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ARTICLE

Nicotine content and Dietary composition of some cultivated Species of Solanaceae family

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Abstract

Despite the fact that vegetables are consumed in large quantities in our environment, there is a dearth of literature that focused on the optimum benefits to man especially in the management of disease like Parkinson's Disease (PD). Nicotine, the major phyto-constituent of *Nicotiana tabacum* of the family Solanaceae has been reported to be present in some other species of the family. This study investigated the nicotine content and the dietary components in the leaves and fruits of selected species of cultivated vegetable plants belonging to Solanaceae family. Edible plants from Solanaceae family were grown till the fruiting stage in the experimental farm of Ekiti State University, Ado Ekiti, while *Nicotiana tabacum* was used as the control plant. Plants samples from mature leaves and fruits of each plant were harvested washed with de-ionized water, oven dried at 30^{o}C. Powdered samples were analyzed for mineral and proximate components according to standard procedure and nicotine content were determined with GC-MS. Nicotine remained the major constituent of tobacco. Nicotyrine, a product of nicotine dehydrogenation was also detected in all the plant samples. *Capsicum annum var. accuminatum* fruit displayed the highest nicotine content (0.5543 mg/L) compared to the others with relatively lower quantities. Nicotyrine content was more available in the plant fruits than nicotine, with *C. annum var abbreviatum* displaying more of nicotyrine content (75.3456 mg/L). *Solanum lycopersicum* displayed the highest moisture contents (19.94 %), followed by tobacco leaf (11.88%). N. tabacum leaf displayed high quantity of protein (56.52%) than other members. The fruits of the solanaceae plant species were rich in carbohydrate, protein with very low amount of fat. This study revealed that the solanaceae plants contained more of nicotyrine than nicotine. In contrast to the previous studies, the nicotine content was higher in the eggplant leaves than the fruits. Eggplant and *Capsicum* species can be recommended for patient suffering from neurodegenerative diseases like PD.

Key words: *Nicotiana tabacum*, Nicotine, Nicotyrine, Solanaceae, Parkinson's Disease

Introduction

Vegetables are considered essential for well-balanced diets in human food as they supply vitamins, minerals, dietary fiber, and phytochemicals associated with overall good health, improvement of gastrointestinal health and vision, reduced risk for some forms of cancer, heart disease, stroke, diabetes, anaemia, gastric ulcer, rheumatoid arthritis, and other chronic diseases (Hyson,2002). Each vegetable group contains a unique combination of phytochemicals in certain amount which distinguishes them from other vegetables within their own group (Dias, 2012). Among these phytonutrients is nicotine, which if consumed in moderate amount along with food, has been noted for having the capability of reducing the risk of developing Parkinson's Disease (PD) (Searles, 2013). Nicotine, the major phytochemical constituent of *Nicotiana tabacum* of the family Solanaceae has been reported to be present in some other species of the family (Castro and Monji, 1986; Sheen 1988). According to Leete (1983), about 12 families and 24 genera, including the nightshade family (Solanaceae) were identified as species containing nicotine to varying degrees. In their work, it was reported that nicotine is certainly present in human foods especially plants that belong to the Solanaceae family, many of which are significantly consumed by humans due to their nutritional values.

Nicotine is an alkaloid predominantly found in the leaves of *Nicotiana tabacum*, called tobacco plant, which belong to the Solanaceae family (Dias, 2012). Tobacco has been the major source of nicotine known worldwide because of its usage and consumption. However, perhaps due to its high contents of nicotine which has been known to have stimulatory effects on the central nervous system and cause addiction, there has not been much record of the nutritive value of the leafy plant. Hence, it has, therefore, not been used as edible dietary vegetable as some other members of the family.
Although these vegetables are largely consumed in our local environments, not much research has been focused on the optimum benefits to man especially in the management of diseases such as PD. Apart from the fact that little information is known to people about the presence of nicotine in variable amounts in various few reported vegetables of the Solanaceae family consumed in different parts of Nigeria, only a few citations can be found in the literature that address nicotine concentration in diverse foods and the ensuing dietary intake of nicotine.
Therefore, this study finds it important to investigate the nicotine content and the dietary components in the leaves and fruits of selected species of cultivated vegetable plants belonging to Solanaceae family, popularly consumed among the Nigerian population.

Materials and Methods

Chemicals
Nicotine standard was purchased from Sigma–Aldrich Company with purity 99.9%. Methanol (BDH, UK), dichloromethane and de-ionized water were of HPLC grade. Anhydrous sodium sulfate (Merck, Germany) was activated by heating at 200 °C before use. Silica gel (60–120 mesh, Loba, India) was activated at 400 °C for 12 h prior to use.

Experimental Design
The experimental set up was arranged in Randomized Complete Block Design with 10 replicates for each of the plant species.

Plant Materials
Edible plant samples from Solanaceae family which include *Capsicum frutescence* var *baccatum* (Ata wewe), *Capsicum annum* var *abbreviatum* (Ata rodo), *Capsicum annum* var acuminatum (Ata bawa), *Solanum macrocarpon*, *Solanum aethiopicum* and *Solanum lycopersicum* were grown till the fruiting stage in the experimental farm of Ekiti State University, Ado Ekiti, Ekiti State while *Nicotiana tabacum* used as the control plant, was harvested from a nearby farm in Ado Ekiti. After collection, the samples were kept in a polyethylene bag with aluminum foil protected cover and stored in refrigerator at 2 °C to avoid any deterioration. Mature leaves and fruits from each plant samples were harvested, washed with de-ionized water to remove dusts and any other foreign particles. Samples were thereafter oven dried at a low temperature of 300C and blended into fine powder.

Precaution against Possible Sources of Contamination.
Special emphasis was put on possible contamination sources of nicotine from the air or any equipment used. Smoking was not permitted around the experimental farm and in the laboratory area.
Preparation of samples for GC- MS Quantitative Determination of Nicotine.

Finely ground samples of the fruits and leaves of each species were used for the GC-MS quantitative determination of nicotine contents. This was prepared by dissolving 0.1g of each sample into 1mL of methanol to give 0.1 g/ mL (0.1 g/mL ≡ 100 mg/mL ≡ 100,000 mg/L or 100,000 ppm). The experiments were carried out in the laboratory of the Department of Biological Sciences, Afe Babalola University, Ado-Ekiti.

Proximate Composition
Proximate compositions of powdered samples were determined according to the procedure of Association of Official Analytical Chemists (AOAC, 2010). For moisture content 2.0g of the sample(s) were placed in an oven maintained at 100 - 103°C for 16 hours with the weight of the wet sample and the weight after drying noted. The drying was repeated until a constant weight was obtained. The moisture content was expressed in terms of loss in weight of the wet sample. Ash content was determined by taking 2.0g of each of the oven-dried samples in powder form were accurately weighed and placed in crucible of known weight. These were ignited in a muffle furnace and ashed for 8 hours at 550°C. The crucible containing the ash was then removed, cooled in a desiccator and weighed and the ash content expressed in term of the oven-dried weight of the sample. Protein, fiber, and fat were analyzed following the same standard procedure while carbohydrate content was determined by ding together the sum of the percentage moisture, ash, crude lipid, crude protein and crude fiber, then subtracting this value from 100.
Analysis was carried out in triplicates and all values were reported in percentage. The instrument used was auto-zeroed using the blank (distilled water) for each element, and the standard was aspirated into the flame from the lowest concentration to the highest concentration. Corresponding absorbance was taken and the graph of absorbance against concentration was plotted. The samples were analyzed with the concentration of metals being shown in parts per million (ppm) after extrapolation from the standard curve (Greenberg et al., 1985).

Estimation of Mineral Composition
The analysis of metal concentration in the samples was determined by weighing one (1)g of each of the ground samples into different platinum crucibles that had been well labeled. It was then placed in a muffle furnace at 450^{0}C - 550^{0}C until all of the carbon present was removed as evidence by white ash. Thereafter, 2mL of distilled water + 1mL of concentrated HNO_3 + 1mL of concentrated HCl was added and was warmed gently so as to speed up the dissolution of the ash. The dissolved ash was then brought up to 10mL. The metal concentration was determined using Atomic Absorption Spectrophotometer (AAS) (Buck Scientific model 210 VGP) by calibration method. Three processes were involved which are: standard preparation, equipment calibration and sample analysis.

Statistical analyses
Data were expressed as means of triplicate measurements. Correlations were obtained by Pearson correlation coefficient in bivariate correlations. Means were compared by Tukey-HSD and LSD (least significant differences). Differences at $P < 0.05$, were considered to be significant.

Results

Table 1: GC-MS Quantitative Analysis of Nicotine and Nicotyrine Concentration in the Fruits of Cultivated Species of Selected Solanaceae Family and the leaf *of Nicotiana tabacum*

	Concentration in the samples (mg/L)						
Components	***S. lycopersicum***	***S. aethiopicum***	***S. macrocarpon***	***C. annum var abbreviatum***	***C. annum var accuminatum***	***C. frutescens var baccatum***	***Nicotiana tabacum***
Nicotine (Pyridine, 3-(1-methyl-2-pyrrol	0.1193	0.1340	0.1553	0.1050	0.5543	0.2129	4477.6800
Nicotyrine (Pyridine, 3-(1-methyl-1H-pyr	20.3567	15.6768	25.4754	75.3456	37.4676	15.0187	671.7400

Values depict variations in the nicotine and Nicotyrine contents. The result showed that *N. tabacum*, the standard plant revealed more of nicotine (4477.68 mg/L) than nicotyrine (671.74 mg/L). Among the fruit samples, *C. annum* var. accuminatum fruit displayed the highest nicotine content (0.5543 mg/L) compared to the other member of the family with relatively lower quantity. C. annum var abbreviatum displayed more of nicotyrine content (75.3456 mg/L) as compared to other fruits which altogether contained an appreciable lesser amount as compared to control plant

Table 2: GC-MS Quantitative Analysis of Nicotine and Nicotyrine Concentrations in the Leaves of Cultivated Species of Selected Solanaceae Family and the leaf of *Nicotiana tabacum*

	Concentration in the samples (mg/L)						
Components	***Solanum lycopersicum***	***S. aethiopicum***	***S. macrocarpon***	***C. annum var abbreviatum***	***C. annum var accuminatum***	***C. frutescens var baccatum***	***Nicotiana tabacum***
Nicotine (Pyridine, 3-1-methyl-2-pyrrol)	0.0271	32.1940	0.0697	0.0789	0.0884	0.1197	4477.6800
Nicotyrine (Pyridine, 3-1-methyl-1H-pyrrol)	24.7274	41.0507	11.5819	14.2875	10.9969	11.7282	671.7400

Table 2 shows that nicotine and nicotyrine were discovered to be present in all the plant samples. Values depict variations in the nicotine and nicotyrine contents of the leaf samples. *Solanum aethiopicum* leaf also known as eggplant showed abundance of nicotine (32.19 mg/L), present in its leaves as compared to leaves of other species with relatively lower amount of nicotine when compared with the nicotine and nicotyrine content of *Nicotiana tabacum* (4477.68 mg/L and 671.74 mg/L, respectively).

Table 3: Proximate composition of the Fruits of Cultivated *Solanum* Species.

Proximate Composition (%)	***Solanum lycopersicum* F**	***S. aethiopicum* F**	***S. macrocarpon* F**	***Capsicum annum var abbreviatum* F**	***C. annum var accuminatum* F**	***C. frutescens var baccatum* F**	***Nicotiana tabacum* L**
Moisture	19.877±0.068	12.167±0.033	10.67±0.035	9.581± 0.035	9.5±0.00	7.523±0.015	11.852±0.015
Protein	35.411±0.039	39.871±0.058	38.127±0.032	37.385±0.032	34.408±0.003	37.40±0.003	56.53±0.012
Carbohydrate	19.844±0.033	24.86±0.031	24.459±0.029	35.301±0.042	33.288±0.007	26.869±0.01	16.163±0.006
Fat	0.467±0.067	0.2±0.058	0.103±0.003	0.82±0.012	0.703±0.003	0.627±0.015	0.207±0.007
Ash	12.171±0.003	7.8± 0.00	9.463±0.032	4.79±0.067	10.320±0.023	7.623±0.019	6.342±0.007
Crude fibre	12.263±0.033	15.171±0.035	17.333±0.033	12.2± 0.058	11.823±0.023	19.927±0.022	8.903±0.003

Values are mean ± standard deviation of triplicate determination.

The result in Table 3 showed that all the fruits of the solanaceae plant species are rich in carbohydrate, protein with very low amount of fat. *N. tabacum* leaf displayed highest quantity of protein (56.523) than other members of the family. *Solanum lycopersicum* displayed highest moisture contents (19.94 %), followed by tobacco leaf (11.88%).

Table 4: Proximate composition of the Leaves of Cultivated Solanum Species.

Proximate Composition (%)	***Solanum lycopersicum* L**	***S. aethiopicum* L**	***S. macrocarpon* L**	**Capsicum annum var abbreviatum L**	***C. annum var accuminatum* L**	***C. frutescens var baccatum* L**	***Nicotiana tabacum* L**
Moisture	8.423± 0.174	11.6± 0.00	13.174± 0.185	9.092± 0.006	9.291±0.00	9.091±0.00	11.879±0.00
Protein	34.401± 0.091	30.945± 0.13	43.75±0.00	37.716± 0.002	37.902± 0.067	33.906±0.012	56.523±0.004
Carbohydrate	17.243± 0.032	29.864± 0.00	14.704 ±0.00	19.493±0.016	21.907 ±0.279	24.294 ±0.009	16.163±0.00
Fat	0.1± 0.00	0.1± 0.00	0.1±0.00	0.5±0.00	0.6±0.00	0.6±0.00	0.2±0.00
Ash	13.645± 0.058	11.3 ± 0.00	13.772 0.02	14±0.00	12.7±0.07	12.7±0.033	6.335±0.00
Crude fibre	16.8 ±0.1	18.7 ±0.00	14.5±0.00	19.2± 0.00	16.9± 0.007	16.9± 0.007	8.9±0.00

Values are mean ± standard deviation of triplicate determination.

The result in Table 4 showed that all the leaves of the solanaceae plant species are rich in carbohydrate, protein with very low amount of fat. *N. tabacum* leaf displayed high quantity of protein (56.52%) than other members of the family. The leaves of *Capsicum frutescens* var *baccatum* had the least protein content (33.91%).

Table 5: Mineral Composition in the Fruits of Cultivated *Solanum* Species

Mineral Components	***Solanum lycopersicum* F**	***S. aethiopicum* F**	***S. macrocarpon* F**	***Capsicum annum var abbreviatum* F**	***C. annum var accuminatum* F**	***C. frutescens v ar baccatum* F**	***Nicotiana tabacum* L**
Na (mg/kg)	10.25 ± 0.25	16.55 ± 0.15	10.25 ±0.15	98.45 ± 0.14	120.5±0.033	116.05 ±0.14	15.2±0.00
Ca (mg/kg)	18.3 ± 0.115	20.8 ± 0.786	33.05 ± 0.15	80.55 ± 0.04	131.35± 0.15	122.2 ± 0.29	20.05 ± 0.25
K (mg/kg)	272.75 ± 0.145	18.65 ± 0.25	14.5 ± 0.024	69.45 ± 0.25	105.85 ± 0.04	91.55 ± 0.04	210.25± 0.25
Mg (mg/kg)	21.3885 ± 0.035	2.2485 ± 0.03	3.614 ± 0.01	35.25 ± 0.15	34.1+0.00	46.55 ± 0.25	14.768± 0.03
Fe (mg/kg)	2.286 ± 0.061	0.598 ± 0.006	0.368 ± 0.003	3.181 ± 0.017	3.214± 0.037	5.035 ± 0.007	3.079± 0.002
Zn (mg/kg)	0.23 ± 0.002	0.532 ±0.024	0.587±0.002	2.513 0.003	2.216 ± 1.49	4.125±0.03	0.335± 0.001
Mn (mg/kg)	0.3965 ± 0.15	0.2185 ± 0.001	0.31 ± 0.002	3.199 ± 0.005	5.1625± 0.033	7.0365± 0.003	0.356± 0.006
Cu (mg/kg)	0.1465 ± 0.021	0.0535 ± 0.001	0.0425 0.005	0.203 ± 0.002	0.374± 0.001	0.2165± 0.001	0.712±0.00
Pb (mg/kg)	0.001±0.00	ND	0.001±0.00	ND	0.001±0.00	ND	ND

Values are mean ± standard deviation of triplicate determination. ND = Not detected

Table 5 shows the mineral composition present in the fruits of cultivated species of selected Solanaceae family. Values depict the mineral contents present in the fruits of the samples. No traces of lead was determined in the *S. aethiopicum* F, *Capsicum annum* var *abbreviatum* F, *C. frutescens* var *baccatum* F, and *Nicotiana tabacum* L.

Table 6: Mineral Composition in the Leaves of Cultivated Solanum Species

Mineral Components	*Solanum lycopersicum* L	*S. aethiopicum* L	*S. macrocarpon* L	*Capsicum annum var. abbreviatum* L	*C. annum var accuminatum* L	*C. frutescens var. baccatum* L	*Nicotiana tabacum* L
Na (mg/kg)	16.25 ± 0.25	19.9 ± 0.2	25.9 ± 0.711	60.5 ± 0.923	100.55 ± 0.945	83±0.874	15.2±0.213
Ca (mg/kg)	18.3±0.774	26.4 ± 0.613	38.4 ± 0.611	50.4 ± 0.1	125.2 ± 0.1	107.65 ±0.15	20.05 ± 0.25
K (mg/kg)	87.25 ± 0.24	22.65 ± 0.15	17.2 ± 0.09	96.25 ± 0.15	89.35 ± 0.15	77.3 ± 0.2	210.25± 0.25
Mg (mg/kg)	11.85 ± 0.21	5.1885 ± 0.01	2.2975 ± 0.01	10.8035 ± 0.01	21.831 ± 0.07	18.633±0.342	14.768± 0.03
Fe (mg/kg)	1.286±0.017	1.0525 0.012	0.611 ± 0.003	1.6395 ± 0.004	3.36 ± 0.81	3.1835± 0.002	3.079± 0.002
Zn (mg/kg)	0.13 ± 0.002	0.411 ± 0.001	0.617 ± 0.002	1.3075 ± 0.001	2.5485 ± 0.008	4.906 ± 0.001	0.335± 0.001
Mn (mg/kg)	0.3654± 0.021	0.3095 ± 0.001	0.39 ± 0.002	0.1475±0.002	3.818 ± 0.002	0.2745± 0.002	0.356± 0.006
Cu (mg/kg)	0.124± 0.002	0.115 ± 0.002	0.0685 ± 0.003	0.191 ± 0.001	0.3955 ± 0.001	0.21± 0.001	0.712± 0.00
Pb (mg/kg)	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00	ND

Values are mean ± standard deviation of triplicate determination. ND = Not detected

Table 6 shows the mineral composition present in the leaves of cultivated species of selected Solanaceae family. Values depict the mineral contents present in the fruits of the samples

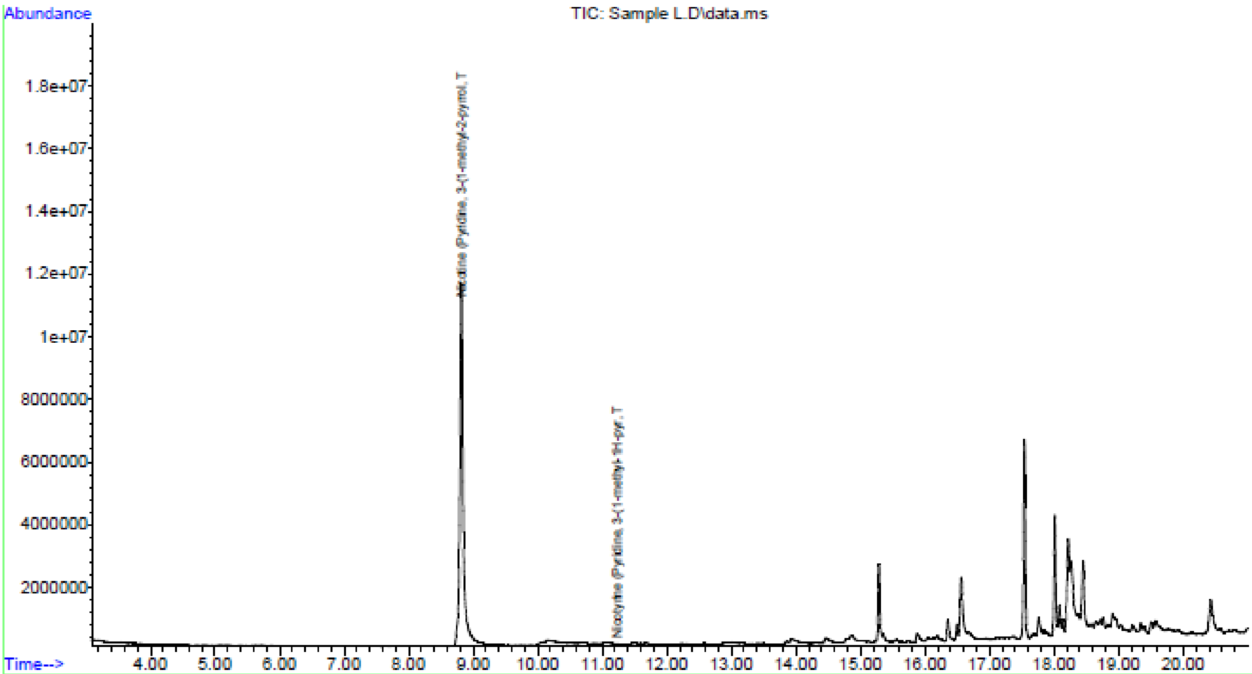

Figure 1: The chromatograph showed the retention time of nicotine and nicotyrine. The nicotine had a retention time of 8.843 mins and Nicotyrine had the retention time of 11. 85 mins.

A

B

C

Fig 3 : Diagrams (A, B, C) of the cultivated species of *Capsicum* species in Ekiti State, Nigeria.

Discussion

Accumulating evidence had suggested that nicotine may be of therapeutic value of Parkinson's disease. In this investigation, *Nicotiana tabacum* leaf was used as standard plant which is already known for its high content of nicotine (Serban et al., 2016). The result of the GC MS analysis confirmed that tobacco plant is highly rich in nicotine content (Table 1 and Table 2). Apart from nicotine, the major constituent of tobacco, nicotyrine, a product of nicotine dehydrogenation was also detected in all the plants including the standard plant itself. Nicotyrine is described as a product of nicotine dehydrogenation in e-vapor and is a known inhibitor of human cytochrome P450 enzyme, which mediates nicotine metabolism (Yeongkwon et al., 2018). Nicotine oxidation during storage was reported capable of forming nicotyrine (Wada et al., 1959). The discovery of nicotyrine in the selected plants of this present study makes it a novel observation which may require more attention for further research. While nicotyrine was found to be more detected in the sample plants than nicotine, nicotine was detected in trace amount in all the sampled plants, from *Solanum* genus including tomato, eggplant, and from *Capsicum* genus, when compared with the control plants. The reverse was the case in *N. tabacum* which revealed more of nicotine than nicotyrine. Nicotine has been known for its various pharmacological functions. It is a known drug that stimulates nicotinic acetylcholine receptors implicated of having therapeutic value on PD (Maryka et al., 2008). The detection of nicotyrine in these plants might serve an added advantage in the bioactivity of this plant family and in the management of some medical challenges especially Parkinson's disease which has been linked to consumption of edible vegetables that contain nicotine in trace amount.

According to the literature, apart from *Nicotiana* species, other members of the Solanaceae family whose edible fruits and tubers including peppers, tomatoes, eggplants and potatoes have been implicated of containing nicotine in lower concentrations (Castro and Monji, 1986; Sheen, 1988; Domino et al., 1993; Siegmund et al., 1999; Searles et al., 2013). Most of the few studies were carried out on the fruit of these plants except the work of Serban et al., (2016) who reported on the tomato leaf which is not often consumed. The fact that the fruits parts of the members of solanaceae family are commonly consumed as food, special interest was placed on investigating the nicotine and dietary contents of the leaf portion of these plants which are not mostly consumed as food. The presence of nicotine in trace amount in the selected plants of this study confirmed the reports that the amount of nicotine absorbed from these foods is considered negligible relative to the amount obtained from active smoking, and probably lower than that from environmental tobacco smoke (Andersson et al., 2003), hence, their therapeutic properties without causing any stimulation to the body. According to the work of Searles et al., (2013), carried out on fresh and processed vegetables, it was stated that vegetable consumption in general did not affect Parkinson's disease risk, but as consumption of edible Solanaceae species increased, Parkinson's disease risk decreased with peppers displaying the strongest association. Andersson et al., (2003) also reported that the level of nicotine in these vegetable plants was by observation varied both among the various plants and between processed and fresh products.

The result of this study agreed with the growing reports which stated that the consumption of certain food groups like the member of Solanaceae family of plants are associated with health benefits and may contain promising components in them that may elicit neuroprotection in PD (Evatt, 2007, Searles et al., 2013; Shaltiel-Karyo et al., 2013). Also, phytochemicals, vitamins, minerals present in the food supplements or fruits, vegetables, and spices are capable of preventing, delaying, or alleviate the clinical symptoms of chronic neurodegenerative diseases, improving cognitive functions, learning, general brain status, and wellbeing (Olasehinde, et al., 2017). Seid et al., (2014), reported that dietary intake of nicotine-containing vegetables from edible Solanaceae including tomatoes, potatoes, and peppers, was associated with a reduced risk of PD in men and woman who had never smoked cigarettes or tobacco (Searles et al., 2013). However, it remains unclear as to whether the observed protective effect was due to the nicotine content or other components of this group of vegetables especially the dietary components.

Further investigation about the dietary components revealed that the proximate composition of the plant samples as shown in Table 3 and Table 4 were very rich in carbohydrate, protein and crude fiber with a very low amount of fat. Regulation of intake of carbohydrates, protein, fluids and fibers and some other nutrients present in fruits and vegetables have been considered to be very important in the nutritional and functional decline associated with aging and may slow the progression of P.D (Liu, 2003; Mostafavi and Hosseini, 2015; and Michele et al., 2019,). The presence of fat content at low quantity in all the plants suggests that the fruits and the leaves of these species had more of carbohydrates and proteins than that of fats. The role that fat plays in PD was considered most likely to be related to the type of fat in the patient's diet (De Lau et al., 2005), the patient's HDL/LDL ratio, total cholesterol levels and genetic factors. There is need to clarify the associations between fat intake and PD by conducting a large randomized controlled study. Inadequate fat in the body could result to body rashes, skin dryness, air loss and weaker immunity therefore, may require the compliment of other supplements to balance the diet. Interestingly, the control plant's leaf, *Nicotiana tabacum*, had higher protein content than the fruits and leaves of other members of the family. The high protein content of this plant might place a new significant importance on tobacco leaf. Previous studies have highlighted some of the health benefits associated with the consumption of *Capsicum* spp. The leaves of *Capsicum frutescens var baccatum* had the least protein content. The highest value of carbohydrate was contained in the fruits of *Capsicum annum var abbreviatum* when compared to other samples while the leaves of tobacco had the lowest content of carbohydrate. More so, fibre was abundant in the fruits of *Capsicum frutescens var baccatum* followed by *Solanum aethiopicum* leaf when compared to the standard plant *Nicotiana tabacum* leaves which had the least crude fiber content. Ogunruku et al., (2014) reported the two pepper varieties *Capsicum annuum var. accuminatum* and *Capsicum chinense*, implicating them of their inhibitory effect on acetylcholinesterase and butyrylcholinesterase activities and also antioxidant properties of *Capsicum* spp. Dietary fiber plays an important role in the maintenance of good intestinal and good digestive health, prevention of cardiovascular disease, some types of cancer, peptic ulcer, improve skin health and reduce the risk of developing obesity, and diabetes mellitus (Buttriss, 2008). It is indicative that these vegetables including other member of the family are capable of possible dietary means by which oxidative stress and symptomatic cognitive decline associated with neurodegenerative conditions could be alleviated.

Table 5 and Table 6 showed the result of the mineral composition of the leaves and the fruits of the selected plant samples. Nearly all the *Solanum* spp and *Capsicum* spp are very rich in Na, K, Ca and Mg. The result revealed that the plants are very good source of mineral elements. This result has by indication showed that the *Solanum* species contain less of all the mineral contents when compared to the *Capsicum* species except for the *Solanum lycopersicum* fruit which is very rich in potassium just like the *Nicotiana tabacum* leaves. Tomato (*Solanum lycopersicum* fruit) and peppers (*Capsicum spp.*) have a worldwide distribution. They are important as vegetable foods and spice and are considered an important source of nutrients in the human diet which are grown in tropical, subtropical, and temperate regions. Various species and varieties occurring within the *Capsicum* genus depending on their shape, size, flavor, and hotness include *Capsicum annum*, *Capsicum frutescence*, and *Capsicum chinens* (Loizzo et al., 2008, Tundis, 2011). Unlike vitamins, there is little or no literature on the importance of mineral elements in the management of PD. This result becomes so important when the usefulness of such essential minerals like Ca, Na, K, Mg, and Fe are all present in the fruits and the leaves of the sample species and they play important role in the management of PD. All the *Capsicum* species are very good source of all the minerals in a very good and appreciable amount. Copper and zinc are the essential trace elements that are needed only in minute quantity by the human body for important biochemical functions. It is not surprising that all the samples contain these two elements in trace amount which is an indication why they are considered important spices in various diets. This suggests their importance as the major source of vegetable to mankind. No traces of lead was determined in the *S. aethiopicum* F, *Capsicum annum* var *abbreviatum* F, *C. frutescens var baccatum* F, and *Nicotiana tabacum* L.

Conclusion

This study revealed that the Solanaceae plants contain more of nicotyrine than nicotine which called for attention to focus on its pharmacological properties in further studies. The nicotine content is more present in the eggplant leaves than the fruits which are contrary to some previous studies. *Nicotiana tabacum* leaves was also discovered to be very rich in protein therefore could serve a health benefit if the nutritional properties are more explored. It can be concluded that consumption of eggplant and *Capsicum* species can be of great benefit to the human health and can be specially recommended for patient suffering from neurodegenerative diseases like PD.

Conflict of Interest

Authors have declared that no conflict of interests associated with this study or any of the procedures and materials used for the purpose of the study.

Author Contributions

Olatunji B.P. designed the work and wrote the manuscript, Arowosegbe S. supervised the project and the write up, Adeleke O.C and Obawumi D carried out the research project while Asowata A.M analysed the results.

References

Andersson, C., Wennström, P., Gry, J. (2003). Nicotine alkaloids in Solanaceous food plants. Copenhagen: Nordic Council of Ministers; TemaNord 2003:513 Doi/10.5281/zendo.818223.

Association of Official Analytical Chemists (AOAC) (2000). *Official Methods of Analysis of AOAC International*, 17th ed.; AOAC International: Gaithersburg, MD, USA.

Association of Official Analytical Chemists (AOAC) (2010). *Official Methods of Analysis of AOAC International*, 18th ed.; AOAC International: Washington, DC, USA.

Buttriss, J.L., Stokes, C.S. (2008). Dietary fibre and health: An overview. Nutrition Bulletin, 33(3); 186-200. http://dx.doi.org/10.1111/j.1467-3010.2008.00705.

Castro, A. and Monji, N. (1986). Dietary nicotine and its significance in studies on tobacco smoking. Biochemical Archives, 1982 (2); 91-97.

Dias, J.S. (2012). Major Classes of Phytonutriceuticals in Vegetables and Health Benefits: A Review, Journal of Nutritional Therapeutics, 1; 31-62.

Davis, R.A., M.F., Stiles, J.D., de Bethizy J.D., and Reynolds J.H. (1991). Dietary Nicotine: A Source of Urinary Cotinine, Food and Chemical. Toxicology, 29; 821–827. DOI: 10.1016/0278-6915(91)90109.

Davis, R.A. (1986). The Determination of Nicotine and Cotinine in Plasma, Journal of Chromatographic Science, 24; 134–141.

De Lau L. M., Koudstaal P. J., Hofman A., and Breteler M. M. (2006). Serum cholesterol levels and the risk of Parkinson's disease, American Journal of Epidemiology, 164; 998–1002 DOI: 10.1093/aje/kwj283. PubMed CrossRef Google Scholar.

Domino, E.F., Hornbach, E., Demana, T. (1993). Relevance of nicotine content of common vegetables to the identification of passive tobacco smokers, Medical Science Research. 21; 571–572.

Evatt, M.L. (2007). Nutritional therapies in Parkinson's disease. Current Treatment Options in Neurology. 9; 198–204. Doi: 10.1007/BF02938409. [PubMed] [CrossRef] [Google Scholar].

Hyson, D. (2002). The health benefits of fruit and vegetables: A scientific overview for health professionals. Produce for Better Health Foundation. Wilmington DE.

Leete, E. (1983). Biosynthesis and metabolism of the tobacco alkaloids, In Alkaloids Chemical and Biological Perspectives; Pelletier, S. W., Ed., John Wiley and Sons: New York. 3; Vol. 1; 86-139.

Liu, R. H. (2003). Health benefits of fruit and vegetables are from additive and synergistic combinations of phytochemicals. American Journal of Clinical Nutrition doi.org/10.1093/ajcn/78.3.517S [PubMed] [Google Scholar].

Loizzo, M. R., Tundis, R., Menichini, F., Statti, G. A., and Menichini F., (2008). Influence of ripening stage on health benefits properties of *Capsicum annuum* var. *cuminatum* L.: *in vitro* studies," Journal of Medicinal Food, vol. 11, No. 1; 184–189, 2008.

Michele, C., Lisa, M., Ivana, C., and Antonio Di Stefano (2019). Role of Dietary Supplements in the Management of Parkinson's Disease, Biomolecules, 2019 Jul; 9(7): 271. Published online 2019 Jul 10. Doi: 10.3390/biom9070271 PMCID: PMC6681233 PMID: 31295842.

Mostafavi, S. A., and Hosseini, S. (2015). Foods and Dietary Supplements in the Prevention and Treatment of Neurodegenerative Diseases in Older Adults. In Foods and dietary supplements in the prevention and treatment of disease in older adults (pp. 63-67). Academic Press.

Njideka, U.O., Oluwadamilola, O.O. and Olajumoke O. O., (2010). Clinical profile of parkinsonism and Parkinson's disease in Lagos, Southwestern Nigeria, BMC, Neurology, 10;1 https://doi.org/10.1186/1471-2377-10-1.

Ogunruku, O.O., Oboh, G., and Ademosun. A.O. (2014). Water Extractable Phytochemicals from Peppers (*Capsicum* spp.) Inhibit Acetylcholinesterase and Butyrylcholinesterase Activities and Prooxidants Induced Lipid Peroxidation in Rat Brain *In Vitro*. Hindawi Publishing Corporation International Journal of Food Science Volume 2014, Article ID 605618, 7 pages http://dx.doi.org/10.1155/2014/605618.

Olasehinde, T., Oyeleye, S.I., Ogunsuyi, O.B., Ogunruku, O. (2017). Functional Foods in the Management of Neurodegenerative Diseases. In: Oboh G., editor. Functional Foods: Unlocking the Medicine in Foods. Graceland Prints; Memphis, TN, USA: 2017. pp. 72–81.

Searles, N.S., Franklin, G.M., Longstreth, W.T., Swanson, P.D., Checkoway, H., (2013). Nicotine from edible Solanaceae and risk of Parkinson disease, Annal of Neurology, 74; 472–477. Doi: 10.1002/ana.23884 [PMC free article] [PubMed] [CrossRef] [Google Scholar].

Seid, S.E., Santiago, J. A, Bilyk, H., and Potashkin, J.A (2014). The emerging role of nutrition in Parkinson's disease. Front Aging Neuroscience, 6;36. Published online 2014 Mar 7. Doi: 10.3389/fnagi.2014.00036.

Serban, C. M., Wayne, A. S, and Darlene, M. L. (2016). Nicotine Analysis in Several Non-Tobacco Plant Materials. Beiträge zur Tabakforschung International Contributions to Tobacco Research Volume 27 @ No. 2 @ April 2016. DOI: 10.1515/cttr-2016-0008.

Shaltiel-Karyo, R., Frenkel-Pinter, M., Rockenstein, E., Patrick C., Levy-Sakin M., Schiller, A., et al. (2013). A blood-brain barrier (BBB) disrupter is also a potent alpha-synuclein (alpha-syn) aggregation inhibitor: a novel dual mechanism of mannitol for the treatment of Parkinson disease (PD). Journal of Biological Chemistry. 288; 17579–17588. Doi: 10.1074/jbc.M112.434787 [PMC free article] [PubMed].

Sheen, S.J. (1988). Detection of nicotine in foods and plant material. Journal of Food Science, 53: 1572–1573. https://doi.org/10.1111/j.1365-2621.1988.tb09328x.

Siegmund, B., Leitner, E., Pfannhauser, W., (1999). Determination of the nicotine content of various edible nightshades (Solanaceae) and their products and estimation of the associated dietary nicotine intake. Journal of Agricultural and Food Chemistry. 47; 3113–3120. doi: 10.1021/jf990089w. [PubMed].

Tundis, R., Loizzo, M. R., Menichini, F. et al., (2011). Comparative study on the chemical composition, antioxidant properties and hypoglycaemic activities of two *Capsicum annuum* L. cultivars (*Acuminatum small and Cerasiferum*). Plant Foods for Human Nutrition, 66; (3):261-269. doi: 10.1007/s11130-011-0248-y.

Wada, E., Kisaki, T., and Saito, K., (1959). Autoxidation of nicotine. Archives of Biochemistry and Biophysics. 79, 124–130. https://doi.org/10.1016/0003-9861(59)90385-6. [Google Scholar].

Yeongkwon, S., Olivia, W., Clifford, W., Stephan, S., Gediminas, M., Cristine, D., and Qingyu M. (2018). Evaluation of E-Vapor Nicotine and Nicotyrine Concentrations under Various E-Liquid Compositions, Device Settings, and Vaping Topographies, Chemical Research in Toxicology, 31; (9). Doi: 10.1021/acs.chemrestox.8b00063.