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INFLUENCE OF DRYING ON THE ANTIOXIDANT PROPERTIES AND SENSORY EVALUATION OF TWO UNDERUTILIZED VEGETABLES

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Abstract
Netlespurge (Jatropha tanjorensis) and black nightshade (Solanum nigrium) vegetables were evaluated based on their antioxidative and sensory properties. Freshly harvested vegetable leaves were blanched and dried (sun, oven at 50 and 60 °C). The total phenolic content (TPC), DPPH (2, 2-diphenyl-2-picrylhydrazyl hydrate), ferric reducing antioxidant power (FRAP), metal chelating assay (MCA) were determined by extraction method. Different vegetable soups were prepared for assessment by panelists. Higher drying temperature lowered the TPC, DPPH, FRAP and MCA. TPC ranged from 0.088 to 0.339 and 0.087 to 0.691 mgGAE/g extract of sample, FRAP ranged from 0.64 to 0.66 and 0.06 to 0.26 mgAAE/g sample, DPPH ranged from 44.28 to 69.98% and 86.01 to 90.05%, MCA ranged from 48.16 to 64.88% and 46.11 to 64.01% respectively for both netlespurge and black nightshade vegetables. Blanching lowered the antioxidative power of the vegetables with a minimum of 5%, 0.05%, 0.44% and 9.08% for TPC, FRAP, DPPH and MCA respectively. Vegetable soups prepared were well accepted by the panelists as shown by the scores recorded that were higher than average on a nine-point hedonic scale. Blanching affected the acceptability of the soups, this might be due colour been preserved by blanching as against unblanched leaves. Drying temperature also affected the acceptability of soups.

Keywords: *Jatropha tanjorensis*, *Solanum nigrium*, blanching, drying, antioxidant and sensory evaluation

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1. INTRODUCTION

In recent times, supposed deficiencies in orthodox pharmacotheraphy have been catered for by herbal prescriptions worldwide (Arika *et al*., 2015). Based on the report of World Health Organization (WHO), for both underdeveloped and developing countries, about 80% populations depend on these herbal prescriptions for their immediate health needs (W.H.O., 2002). According to Nyamai *et al*. (2016), the presence of phytochemicals (alkaloids, flavonoids, tannins, phenolic acids, saponins, etc) in these medicinal plants could have been responsible for their therapeutic effects. As secondary metabolites, they offer numerous health aids to humans. They function as synergistic agents, permitting efficient usage of nutrients by the body (Andre *et al.,* 2010). They have easy accessibility and function as antimicrobial, antioxidative, antineoplastic properties, detoxification enzymes, immune system stimulant (Andre *et al.,* 2010).

Leafy vegetables have been reported to have high medicinal values. They are necessary for maintaining and promoting healthy body weight because they are low in calorie, carbohydrate as well as glycemic index, but are high in fiber (Chadha, 2003). They also aid in decreasing type II diabetes. Obe-Lawson (2005) reported that adequate intake of leafy vegetables could alleviate the prevalence of hunger and malnourishment. Consumption of green leafy vegetables will additionally enrich the nutritional status of both meager rural and urban families (Chadha, 2003) who may not be in a situation to eat satisfactory vegetables owning to affordability. There will also be crop diversity, poverty alleviation and food security (Barry *et al*., 2008).
Netlespurge vegetable (*Jatropha tanjorensis*), a lesser-known vegetable has been reported to delay the onset of degenerative diseases thereby functioning as an antioxidant (Ezengige, 2017). Because of its hypoglycemic action, it is used in treating diabetes mellitus. It has been long used as malaria cure; there have been cases of people

using it as preventive measure to manage their hypertensive status and it also supports spermatogenesis (Ezengige, 2017). Black nightshade vegetable (*Solanum nigrium)* is a neglected medicinal rich vegetable. It has been used in treating people with sickness such as fever, dysentery, mouth ulcer, asthma and stomach disorders (Jian *et al*., 2008). It is an extensively employed plant due to its antipyretic, diuretic, antitumorigenic, antioxidant, hepatoprotective and anti-inflammatory properties (Jain *et al*., 2011).
Antioxidants as chemical constituents provide electron to the free radical and change it to an inoffensive molecule (Olayinka *et al*., 2012). They can either be naturally produced or externally provided from food supplements (Alin and Hakkarainen, 2011; Finley *et al*., 2011). The externally produced antioxidants are sourced from food items that are rich in antioxidant substances like vitamins A, C, E, minerals, polyphenols, phytochemicals (Goodarzi *et al.,* 2018). Antioxidants function via different mechanisms, these are explicably defined viz; total phenolic content, metal chelation, ferric reducing antioxidant power and DPPH (2, 2-diphenyl-2-picrylhydrazyl hydrate). The objective of this work is to determine the antioxidant properties and the sensory acceptability of these underutilized vegetables with a view to expanding their utilizations.

2. MATERIAL AND METHODS

Netlespurge (*Jatropha tanjorensis*) vegetable was harvested from Obafemi Awolowo University Teaching and Research Farm, Ile-Ife, Nigeria. Black nightshade (*Solanum nigrium*) vegetable was bought in situ from a farmer in Ile-Ife, Nigeria. Palm oil, pepper, melon, onion, salt and stock fish were obtained from retail outlets in Ile-Ife. All chemicals used were of analytical grade.

Sample Preparation

Netlespurge and black nightshade samples were prepared according to the modified method of Laura and Constance (2014). Freshly harvested vegetable leaves of (*Jatropha tanjorensis*) and (*Solanum nigrium*) were washed, destalked, and sliced using a sharp kitchen knife. Each vegetable type was then separated into two equal portions; one portion was blanched in water at 100 °C for 60 sec while the second portion was not blanched. This step was followed by different drying techniques: sun and oven. Sun drying processes were carried out from 9 am to 5 pm when the sun's insolation was high. They were also dried in the oven (Gallenhamp oven, Model OV-420, England) at the selected temperatures (50 and 60 ^{0}C).

Determination of antioxidant properties

Determination of total phenolic content was carried out using Folin-Ciocalteu's phenol reagent reaction as described by Singleton *et al*. (1999).
The radical scavenging ability of the vegetable samples were determined using the stable radical DPPH (2, 2-diphenyl-2-picrylhydrazyl hydrate) as described by Pownall *et al*. (2010).
The principle of FRAP method was based on the reduction of a colourless ferric tripyridyltriazine complex to its blue ferrous coloured form due to the donation of electron by antioxidant compounds. The ferric reducing antioxidant power (FRAP) assay was carried out according to the method of Benzie and strain (1999).
The metal-chelating assay of the samples was carried out according to the method of Singh and Rajini (2004).

Preparation of vegetable soups and their sensory evaluation

The soup was prepared according to the modified recipe of Nnamezie *et al*. (2019). The dried vegetable samples were each rehydrated using 20.00 mL of water at 100 ºC for 15 min, the vegetables were drained using sieve. Palm oil was poured in a dried pot on fire, melon already mixed with water was fried in the palm oil, ingredients (pepper, onion and crayfish) already blended were added after which maggi and salt were included. Vegetable samples were lastly added, left to simmer and then packed.
Sensory evaluation was carried out according to the method of Nupo *et al.* (2013). Ten (10) semi trained panelists were given the prepared vegetables for assessment. The panelists were

asked to score each sample on a nine-point hedonic scale, where 1 and 9 represent dislike extremely and like extremely respectively. Each sample was assessed for its sensory qualities such as colour, texture, aroma, taste and overall acceptability.

Statistical Analysis

All analyses were done in triplicate and data obtained were subjected to appropriate statistical analyses. Microsoft Excel 2010 was used for analyzing the raw data. SPSS 16.0 was used for the data grading.

3.RESULTS AND DISCUSSIONS

Antioxidant properties

These vegetables contains considerably quantities of the antioxidant assays determined (Table 2). The total phenolic content of netlespurge (*Jatropha tanjorensis)* vegetable ranged from 0.088 to 0.339 mgGAE/g extract of sample. Black Nightshade (*Solanum nigrium*) vegetable ranged from 0.087 to 0.691 mgGAE/g extract of sample. These values are lower than those reported by Bamidele *et al.* (2017) for selected green leafy vegetables and the results of Siti *et al.* (2018) on *Ocimum basilicum* leaves. These variations in the total phenolic content of vegetables would be due to genetic and environmental factors (Tomas-Barberan and Espin, 2001). Blanching reduced the TPC value of samples as unblanched samples are higher in TPC (values) than the blanched samples (values). This agrees with reports of many authors: Fletcher and Hunter (2002) and Amin *et al.* (2006). Olayinka *et al.* (2012) suggested that the reduction of TPC might be due to leaching during blanching. Francisco *et al.* (2010) however stated that the leaching is due to the disruption of the cell wall of the plant. Exposure to intense heat affected the TPC of the samples. Olayinka *et al.* (2012) reported that temperature and time are two critical factors that affect the antioxidant properties. According to Petti and Scully (2009), phenolic contents are plant metabolites possessing numerous phenol groups, which are highly active in donating electrons to form compounds with free electrons. They inhibit lipid peroxidation by scavenging free radicals such as hydroxyl radicals (OH) and peroxyl radicals (ROO) resulting in the formation of low energy phenolic radicals whose energy is not sufficient to promote lipid oxidation at biologically significant rates (Decker, 2002).

Netlespurge vegetable had FRAP values in the range 0.64 to 0.66 mgAAE/g sample while black nightshade vegetable had values ranged from 0.06 to 0.26 mgAAE/g. The FRAP of these vegetables falls within the range of selected Chinese medicinal plants reported by Feng-Lin *et al.* (2010). Unblanched samples had higher FRAP values than the blanched samples. Blanching has been reported to reduce FRAP by Galoburda *et al.* (2012), Amin *et al.* (2006) reported a 50 % decrease in antioxidant activity of leafy vegetables due to blanching. Oven-dried samples had higher FRAP values than the sun-dried samples. Ferric reducing antioxidant power is based on the reduction of Fe^{3+} (ferricyanide complex) to Fe^{2+} in the presence of reductants (antioxidants). According to Ogunmoyole *et al.* (2009), the ability of substances to reduce ferric to ferrous is considered a defense mechanism due to its ability to donate electron or hydrogen atom to stabilize free radicals or oxidants.

The DPPH values of netlespurge vegetable ranged from 44.28 to 69.98%, that of black nightshade vegetable ranged from 86.01 to 90.05%. These values were lower than those recorded by Arun and Brindha (2012) for ethanolic extract of 100 µg/mg (87.6%) of Netlespurge. Blanched samples had lower DPPH values than the unblanched samples. Galoburda *et al.* (2012) also reported that blanching reduced the DPPH effect of dried dills. Drying temperature affected the DPPH values of samples. Samples oven-dried at 50 ºC had the highest DPPH, followed by samples oven-dried at 60 ºC while sun-dried samples had the least DPPH values. The result of Babalola and Taiwo (2019) on cardaba banana and plantain flour samples agreed with this result of this work that higher drying temperature with shorter drying time reduced DPPH. Mrkic *et al.*

(2006) stated that drying temperature-time combination could damage bioactive compounds. DPPH is a stable free radical mostly utilized in examining the antioxidant activities of materials (Olagunju *et al*., 2018). It measures the extent of free scavenging abilities of food samples through the donation of ions to the free radical thereby inhibiting the chain reactions that could cause oxidative deterioration (Charoensiri *et al.,* 2009).
The MCA of Netlespurge vegetable ranged from 48.16 to 64.88% while that of black nightshade vegetable ranged from 46.11 to 64.01%. It was observed that blanching reduced the chelating abilities of samples and the temperature of drying did not significantly ($p > 0.05$) affect the chelating abilities. Chelating ability measures the effectiveness of a compound to compete with ferrozine for ferrous ion. It chelates this to prevent reactive oxygen species (ROS) formation (Singh and Rajini, 2004).

Sensory evaluation of vegetable soups

Vegetable soups prepared from netlespurge vegetable scored between 6.2 and 6.7 in terms of appearance while the control soup scored 8.0, 5.6 to 6.7 in terms of colour while the control soup scored 8.1 (Table 3). Soups from unblanched dried vegetable leaves were preferred to soups from blanched leaves, this might be due to the appearance/colour preserved by blanching. Also, soups from sun-dried leaves were preferred to soups from oven-dried leaves. Vegetable soups prepared from black nightshade vegetable scored between 5.0 and 6.6 in terms of appearance while the control soup scored 7.8, 5.5 to 6.6 in terms of colour while the control soup scored 8.0. Soups from blanched dried leaves were preferred to soups from unblanched leaves. Also, soups from sun-dried leaves were preferred to soups from oven-dried leaves. The scores were above 5 points on a 9-point hedonic scale, indicating that they were on the average accepted based on colour/appearance. However, the soups were not well accepted as the control soups scored higher than the sample soups.
Netlespurge vegetable scored between 6.1 and 6.8 while control soup scored 7.9 based on chewiness. Black nightshade vegetable scored between 6.1 and 6.5 while control scored 8.0. Soups from blanched oven-dried slices were preferred to soups from unblanched sun-dried slices. Netlespurge vegetable scored between 5.6 and 6.4 while control soup scored 8.5 based on flavour. Black nightshade vegetable scored between 5.6 and 6.5 while control scored 7.5. Soups from blanched oven-dried leaves were preferred to soups from unblanched sun-dried leaves. Netlespurge vegetable was scored between 5.7 and 6.7 while control soup scored 8.0. Black nightshade vegetable scored between 5.2 and 6.4 while control scored 8.0. Soups from unblanched sun-dried leaves were preferred to soups from blanched oven-dried leaves. Netlespurge vegetable scored between 5.9 and 6.5 while control soup scored 7.8. Black nightshade vegetable scored between 5.2 and 6.7 while control scored 7.5. Soups from blanched sun-dried leaves were preferred to soups from unblanched oven-dried leaves.

4. CONCLUSION

Blanching as well as higher drying temperature lowered the TPC, DPPH, FRAP, MCA and Ascorbic acid content of the vegetables. On sensorial assessment, scores were above 5 points on a 9-point hedonic scale, indicating that they were averagely accepted, although, the control soups scored higher than the sample soups.The study concluded that both netlespurge (*Jatropha tanjorensis*) and black nightshade (*Solanum nigrium*) vegetables can be preserved by drying, are good sources of phytochemicals and nutrients and as such be consumed as soups.

Table 1: Vegetable Soup Recipe

Ingredient	Quantity (g)
Vegetable sample	6.0
Melon	30.0
Palm oil	114.0
Pepper	23.0
Onion	5.0
Crayfish	1.0
Maggi	2.0
Salt	0.2

Table 2: Antioxidant properties of vegetable flours

Sample	TPC(mgGAE/g extract)	FRAP (mgAAE/g sample)	DPPH (%)	MCA (%)
USI	0.0851 ± 0.00^{d}	0.6449 ± 0.00^{a}	53.2507 ± 1.85^{f}	54.0269 ± 0.83^{d}
BSI	0.0523 ± 0.00^{f}	0.6446 ± 0.00^{a}	45.7517 ± 1.99^{g}	49.1220 ± 0.88^{f}
ULI	0.1261 ± 0.00^{a}	0.6549 ± 0.01^{a}	67.8758 ± 1.55^{c}	63.8274 ± 0.92^{a}
BLI	0.0897 ± 0.00^{c}	0.6466 ± 0.00^{a}	60.8145 ± 1.02^{e}	53.0482 ± 0.52^{d}
UHI	0.1051 ± 0.00^{b}	0.6500 ± 0.01^{a}	65.7167 ± 1.62^{d}	59.6989 ± 0.44^{c}
BHI	0.0664 ± 0.00^{e}	0.6470 ± 0.00^{a}	60.0614 ± 1.32^{e}	51.0216 ± 0.82^{e}
USO	0.0380 ± 0.00^{k}	0.1280 ± 0.01^{d}	86.6499 ± 0.56^{b}	60.3932 ± 0.57^{c}
BSO	0.0343 ± 0.00^{l}	0.0612 ± 0.00^{f}	86.2695 ± 0.26^{b}	47.3167 ± 1.07^{g}
ULO	0.0524 ± 0.00^{f}	0.2491 ± 0.00^{b}	89.9376 ± 0.10^{a}	64.0079 ± 0.01^{a}
BLO	0.0497 ± 0.00^{h}	0.1718 ± 0.00^{c}	87.9746 ± 0.55^{bc}	53.1256 ± 1.48^{d}
UHO	0.0453 ± 0.00^{i}	0.1887 ± 0.02^{c}	88.3620 ± 0.46^{bc}	62.2234 ± 0.32^{b}
BHO	0.0411 ± 0.00^{j}	0.0882 ± 0.00^{e}	87.0875 ± 0.17^{b}	51.2856 ± 0.37^{e}

Values reported are means ± standard deviation of triplicate determinations. Mean values with different superscript within same column are significantly ($p < 0.05$) different.

Key:

USI: Unblanched sun-dried *"Iyana Ipaja"* (*Jatropha tanjorensis*), BSI: Blanched sun-dried *"Iyana Ipaja"* (*Jatropha tanjorensis*) ULI: Unblanched *"Iyana Ipaja"* (*Jatropha tanjorensis*) oven-dried at 50 ˚C, BLI: Blanched *"Iyana Ipaja"* (*Jatropha tanjorensis*) oven-dried at 50 ˚C , UHI: Unblanched *"Iyana Ipaja"* (*Jatropha tanjorensis*) oven-dried at 60 ˚C, BHI: Blanched *"Iyana Ipaja"* (*Jatropha tanjorensis*) oven-dried at 60 ˚C, USO: Unblanched sun-dried "*Odu*" (*Solanum nigrium*), BSO: Blanched sun-dried "*Odu*" (*Solanum nigrium*), ULO: Unblanched "*Odu*" (*Solanum nigrium*) oven-dried at 50 ˚C, BLO: Blanched "*Odu*" (*Solanum nigrium*) oven-dried at 50 ˚C, UHO: Unblanched "*Odu*" (*Solanum nigrium*) oven-dried at 60 ˚C, BHO: Blanched "*Odu*" (*Solanum nigrium*) oven-dried at 60 ˚C

Table 3: Sensory Evaluation of Soup from Netlespurge and Black nightshade Vegetables

Sample	Appearance	Chewiness	Flavour	Taste	Overall impression
Control	8.0 ± 0.94^{a}	7.9 ± 0.99^{a}	8.5 ± 0.53a	8.0 ± 0.94^{a}	7.8 ± 0.92^{a}
USI	6.7 ± 1.27^{a}	6.1 ± 1.76^{b}	5.6 ± 0.67^{b}	6.7 ± 1.01^{ab}	6.5 ± 0.93^{ab}
BSI	6.6 ± 0.92^{a}	6.3 ± 1.35^{b}	6.0 ± 1.04^{b}	6.3 ± 1.74^{b}	6.5 ± 0.69^{ab}
ULI	6.4 ± 1.43^{b}	6.4 ± 1.69^{b}	6.1 ± 1.57^{b}	6.2 ± 1.21^{b}	6.0 ± 1.67^{b}
BLI	6.2 ± 1.76^{b}	6.8 ± 0.79^{a}	6.4 ± 1.88^{b}	5.7 ± 2.23^{b}	6.2 ± 1.95^{b}
UHI	6.4 ± 2.20^{b}	6.3 ± 1.95^{b}	6.0 ± 1.26^{b}	6.5 ± 1.90^{ab}	5.9 ± 1.81^{b}
BHI	6.3 ± 1.80^{b}	6.5 ± 1.04^{b}	6.4 ± 1.95^{b}	6.0 ± 1.83^{b}	6.4 ± 2.20^{ab}
USO	6.5 ± 1.44^{a}	6.1 ± 1.04^{b}	6.2 ± 1.25^{b}	5.8 ± 1.33^{b}	6.7 ± 1.19^{ab}
BSO	6.6 ± 2.06^{a}	6.3 ± 2.49^{b}	6.5 ± 2.07^{b}	6.4 ± 1.75^{b}	6.7 ± 2.05^{ab}
ULO	5.0 ± 1.21^{b}	6.1 ± 1.43^{b}	6.0 ± 1.55^{b}	5.9 ± 1.14^{b}	6.0 ± 1.10^{bc}
BLO	5.6 ± 2.42^{b}	6.4 ± 1.58^{b}	6.1 ± 1.92^{b}	6.4 ± 2.06^{b}	6.3 ± 1.95^{bc}
UHO	5.6 ± 2.37^{b}	6.3 ± 0.77^{b}	5.6 ± 1.69^{b}	5.2 ± 1.66^{b}	5.2 ± 1.60^{c}
BHO	5.7 ± 2.41^{b}	6.5 ± 1.37^{b}	6.3 ± 0.90^{b}	6.1 ± 1.45^{b}	6.1 ± 1.70^{bc}
Control	7.8 ± 0.94^{a}	8.0 ± 0.99^{a}	7.5 ± 0.53a	8.0 ± 0.94^{a}	7.5 ± 0.92^{a}

Values reported are means ± standard deviation of triplicate determinations. Mean values with different superscript within same column are significantly ($p < 0.05$) different.

Key:

USI: Unblanched sun-dried *"Iyana Ipaja"* (*Jatropha tanjorensis*), BSI: Blanched sun-dried *"Iyana Ipaja"* (*Jatropha tanjorensis*) ULI: Unblanched *"Iyana Ipaja"* (*Jatropha tanjorensis*) oven-dried at 50 ˚C, BLI: Blanched *"Iyana Ipaja"* (*Jatropha tanjorensis*) oven-dried at 50 ˚C, UHI: Unblanched *"Iyana Ipaja"* (*Jatropha tanjorensis*) oven-dried at 60 ˚C, BHI: Blanched *"Iyana Ipaja"* (*Jatropha tanjorensis*) oven-dried at 60 ˚C, USO: Unblanched sun-dried "*Odu*" (*Solanum nigrium*), BSO: Blanched sun-dried "*Odu*" (*Solanum nigrium*), ULO: Unblanched "*Odu*" (*Solanum nigrium*) oven-dried at 50 ˚C, BLO: Blanched "*Odu*" (*Solanum nigrium*) oven-dried at 50 ˚C, UHO: Unblanched "*Odu*" (*Solanum nigrium*) oven-dried at 60 ˚C, BHO: Blanched "*Odu*" (*Solanum nigrium*) oven-dried at 60 ˚C

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