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Abstract - This study attempt to circumvent the hurdle associated with the utilization of laborious and expensive procedure to assess some health promoting properties of eggplant fruits. The feasibility of using simple and cheap procedure as a surrogate tool to gain insight into the antioxidant potentials of eggplant cultivars was evaluated. Some eggplants cultivars obtained fresh were used for the work. Extracts from the garden eggs were analysed for relative reducing power, total phenolic content and radical scavenging activity using DPPH. Physical and Sensory attributes such as foaming capacity and foaming stability respectively. Simple and cheap quality control protocol could be used as surrogate tool to gain insight into the antioxidant markers, a health promoting endowment of some eggplants.

Keywords - Eggplants, bitterness, foaming capacity, surrogate tool, antioxidant potentials.

1 INTRODUCTION

Consumption of fruits and vegetables has been shown through epidemiological studies to be health beneficial in prevention of chronic diseases (Jones, 2002; Cheel et al., 2007; Aberoumand and Deokule, 2010). This is due to its known high content of wide variety of vitamins, minerals, antioxidants, including phenolic compounds (Gull et al., 2012; Yemanu, 2013). Antioxidants derived from plants and their potential to decrease the risk of oxidative stress induced diseases are of particular interest. Consumption of at least 400 g/day of fruits and vegetables has been reported to be essential for the prevention of cardiovascular, atherosclerosis, carcinogenesis, accelerated ageing cancer, obesity and diabetes (WHO/FAO, 2003).

Eggplant fruit commonly known as garden egg is an economically important fruit originating from India and China and spread to tropical and temperate parts of the world. Eggplant is an important component of the human diet in many countries including Nigeria. It can be eaten fresh or used for soup preparation, and also used in traditional medicine for the treatment of several human disorders such as asthma, bronchitis, diabetes and arthritis (Magioli and Mansur, 2005). Eggplant belongs to the family Solanaceae with over a thousand species globally. In Nigeria, there are about 25 cultivars of eggplants comprising both domesticated and wild varieties. The fruit is well consumed in Nigeria by both rural and urban families. It forms part of sub-Saharan African culture, the fruits is said to represent blessings and fruitfulness and usually offered as a token of goodwill during marriages, visits and other social events (Eze and Kanu, 2014; Eletta et al., 2017). Eggplant fruits have great variability, with wide range of shapes (ovoid, globular, oblong, semi-long, long, serpentine), colours (green, white, violet, purple, striped, black or orange) and sizes (varies from a few grams to over one kilogram).

Eggplants are among the top ten vegetables in terms of antioxidants activities due to its content of phenols and flavonols (Singh et al., 2009; Jung et al., 2011). Eggplant extracts have been reported to be effective for curing diseases such as high blood pressure, and hepatitis due to content of anthocyanins and strychnine (Magioli and Mansur, 2005). Kandoliya et al. (2015) reported high antioxidant and nutritional components of eggplant fruits. Okmen et al. (2013) also reported substantial amount of antioxidant and phenolic content in some Turkish eggplants cultivars. Some physical and sensory attributes such as bitterness in eggplant has been related to the presence of alkaloids (Mc Gee, 2004). Eggplants have been reported to contain a rare and very beneficial antioxidant known as nasunin. Nasunin is a type of anthocyanin antioxidants found in all types of eggplant varieties in addition to other deeply coloured fruits and vegetables (Sadilova et al., 2006).

Researchers have explored the phytochemical and nutritional analysis of different cultivars of eggplants using standard laboratory procedures (Okmen et al., 2009; Kandoliya et al., 2015; Eletta et al., 2017). Although there are standard procedures for determining antioxidant content of garden eggs, however there is need for a simple but effective method to gain an insight into the antioxidant potential of garden eggs especially in rural areas where there is no facilities for chemical analysis. This work is therefore aimed at determination of the antioxidants and sensory attributes of some eggplants cultivars and to establish a correlation between them with a view to use sensory attributes as surrogate for assessing antioxidant potential of six eggplant cultivars.

2 MATERIALS AND METHODS

2.1 PROCUREMENT OF EGGPLANT SAMPLES

The six different varieties of eggplants used for this work were procured fresh from the local market in Ado Ekiti, Ekiti State, Nigeria. Table 1 shows the sample name and description of each eggplant variety used in this study.
Table 1. Sample Name and Description of Eggplant Samples

<table>
<thead>
<tr>
<th>Sample Name</th>
<th>Fruit description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solanum melongena var 1</td>
<td>Purple, big and oblong</td>
</tr>
<tr>
<td>Solanum melongena var 2</td>
<td>White, big and oblong</td>
</tr>
<tr>
<td>Solanum macrocapon</td>
<td>White and round</td>
</tr>
<tr>
<td>Solanum gilo</td>
<td>Green and white, round</td>
</tr>
<tr>
<td>Solanum aethiopicum</td>
<td>Green and round</td>
</tr>
<tr>
<td>Solanum anguivi</td>
<td>Green, small, round</td>
</tr>
</tbody>
</table>

2.2 PREPARATION OF EGGPLANT EXTRACT

Five gram of each fresh eggplant was weighed and blended with 50 ml of distilled water using a blender for 2 mins; the suspension was filtered through a whatman No 1 filter paper. The extract filtered was stored under refrigeration conditions prior to further analysis.

2.3 DETERMINATION OF TOTAL PHENOLIC CONTENT

Total Phenolic Content (TPC) of the extracts was determined according to the method of Gutfinger (1981). About 1 ml of each eggplant extract with concentration of 1 mg/ml was mixed with 1 ml of 2% sodium carbonate followed by standing for 3 min. And then 0.2 ml of 50% Folin-Ciocalteau reagent was added to the mixture. After standing for 30 min, the mixture was centrifuged at 13,400 × g for 5 min. The absorbance was measured at 750 nm wavelength using UV Spectrophotometer (INESA 752N UV-VIS) and the measurement was compared to a standard curve of prepared gallic acid solutions. TPC was expressed as gallic acid equivalents (GAE)/g sample.

2.4 DETERMINATION OF RELATIVE REDUCING POWER

The reducing power of each extract was determined according to the method of Oyaizu (1986). To 1 ml of the eggplant, 1.0 ml of sodium phosphate buffer (0.2 M, pH 6.6), and 1.0 ml of potassium ferricyanide (10 mg/ml) were mixed and incubated at 50°C for 20 min. Then, 1.0 ml of 10% TCA (trichloroacetic acid) was added to the mixture and centrifuged at 13,400 × g for 5 min. 1 ml of supernatant was mixed with 1.0 ml of H2O and 0.1 ml of 0.1% ferric chloride, and then the absorbance was measured at 700 nm. A standard curve was prepared by using known concentration of aqueous solution of ferrous sulphate heptahydrate (FeSO4. 7H2O). The values obtained were expressed as micromoles of ferrous equivalent Fe (II) per gram of dried sample.

2.5 MEASUREMENT OF RADICAL SCAVENGING ACTIVITY USING DPPH

Scavenging activity on DPPH (2,2-diphenyl-1-picrylhydrazyl) free radicals by the extract was assessed based on the slight modification of method described by Xu and Chang (2007). An aliquot (1 ml) of sample extract was mixed with 6 ml of DPPH solution. Blank experiment was prepared by mixing 1 ml of methanol with 6 ml of DPPH solution. The mixtures to be tested were prepared in test tubes with lid, and were wrapped with aluminum foil. The mixture was vortexed and kept in the dark for 30 minutes at room temperature. Absorbance was measured at 517 nm against blank. The results obtained were calculated and expressed in the term of % DPPH inhibition by using the formula below:

% inhibition of DPPH = [(Acontrol - ASample)/Acontrol] × 100 %

Where, Acontrol is the absorbance of blank, and ASample is absorbance of sample.

2.6 DETERMINATION OF FOAMING CAPACITY AND STABILITY

The foaming capacity and foaming stability was determined as described by Coffman and Garcia (1977). A measured quantity of the eggplant fruits was blended with 100 ml distilled water and stirred using magnetic stirrer at 1,500 rpm for 5 min. The foaming mixture was immediately transferred into a 250 ml graduated measuring cylinder and the foam volume was measured. The foaming capacity was expressed as the percentage volume increase (% v/v). The foaming stability was expressed as foam volume remaining after 30 min.

2.7 SENSORY EVALUATION OF EGGPLANT FRUITS

Sensory evaluation was carried out on the eggplant fruits using panel of judges selected based on their familiarity with the samples and their consistency in scoring. The samples were evaluated for bitterness using a modified method of Ihekoronye and Ngoddy (1985) with the scale of 1 to 7, where 7 indicate extremely bitter and 1 indicate not bitter.

2.8 STATISTICAL ANALYSIS

All determinations were carried out in triplicates and results were analysed using analysis of variance (ANOVA) and means separated by Duncan’s multiple range test. The statistical package SPSS version 21.0 (SPSS Inc., Chicago, Illinois USA) computer program was used and significant differences was noted at 95 % confidence limit.

3 RESULTS AND DISCUSSION

3.1 TOTAL PHENOLIC CONTENT

The Total phenolic content (TPC) of the selected eggplants used for this work varied significantly with the range of values from 2.266 mg/g in S. macrocapon to 6.406 mg/g in S. anguivi (Table 2). This is in agreement with the reports of various researchers that the quality and quantity of phenolic phytochemicals present in fruits and vegetables is significantly influenced by cultivars, environment, soil type, growing and storage conditions (Lee et al., 2004; Luthria, 2006; Robbins, 2003; Achouri et al., 2005). Hanson et al. (2006) and Okmen et al., (2009) also reported a similar level of diversity in phenolic content of some eggplant cultivars (Solanum melongena L.) examined. The TPC of the eggplants examined in this study were in the order of S. anguivi (6.406 mg/g), S. melongena var 1 (3.984 mg/g), S. melongena var 2 (3.906 mg/g), S. aethiopicum (3.438 mg/g), S. gilo (2.656 mg/g) and S. macrocapon (2.266 mg/g). There was no significant difference in the TPC of the two varieties of S. melongena eggplant cultivars. S. anguivi cultivar with the highest level of antioxidant activity among the six cultivars examined could be used as parent in breeding new varieties with enhanced food functional properties most especially higher antioxidant and phenolic content. The range of TPC of the six
cultivars is lower than 9 mgGAE/g reported in garlic and 15.87 mg GAE/g in onion (Gorinstein et al., 2009). The range however compared fairly with 274 mg/100g TPC reported for cauliflower (Wu et al., 2004), and higher than the range of 22.05-25.0 mg/100g reported for different parts of Solanum melongena L. (Sultana et al., 2013). The variations in the TPC may be due to variation in the food crops analysed by the Researchers and eggplant cultivars used in the present study. The range of values of TPC obtained in this study is also lower than the range of values of 1184.3-2043.2 mg/100g TPC reported for methanolic extract of eggplant flour (Uthumporn et al., 2016). Phenolic extracts of plants have been reported to be selectively soluble in solvents, and methanol had been concluded to have greater recovery of phenolics (Shi et al., 2005). The solvent of extraction may account for the wide reduction in the TPC obtained in the present study.

3.2 Free Radical Scavenging Activity using DPPH

The radical scavenging activity (DPPH) of the eggplants ranged from 35.00 to 82.50 (% inhibition) with S. macrocapon having the least activity and S. anguivi cultivar having the highest value. The values of Radical scavenging activity (RSA) in the eggplants cultivars analysed varied significantly. The range of values obtained for the varieties examined in this study is higher than the range of 25.17-40.35 % reported for fruit pulp of different Brinjal eggplant varieties (Kandoliya et al., 2015). The range of values however compared fairly with the range of 50.0-70.1 % reported for aubergine eggplant cultivars (Sultana et al., 2013). Eletta et al. (2017) reported the range of values of 24.83-75.61 % and 23.13-69.10 % for S. macrocapon and S. aethiopicum eggplant varieties. The values obtained for free RSA perfectly followed the same trend with the total phenolic content (TPC) of the eggplant cultivars (Table 2).

3.3 Relative Reducing Power

The results of the bitterness, foaming capacity and stability of the eggplants are depicted in figure 1. The bitterness, foaming capacity and stability of the eggplant varied significantly. The results obtained ranged from 8.00-47.00 %, 5.00-25.00 % and 1.88-7.00 for foam ability, foam stability and bitterness respectively. Solanum anguivi was rated highest in all the sensory and physical attributes examined while S. melongena var. 1 was rated the least.

Antioxidant activity has been reported to be directly related to the potential of a material to reduce ferric/ferricyanide complex to its Ferrous (Fe$^{2+}$) state (Sultana et al., 2013). The amount of Fe$^{2+}$ which is assayed by quantitative determination of the absorbance at 700 nm is directly related to the reducing power of the material and thus ultimately the antioxidant potential of the material (Sultana et al., 2013). The relative reducing power (RRP) of the eggplant fruits extracts varied significantly from 0.139 µmol Fe$^{2+}$/g in S. melongena var. 1 to 1.145 µmol Fe$^{2+}$/g in S. anguivi. The range of values obtained is lower than the range of 211.1-624.5 µmol Fe$^{2+}$/g reported for various types of eggplant flour (Uthumporn et al., 2016). The trend in the RRP obtained for the cultivars in this study was found to be generally similar with that of RSA obtained.

3.4 Bitterness, Foaming Capacity and Foaming Stability of Eggplant

<table>
<thead>
<tr>
<th>Eggplant Cultivar</th>
<th>Bitterness</th>
<th>Foaming Capacity</th>
<th>Foaming Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. melongena var. 1</td>
<td>9.07 ± 0.05</td>
<td>5.20 ± 0.03</td>
<td>4.90 ± 0.04</td>
</tr>
<tr>
<td>S. melongena var. 2</td>
<td>9.12 ± 0.04</td>
<td>5.25 ± 0.03</td>
<td>4.95 ± 0.04</td>
</tr>
<tr>
<td>S. gilo</td>
<td>9.25 ± 0.03</td>
<td>5.30 ± 0.02</td>
<td>5.00 ± 0.03</td>
</tr>
<tr>
<td>S. aethiopicum</td>
<td>9.30 ± 0.02</td>
<td>5.35 ± 0.01</td>
<td>5.05 ± 0.02</td>
</tr>
</tbody>
</table>

Values are means of three determinations ± standard deviation. Values with different superscripts on the same column are significant (p ≤ 0.05). TPC- Total polyphenol content, RSA- Radical scavenging activity, RRP- Relative reducing power.

Table 2. Antioxidant Properties of Eggplants

<table>
<thead>
<tr>
<th>Eggplant</th>
<th>TPC (mg/g)</th>
<th>RSA (% Inhibition)</th>
<th>RRP (µmol Fe$^{2+}$/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. melongena var 1</td>
<td>3.98 ± 0.07b</td>
<td>56.18 ± 0.08</td>
<td>0.139 ± 0.069b</td>
</tr>
<tr>
<td>S. melongena var 2</td>
<td>3.90 ± 0.05b</td>
<td>54.00 ± 0.06</td>
<td>0.451 ± 0.104f</td>
</tr>
<tr>
<td>S. macrocapon</td>
<td>2.26 ± 0.07e</td>
<td>35.00 ± 5.00e</td>
<td>0.346 ± 0.138e</td>
</tr>
<tr>
<td>S. gilo</td>
<td>2.65 ± 0.06d</td>
<td>42.50 ± 5.00d</td>
<td>0.270 ± 0.068e</td>
</tr>
<tr>
<td>S. aethiopicum</td>
<td>3.43 ± 0.04c</td>
<td>45.00 ± 5.00c</td>
<td>0.624 ± 0.069b</td>
</tr>
<tr>
<td>S. anguivi</td>
<td>6.40 ± 0.19e</td>
<td>82.50 ± 5.00e</td>
<td>1.145 ± 0.105e</td>
</tr>
</tbody>
</table>

Fig. 1: Bitterness, Foaming Capacity and Stability of Eggplants Cultivars
3.5 Correlation of Antioxidant Properties with Selected Physical and Sensory Attributes

Table 3 shows the correlation matrix of antioxidant and sensory properties of garden eggplants. A strong positive correlation was observed between all the parameters assayed in this study. A highly significant correlation \((r = 0.7988, r = 0.7895, \text{ and } r = 0.9369)\) was observed between TPC and RSA, TPC and RRP, and RSA and RRP respectively. This is expected since phenolic compounds are some of the most important water soluble antioxidants and can be present at high concentration in plants. Similar positive correlation between total phenolic content and antioxidant activities (RSA, RRP) have been reported for various eggplant cultivars and also observed in some other fruits and vegetables (Okmen et al., 2009; Hanson et al., 2006; Sultana et al., 2013; Jung et al., 2011; Hanson et al., 2004a; Hanson et al., 2004b and Deepa et al., 2005).

TPC, RSA DPPH and RRP showed positive correlations \((r = 0.602-0.8033; r = 0.8619-0.9053; \text{ and } r = 0.8515-0.9589)\) with bitterness, foaming capacity and foaming stability respectively. This may be an indication that simple method of assessment such as sensory (taste) and physical properties (Foaming) could be used to gain an insight into the antioxidant properties of garden eggplants and thus serve as surrogate tool for the otherwise more expensive, time consuming and technical chemical analysis used for the determination of these antioxidant activities. Bitterness showed highest positive correlation with RSA \((r = 0.8033)\), while foaming capacity and stability showed highest positive correlation with RRP \((r = 0.9583 \text{ and } 0.9589)\) respectively. This shows that the more bitter the eggplant fruit is, the more likely the free radical scavenging activity (RSA) of the fruit. Strong positive correlations also exist between the bitterness, foamy ability and foaming stability.

Table 3. Correlation Matrix of Antioxidant and Sensory Properties of Garden Eggplants

<table>
<thead>
<tr>
<th></th>
<th>TPC</th>
<th>RSA</th>
<th>RRP</th>
<th>BT</th>
<th>FC</th>
<th>FS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPC</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSA</td>
<td>0.79882</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RRP</td>
<td>0.78951</td>
<td>0.93698</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BT</td>
<td>0.60261</td>
<td>0.80335</td>
<td>0.79377</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FC</td>
<td>0.86188</td>
<td>0.88745</td>
<td>0.90533</td>
<td>0.82691</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>FS</td>
<td>0.85146</td>
<td>0.88838</td>
<td>0.95894</td>
<td>0.80279</td>
<td>0.97767</td>
<td>1</td>
</tr>
</tbody>
</table>

TPC: Total polyphenol content; RSA: Radical scavenging activity, RRP: Relative reducing power, BT: Bitterness, FC: Foaming capacity, FS: Foaming stability.

4 Conclusion

The total phenolic content, free radical scavenging activity and relative reducing power of the six eggplant cultivars varied significantly and generally followed the same trend with Solanum anguivi having the highest values. The antioxidant activities of the garden eggplants positively correlated with bitterness and foaming properties. Bitterness showed highest positive correlation with RSA, while foaming capacity and stability have highest correlation with RRP. Therefore simple sensory evaluation (tasting) and determination of foaming properties could be used as surrogate tool in gaining an insight into the antioxidant potentials of eggplants fruits.

References


Hanson, P.M., Yang, R.Y., Tsou, S.C.S., Ledesma, D., Engle, L. and Lee, T.C. (2004a). Diversity in eggplants (Solanum melongena) for...


