assay (DPPH) and ferric reducing ability of plasma (FRAP) of dried herbal tea from *Vernonia amygdalina* leaves by the infrared irradiation. The results showed that these leaves should be blanched at 25s and then being dried at power 120W, temperature 50°C with air velocity 1.4 m/s in the infrared dryer. From this study, major phytochemical and antioxidant properties such as total phenolic, flavonoid, DPPH, FRAP in the dried *Vernonia amygdalina* leaf could be preserved and maintained. Due to the advantages of the infrared irradiation, it would be an innovative approach for blanching and drying to preserve maximum valuable phytochemical and antioxidant constituents of dried *Vernonia amygdalina* leaf.

KEY WORDS: VERNONIA AMYGDALINA, BLANCHING, DRYING, INFRARED IRRADIATION, PHENOLIC, FLAVONOID, DPPH, FRAP.

INTRODUCTION

Vernonia amygdalina commonly called bitter leaf is a perennial shrub belonging to the family Asteraceae (Ijeh and Ejike, 2011). It is a perennial shrub that is widely distributed in tropical region. It's a great source of vitamins, minerals, polyphenols, alkaloids, saponins, flavonoids and steroids (Atangwho et al., 2009). This plant contains two sesquiterpene lactones: vernolide and vernodalol (Erasto et al., 2006). It is a versatile plant that possesses several prophylactic and therapeutic potential such as antidiabetic, anthelminthic, antiplasmodial, antimicrobial, antioxidant, antianaemic, immunomodulatory, cardiovascular properties (Atangwho et al., 2010; Saliu et al., 2012; Okolie et al., 2008; Akpaso et al., 2011; Ademola et al., 2011; Abay et al., 2015; Zofou et al., 2011; Omolola et al., 2013; Adesanoye et al., 2014; Oyeyemi et al., 2015; Momoh et al., 2012; Ezeonu et al., 2016; Abdulmalik et al., 2016). It is popularly consumed as a vegetable and is used for medicinal purposes such as to cure yellow fever, dysentry, constipation, malaria and stomach ache (Adegbite et al., 2009; Ebong et al., 2008, Suleiman et al., 2018).

In dehydration, the water content is decreased to a certain level where microbial proliferation will not happen while preserving the highest proximate composition. Medicinal and aromatic herbs are mostly maintained by air drying.

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Dehydrated products can be kept for a long storage and can be easily blended, powdered or packed for specific application or for deeper processing in the food or pharmaceutical purposes (Albert and Joachim, 2007). Infrared drying reveals several advantages compared to traditional drying. Infrared heating is faster than convective drying (Nowak & Lewicki, 2005). Infrared energy is transferred from the heating element to the sample, heating the material more rapidly and uniformly. Much more moisture emits from the irradiated surface and drying duration is shortened (Nowak & Lewicki, 2004). The leaf drying technique involves reducing moisture content of leaves to a point at which biochemical changes are limited while maintaining cell structure, pigment content and overall appearance (Singh and Dhaduk, 2005, Zaharaddeen and Samuel, 2019).

There are several notable studies mentioned to drying of *Vernonia amygdalina* species. The drying behavior of *Vernonia amygdalina* leaves was investigated using open sun and shade drying. Open sun drying resulted in severe deformity of the leaf morphology which may lead to degradation of the phytochemicals (Oluwaseun et al., 2018). The effect of air, sun, oven and solar drying methods on the organic and dietary elemental composition of *Vernonia amygdalina* leaves was evaluated. Drying improved the concentration of both organic and dietary elemental components (Zaharaddeen and Samuel, 2019). Objective of this present study focused on the effectiveness of blanching, infrared drying power, temperature and velocity on total phenolic, flavonoid, DPPH, FRAP of dried herbal tea from *Vernonia amygdalina* leaves under the infrared irradiation.

MATERIAL AND METHODS

Vernonia amygdalina leaves were collected from Soc Trang province, Vietnam. After collecting, they must be kept in cool and dry cotton box, conveyed to laboratory for experiments. They were subjected to the blanching and infrared dehydration under different conditions. All standards and reagents such as Folin-Ciocalteu reagent, Na_2CO_3, gallic acid, $Al(NO_3)3$, potassium acetate, DPPH, methanol, ethanol, acetate buffer, 2,4,6- tripyridyl-s-triazine, HCl , $FeCl_3.6H_2O$ were analytical grade and purchased from Sigma-Aldrich. Lab utensils and equipments included weight balance, blender, infrared dryer, spectrophotometer.

Effect of blanching duration (s) to phytochemical and antioxidant properties of *Vernonia amygdalina* leaf: Raw *Vernonia amygdalina* leaves were blanched at 100oC in different duration (15, 20, 25, 30, 35s). After being blanching, these blanched leaves would be would be dried by infrared dryer with drying power 40W at temperature 40oC with air velocity 0.8 m/s. The dried samples were analyzed the total phenolic (mg GAE/100 g), flavonoid (mg QE/100 g), DPPH (%) and FRAP (mM TE/100g).

Effect of infrared drying power (W) to the phytochemical and antioxidant properties of dried *Vernonia amygdalina* leaf: After finding the optimal blanching condition, these blanched leaves would be dried by infrared dryer under different powers (40, 80, 120, 160, 200 W) at temperature 40oC with air velocity 0.8 m/s. After this experiment, the dried leaves would be analyzed the total phenolic (mg GAE/100 g), flavonoid (mg QE/100 g), DPPH (%) and FRAP (mM TE/100g).

Effect of infrared drying temperature (^{o}C) to the phytochemical and antioxidant properties of dried *Vernonia amygdalina* leaf: By selecting the optimal steaming time and drying power, these blanched leaves would be dried by infrared dryer under power 120 W at different temperature (40, 45, 50, 55, 60^{o}C) with air velocity 0.8 m/s. After this experiment, the dried leaves would be analyzed the total phenolic (mg GAE/100 g), flavonoid (mg QE/100 g), DPPH (%) and FRAP (mM TE/100g).

Effect of infrared drying air velocity (m/s) to the phytochemical and antioxidant properties of dried *Vernonia amygdalina* leaf: By selecting the optimal steaming time, drying power and drying temperature, these blanched leaves would be dried by infrared dryer under power 120 W at temperature 50oC with different air velocity values (0.8, 1.0, 1.2, 1.4, 1.6 m/s). After this experiment, the dried leaves would be analyzed the total phenolic (mg GAE/100 g), flavonoid (mg QE/100 g), DPPH (%) and FRAP (mM TE/100g).

Phytochemical and antioxidant estimation: Total phenolic content (mg GAE/100g) was evaluated using Folin–Ciocalteu assay (Nizar et al., 2014). Total flavonoid content (mg QE/100g) was evaluated by the aluminium calorimetric method (Formagio et al., 2015). The antioxidant activity was evaluated using DPPH (%) radical scavenging assay which was described by Huang et al. (2005). FRAP (mM TE/100g). FRAP (mM TE/100g) were performed according to Ivanov et al. (2014).

Statistical analysis: The experiments were run in triplicate with three different lots of samples. The data were presented as mean±standard deviation. Statistical analysis was performed by the Statgraphics Centurion version XVI.

RESULTS AND DISCUSSION

Effect of blanching time (s) to the phytochemical and antioxidant properties of *Vernonia amygdalina* leaf: Blanching is an important step before drying of herbal materials to inactivate enzymes that cause browning and loss of bioactive constituents. Raw *Vernonia amygdalina* leaves were blanched by hot water at 100^{o}C in different durations (15, 20, 25, 30, 35s). After being blanching, these blanched leaves would be would be dried by infrared dryer with drying power 40W at temperature 40^{o}C in air velocity 0.8 m/s. Results are presented in table 1.

It's clearly noticed that 25s in blanching was adequate to maintain the highest amount of total phenolic, flavonoid, DPPH and FRAP. So this value was selected for further experiments. Omede et al. (2018) evaluated the antioxidant activity and cytotoxic properties of *Vernonia amygdalina*. They confirmed that the extracts possessed very low cytotoxicity (IC50 = 1.83 mg/ml), high total phenolic content (158.8 mg GAE/100g), total flavonoid (85.7 mg QE/100g).

Table 1. Effect of blanching time (s) to the phytochemical and antioxidant properties of *Vernonia amygdalina* leaf

Blanching duration (s)	15	20	25	30	35
Total phenolic (mg GAE/100g)	24.51±0.02[b]	26.30±0.01[ab]	29.47±0.02[a]	22.79±0.03[bc]	20.05±0.01[c]
Total flavonoid (mg QE/100g)	10.73±0.01[b]	12.64±0.00[ab]	14.55±0.03[a]	9.17±0.01[bc]	7.32±0.00[c]
DPPH (%)	31.50±0.00[c]	33.79±0.03[b]	36.04±0.01[a]	34.83±0.00[ab]	32.65±0.02[bc]
FRAP (mM TE/100g)	11.74±0.02[c]	13.01±0.01[b]	15.48±0.00[a]	14.84±0.02[ab]	12.36±0.03[bc]

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%).

Effect of infrared drying power (W) to the phytochemical and antioxidant properties of dried *Vernonia amygdalina* leaf: Drying can lead to considerable loss of the available bioactive components due to thermal degradation depending on the drying method and temperature conditions (Naomi et al., 2018).

They proved that total phenolic content, antioxidant capacity were significantly affected by drying method and drying temperature. By finding the optimal blanching condition, these blanched leaves would be dried by infrared dryer under different powers (40, 80, 120, 160, 200 W) at temperature 40°C with air velocity 0.8 m/s. Our results were presented in table 2. It's clearly noted that the optimal infrared drying power should be 160 W to preserve the best phytochemical and antioxidant attributes of dried *Vernonia amygdalina* leaf. So this value was selected for further experiments.

Table 2. Effect of infrared drying power (W) to the phytochemical and antioxidant properties of dried *Vernonia amygdalina* leaf

Drying power (W)	40	80	120	160	200
Total phenolic (mg GAE/100g)	29.47±0.02[c]	33.49±0.03[bc]	38.64±0.01[a]	36.12±0.00[ab]	34.41±0.03[b]
Total flavonoid (mg QE/100g)	14.55±0.03[c]	15.74±0.01[bc]	17.63±0.03[a]	17.05±0.02[ab]	16.54±0.00[b]
DPPH (%)	36.04±0.01[bc]	38.61±0.00[ab]	40.82±0.02[a]	37.53±0.01[b]	33.71±0.02[c]
FRAP (mM TE/100g)	15.48±0.00[c]	17.01±0.02[b]	19.26±0.00[a]	18.95±0.03[ab]	16.58±0.01[bc]

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%).

Effect of infrared drying temperature (°C) the phytochemical and antioxidant properties of dried *Vernonia amygdalina* leaf: Infrared irradiation has potential for drying herbs because it is gentle and shortens the processing duration. The leaf drying is an important post-harvest strategy for improving product quality as well as providing added value. By selecting the optimal steaming time and drying power, these blanched leaves would be dried by infrared dryer under power 120W at different temperature (40, 45, 50, 55, 60°C) with air velocity 0.8 m/s.

Our results are shown in table 3. The optimal drying temperature was recorded at 50°C to preserve the best phytochemical and antioxidant attributes of dried *Vernonia amygdalina* leaf so we choose this value for further experiments. In one report, Oluwaseun et al. (2018) proved that shade drying was the better way of drying *V. amygdalina* leaves to preserve the nutrients compared to open sun drying.

Table 3. Effect of infrared drying temperature (oC) to the phytochemical and antioxidant properties of dried *Vernonia amygdalina* leaf

Drying temperature (oC)	40	45	50	55	60
Total phenolic (mg GAE/100g)	38.64±0.01[c]	39.14±0.03[bc]	40.53±0.02[a]	40.09±0.03[ab]	39.64±0.00[b]
Total flavonoid (mg QE/100g)	17.63±0.03[c]	18.25±0.01[bc]	19.78±0.00[a]	19.33±0.01[ab]	18.96±0.03[b]
DPPH (%)	40.82±0.02[c]	41.98±0.00[ab]	42.56±0.01[a]	41.32±0.02[b]	41.07±0.00[bc]
FRAP (mM TE/100g)	19.26±0.00[c]	20.76±0.02[bc]	21.83±0.03[a]	21.35±0.00[ab]	21.01±0.01[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%).

Effect of infrared drying air velocity (m/s) the phytochemical and antioxidant properties of dried *Vernonia amygdalina* leaf: By selecting the optimal steaming time, drying power and drying temperature, these blanched leaves would be dried by infrared dryer under power 12 W at temperature 50oC with different air velocity values (0.8, 1.0, 1.2, 1.4, 1.6 m/s). Our results are shown in table 4.

Table 4. Effect of air drying velocity (m/s) to the phytochemical and antioxidant properties of dried *Vernonia amygdalina* leaf.

Air drying velocity (m/s)	0.8	1.0	1.2	1.4	1.6
Total phenolic (mg GAE/100g)	40.53±0.02[b]	40.98±0.01[ab]	41.25±0.03[ab]	41.39±0.00[a]	41.43±0.01[a]
Total flavonoid (mg QE/100g)	19.78±0.00[b]	20.03±0.03[ab]	20.27±0.01[ab]	20.88±0.02[a]	20.91±0.03[a]
DPPH (%)	42.56±0.01[b]	42.88±0.02[ab]	42.97±0.00[ab]	43.31±0.03[a]	43.36±0.02[a]
FRAP (mM TE/100g)	21.83±0.03[b]	22.01±0.00[ab]	22.34±0.02[ab]	22.65±0.00[a]	22.69±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 = 5%)

The optimal air velocity was recorded at 1.4 m/s to preserve the best phytochemical and antioxidant attributes of dried *Vernonia amygdalina* leaf so we choose this value for application. In one study, Zaharaddeen and Samuel (2019) proved that oven–solar drying method could be useful in preserving *Vernonia amygdalina* leaves in a more hygienic way and ensure its all-the-year round availability and possibly elimination of most nutrient deficiencies.

CONCLUSION

V. amygdalina contains numerous phytochemical constituents associating with its potent pharmacological properties to treat various ailments. We have successfully examined different technical variables influencing to the blanching and drying process of *Vernonia amygdalina* leaf. Due to low moisture content, these dried leaves can be kept in ambient environment for longer periods without losing their appearance and pharmaceutical value. *V. amygdalina* would be a safe potential source of natural antioxidant agent as a functional food.

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