The Effect of Processing on Some Nutritional Indices of Purple Onion, (*Allium cepa* Linn), Bulb

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ABSTRACT

Onion *(Allium cepa L.*), also referred to as "Queen of the kitchen", is a common vegetable that is widely consumed all over the world. It is has peculiar taste, unique flavor, highly valued aroma, and various health benefits. This all important condiment however, has a short shelf life which is a major cause of postharvest losses during the peak of harvesting season. Scarcity resulting from the losses has led to a thought of its processing with the aim of retaining its medicinal and nutritional properties. The present study was therefore, aimed at evaluating the effect of processing on the Vitamins and Minerals composition of purple onion using two processing methods (sun drying (SD) and oven drying (OD) at 70^{o}C), compared to fresh samples. These Parameters were evaluated using standard Biochemical methods. The results obtained showed that all the parameters tested were affected significantly ($P < 0.05$) by oven drying process when compared to the fresh sample. The Vitamins (A, B_1, B_2, B_3, B_6, B_9, C, and E,) composition showed an increasing composition of the parameters in the order of Fresh < SD < OD. From the foregoing, it can be suggested that oven drying (70^{o}C) is an efficient method of processing and preservation of purple onion. The results from the study could be a direction towards the promotion of preservation of purple onions and an encouragement of the industrialization of the process of producing onion powders, which is readily available in all seasons and meet consumer requirements.

INTRODUCTION

Onion (*Allium cepa L.*, from Latin *cepa* meaning "onion") is a common vegetable and is widely consumed all over the world (Pareek *et al.,* 2017). It is believed to have originated in central Asia and is one of the oldest cultivated plants, with cultivation records dating back more than 4000 years. Since ancient times, onion has been recognized as a food and medicinal plant, and Nigeria is seventeenth in the World list of countries that cultivate the plant with 1.72% of the produce (Food and Agricultural Organization, 2018, 2019; Dossa *et al.,* 2018; Pareek *et al.,* 2018). It is also the second most valuable crop in terms of total global production after tomato (FAO, 2021; Geisseler *et al.,* 2022). Because of its peculiar taste, unique flavor, highly valued aroma, and various health benefits, it is sometimes referred to as the "Queen of the kitchen" (Griffiths *et al.,* 2002). It belongs to the family of Alliaceae and is one of the oldest commonly used vegetables known to mankind around the globe. There are three types of onion based on color; the purple/red, the yellow and the white, and all have different flavors and pungency from mild to highly strong according to color (Khandagale and Gawande, 2019).

According to animal research and clinical studies, onion has been used for the treatment/management of various ailments such as asthmas, cancer, diabetes, hypocholestremic, and osteoporosis (Marrelli *et al.,* 2019). Regular consumption of onions has been reported to reduce the risk of cancer, cataract, DNA

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damage, vascular and heart diseases (Arung *et al.*, 2011). Bamidele, *et al*. (2018), reported that pre-treatment with ethanol extract of *Allium cepa L*, (Purple onion) conferred protection on the hepatocytes of Albino rats against CCl_4-induced liver injury. The sweet taste in cooked onions is due to the reaction of heat on sulphur compound and the flavours come from sulphur compound activated by the enzyme allinase. Onion contains thio-pronanal oxide which produces a weak sulphurous acid that cause pains in the eyes, thus producing tears (Ihekoronye and Ngoddy, 1985). It has been observed that during processing, ketones are released by the Maillard reaction that is responsible for the aroma of onion (Liu *et al.*, 2020). Two principal subgroups of flavonoids are anthocyanins, quercetin, and quercetin derivatives, which impart different colors to onion skins from yellow to purple (Benítez *et al.*, 2011). Quercetinaglycone, quercetindiglucoside, quercetin 4′-glucoside, and kaempferol are the primary flavonoids of onion (Sagar *et al.*, 2020). Waste onion skin also contains a higher level of flavonoids than the edible part (Duan *et al.*, 2015) due to the oxidation of quercetin flavonol into3,4-hydroxybenzoic acid and 2,4,6 trihydroxyphenylglycosilic acid and concentrated in dried onion skin to protect the bulb from soil microbes.

Even though *Allium cepa L.* is widely used as a food and medicinal crop since ancient times, there is paucity of literature on the effect of processing on the vitamins and minerals compositions. This study therefore, will provide critical information on vitamin and mineral composition after its transformation from fresh to dry. It will also help to make an appropriate choice of the method of processing that will produce health promoting onion powder meeting modern consumer requirements.

Plate 1: Fresh purple onion bulb for fresh (Photo by Ijeoma, 2022)

Plate 2: Fresh sliced purple onions for Sun drying (Photo by Ijeoma, 2022)

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Plate 3: Fresh sliced purple onions for oven drying at 70^{o}C (Photo by Ijeoma, 2022)

MATERIALS AND METHODS

Sample collection and identification

One and half (1.5) kilograms of purple onion bulb (*Allium cepa L.*) was purchased from Ose Market, Onitsha North Local Government Area, Anambra State. The primary source of the onions according to the sellers was from Aliero, a town in Kebbi State of Nigeria. The samples were randomly selected based on their freshness. Bulbs were checked for physical defect(s) and those considered fresh were transported in polyethylene bags to Awka. The samples were identified and authenticated by a Taxonomist at the Department of Botany, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria. A voucher number (NAUH-25^{A}) was issued to the specimen and part of it was deposited at Herbarium.

Sample preparation

The epicarps of the purple onion bulb were removed and separated from the stalks for easy assessment. About 500g of raw purple onion bulbs for fresh sample were stored in a cool, dry, well-ventilated place until sun dried and oven dried samples were ready for analyses. About 500g of samples for oven drying were sliced into chips and dried in an electric oven at a temperature of 70^{o}C for 48hours. Also, about 500g of samples for sun drying were sliced into chips and dried under the sun from 8:00am – 6:00pm daily for 21days in March (2022) and packed in polyethylene bags to avoid accumulation of moisture. After drying, the chips were pulverized into fine powder using Electric blender. The powdered samples were stored in an air tight bottle at room temperature (between 25-30^{o}C); then both are ready for use for analyses. Then the bulb onion sample for fresh was sliced and pulverized into fine paste using Electric blender. The paste sample was stored in an air tight bottle for analyses.

Vitamin analyses

Determination of vitamin A content was carried out using the method of Rutkoski *et al.*, (2006).

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Vitamins B_1 and B_2 were determined by the method of Kirk and Sawyer, (1991). This was based on the selective absorption of the vitamins in UV region at 262nm and 242nm respectively.

The Vitamin B_3 content was analyzed using the method of Kirk and Sawyer (1991). While the Vitamin B_6 content determination was carried out using the method of Raeed and Azam (2008).

Vitamin B_9

Determination of vitamin B_9 (Folic acid) content was carried out using the method of Padmarajaiah*et et al.* (2002). This is based on the reaction between diazotization of the *p*-aminobenzoylglutamic acid obtained after reduction of folic acid and *3*-amonophenol.

Determination of vitamin C content was carried out using the method of Klein and Perry, (1982) and **V itamin E** content was determined using the method of Rutkoski*et al.,* (2005).

Mineral contents Determination

Determination of mineral contents was carried out using Atomic Absorption Spectrometer method of AOAC, (2003). The concentration of minerals in each sample was calculated and recorded from a reference standard.

Statistical analyses

All the samples and readings were prepared and measured in triplicate. The results were presented in mean ± standard deviation. The data were subjected to one-way analysis of variance (ANOVA) and the differences between various concentrations were determined using SPSS software version 25. The $p<0.05$ at 95% confidence level was selected as the level of significance. Microsoft Office Excel 2007 worksheet was used to analyze all the results graphically and standard error of the mean was used to represent the error bar of the bar chart.

RESULTS AND DISCUSSION

Vitamin composition of fresh, sun dried and oven dried purple onions:

Results of vitamin composition of fresh, sun dried and oven dried purple onions as shown in the Table 1 below. The results revealed that oven dried sample is richer in all the vitamins when compared to sun dried and fresh sample but vitamin A, which was more in the fresh sample. Sun dried sample has the lowest concentrations of all the parameters assessed except the B_6 which is higher in sun dried sample than in fresh sample.

Table 1: Vitamin composition of Fresh Sun dried and Oven dried purple onion (*Allium cepa L.*) bulb.

Vitamins	Fresh	Sun dried	Oven dried (70^{o}C)
A (µg/100g)	0.63±0.02	0.37±0.02$^{—}$	0.62±0.03
B1 (µg/100g)	39.00±1.00	26.00±2.00$^{—}$	39.60±1.79
B2 (µg/100g)	20.30±0.11	14.20±0.41$^{—}$	23.60±0.91^{++}
B3 (mg/100g)	0.12±0.01	0.10±0.01$^{–}$	0.13±0.02^{++}
B6 (mg/100g)	0.08±0.01	0.09±0.01^{+}	0.12±0.01^{++}
B9 (µg/100g)	20.22±0.08	17.14±0.04$^{—}$	23.65±0.56^{++}

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C (mg/100g)	8.06±0.34	7.55±0.11	13.86±0.46^{++}
E (µg/100g)	20.10±0.23	19.32±0.10	22.50±0.58^{++}

Values are expressed as Means ± standard deviation of Triplicate determinations.

$^{+}$Indicates significant increase from fresh sample, $^{++}$Indicates significant increase from both fresh and sun dried samples, $^{--}$Indicates significant decrease from both fresh and oven dried samples

Mineral composition of fresh, sun dried and oven dried purple onions:

Results of mineral composition of fresh, sun dried and oven dried purple onions as shown in the Table 2 below. The results revealed that oven dried sample is richer in all the minerals assessed [Calcium (Ca), Copper (Cu), Sodium (Na), Potassium (K), Magnesium (Mg), Iron (Fe), Zinc (Zn) and Selenium (Se)] when compared to sun dried and fresh sample but for Phosphorus (P) which is higher in sun dried and fresh samples, and Manganese (Mn) which is higher in sundried sample.

Table 2: Mineral compositions of Fresh, Sun dried and Oven dried purple onion (*Allium cepa L.*) bulb.

Minerals (mg/100g)	**Fresh**	**Sun dried**	**Oven dried (70^{o}C)**
Ca	23.00±0.82	37.17±0.03^{+}	39.29±0.09^{++}
Cu	0.03±0.00	0.08±0.00^{+}	0.09±0.00^{++}
Na	4.12±0.29	8.20±0.24^{+}	8.87±0.27^{+}
K	146.00±2.45	197.67±3.96^{+}	206.00±4.08^{++}
Mg	8.80±0.22	14.30±0.73^{+}	14.87±0.29^{+}
Fe	0.24±0.01	0.37±0.04^{+}	0.47±0.03^{++}
Zn	0.19±0.01	0.30±0.02^{+}	0.32±0.01^{+}
Se	0.48±0.03	0.78±0.02^{+}	0.73±0.02^{+}
P	29.33±0.68	52.67±1.88^{+}	0.51±0.01^{+}
Mn	0.12±0.01	0.18±0.01^{+}	0.16±0.01^{+}
Ca/P**	0.78	0.68	77
Na/K**	0.03	0.04	0.04

Values are expressed as Means ± standard deviation of Triplicate determinations.

**Calculated values. $^{+}$Indicates significant increase from fresh sample, $^{++}$Indicates significant increase from both fresh and sun dried samples.

Discussion

From the results of vitamins in Table 1 above, Vitamin A was present in minimal quantity across fresh, sun dried and oven dried samples, but oven dried sample shows an insignificant ($p>0.05$) decrease in amount when compared to the fresh sample while the sun dried sample shows a significant decrease in vitamin A concentration. The result could be attributed to the oxidation of vitamin A on exposure to heat and the atmospheric oxygen. This is in agreement with the findings of Pengjiao, *et al.* (2023), which reported that Vitamin A loss increases with increasing temperature and increasing moisture loss. Vitamin B_1, B_2, B_9, C and E were found in high amount across fresh, sun dried and oven dried, with the oven dried having significantly higher ($P< 0.05$) concentrations of Vitamins B_2, B_9, C, and E when compared to either of the fresh or sun dried samples. Vitamin C and E are very important antioxidants which protect the cell membranes from oxidative stress/damage caused by free radicals (Guyton and Hall, 2006). Deficiencies of

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these vitamins predispose the red cell membranes to damage leading to haemolysis (Adesina, 2006). Vitamins B_3 and B_6 were detected in trace amounts across fresh, sun dried and oven dried, but even though they are in trace amounts, oven dried sample shows significant increase ($P< 0.05$) in concentrations of both Vitamins B_3 and B_6 when compared to both the fresh and sun dried samples while sun dried sample shows a significant decrease ($P> 0.05$) in vitamin B_3 concentration.

The mineral compositions of fresh, sun dried and oven dried onion are shown in Table 2 above. It was observed that Calcium was present in moderate amount across fresh, sun dried and oven dried, but oven dried sample showed a significantly higher concentration ($P< 0.05$), when compared to other samples. Calcium is reported to be essential for blood clotting, bone and teeth formation and as a co-factor in some enzyme catalysis (Robert *et al.,* 2003). Sodium and magnesium were observed considerably low amount across fresh, sun dried and oven dried samples both was significantly higher in oven dried, when compared to the fresh sample. Low sodium diet has been reported to be beneficial in the prevention of high blood pressure (Lichtenstein *et al.,* 2006). In human, Magnesium is required in the plasma and extracellular fluid, where it helps maintain osmotic equilibrium (Thomas and Krishnakumari, 2015). Potassium was found in high amount across fresh, sun dried and oven dried, but oven dried sample showed higher potassium contents when compared to other samples. Potassium is essential and is required in large amounts for proper growth and plant reproduction. Phosphorus was found in moderate amount in fresh and sun dried but was detected in trace amount in oven dried sample. Moreover, copper, iron, zinc, selenium and manganese were detected in trace amounts across fresh, sun dried and oven dried. These mineral elements are considered critical for the normal functioning of the human body. Iron is required for bone development and hemoglobin production respectively, and also phosphorous is an important component of energy intermediates (Vance *et al.,* 2003). Zinc is vital in protein synthesis, cellular differentiation and replication, sexual functions, membrane stabilizer and a stimulator of the immune response. Copper is a component of many enzyme systems such as cytochrome oxidase, lysyl oxidase and ceruloplasmin, an iron-oxidizing enzyme in blood (Mills, 1981). Manganese, an essential element for hemoglobin formation, was reported to fall within the same range in all the three samples. Na and K maintain the ionic balance of the human body and maintain tissue excitability. Na plays an important role in the transport of metabolites and K is important for its diuretic nature. The ratio of sodium to potassium (Na/K) in any food is an important factor associated with hypertension and arteriosclerosis. Na enhances blood pressure while K depresses blood pressure (Saupi *et al*., 2009). Na/K ratio in the body is of great concern for prevention of high blood pressure; Na/K ratio less than 1.0 is recommended (WHO, 2012). The Na/K ratio (lower than 1) revealed that the vegetables could be valuable in ameliorating sodium-related health risks (Appiah *et al*., 2011). Hence, in the study, fresh, sun dried and oven dried are reported as 0.03, 0.04 and 0.04 respectively, indicating that all the samples would probably reduce high blood pressure because all had Na/K ratio less than 1. Ca/P ratio is low (low calcium, high phosphorous intake), more than the normal amount of calcium may be lost in the urine, decreasing the calcium level in the bones. Food is considered good if the ratio is above one and poor if the ratio is less than 0.5 (Nieman *et al.,* 1992). The Ca/P ratio of fresh, sun dried and oven dried purple onions are 0.78, 0.68 and 77 respectively, indicating that fresh, sun dried and oven dried purple onions would serve as a good sources of the mineral for bone formation. But highest value of 78 was recorded in the fresh sample is better when compared to sun dried and oven dried.

CONCLUSION

Based on the results from the present study, processing of purple onion by oven drying (using electrically powered oven at 70^oC), resulted in the improvement in the quantitative composition of minerals and vitamins of the sample. It also has good Na/K and Ca/P ratios compared to the WHO set standard. Sun drying however, reduced the concentrations of some of the vitamins (A, B_1, B_2, B_3 and B_9), therefore, making it a less preferred way of processing. It can therefore, be concluded that oven drying (at 70^oC) is preferred to sun drying as a processing method, because it produces health promoting onion powder that is a

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rich source of vitamins and minerals. Therefore, it can be concluded that oven drying (at70^{o}C) of purple onions is preferred to sun drying as a processing method, since it enhances its vitamins and minerals composition and make it a good candidate for supplementation of these nutrients in our foods. It is therefore, recommended that *in vivo* studies on the effect of these samples (oven dried onions) on vitamins and minerals deficiency diseases be conducted to ascertain the bioavailability of these nutrients. Also, a sensory evaluation of the processed onion is important in ascertaining the effect of processing on the flavoring effect of the vegetable,

REFERENCES

1. Adesina, S. K., (2006). Studies of some plants used as anticonvulsants in American and African traditional medicine. London, **42** (8): 48-59.
2. Ahmad, S., Nurhan, U., Mehmet, A. O, (2020). The effect of oven drying on bioactive compounds, antioxidant activity and phenolic compounds of white and red-skinned onion slices. Journal of food processing and preservation, **45**(3).
3. Animesh, S., Md, W. H., Mahabub, A., Rahul, B., Mukta, R. and Md, I. H. (2023). Drying conditions and varietal impacts on physicochemical, antioxidant and functional properties of onion powder. Journal of Agriculture and Food Research**, 12**(2): 100578**.**
4. Appiah, F., Oduro, I. and Ellis, W. O. (2011). Proximate and mineral composition of Atocarpusaltilispulpflour as affected by fermentation. Pakinstan Journal Nutrition, **10**(7): 653–657.
5. Arung, E. T., Furuta, S., Ishikawa, H., Kusuma, I. W., Shimizu, K. and Kondo, R. (2011). Anti-melanogenesis properties of quercetin- and its derivative-rich extract from Allium cepa. Food Chemistry. **124(**3): 1024–1028.
6. Ardestani, A., and Yazdanparast, R., (2007). Antioxidant and free radical scavenging potential of *Achilleasantolina* extracts. Journal Food Chemistry, **104**:21–29.
7. Bamidele, T. O., Enemali, M. O**.** and Ijeomah, A. U. (2018) Hepatoprotective Activity of
8. Ethanol Extract of Purple Onion Bulb (Allium cepa Linn) on CCl_4-Induced Hepatotoxicity in Wistar Rats. FUW Trends in Science & Technology Journal 3(1); 149 – 152
9. Barros, L., Ferreira, M. J., Queiros, B., Ferreira, I. C. F. R. and Batista, P. (2007). Total phenols, ascorbic acid, á-carotene and lycopene in portuguese wild edible mushrooms and their antioxidant activities, Food Chemistry. **103**:1314 – 419.
10. Benítez, V., Mollá, E., Martin, A., Lopez, F., Downes, K., Terry, L. and Esteban, R. (2011). Study of bioactive compound content in different onion sections. Plant Foods for Human Nutrition, **66**(1): 48– 57.
11. Dong-Jin, L., Jung-Ah, H., and Seung-Taik, L. (2016). Enhancement of Antioxidant activity of onion powders by browning during drying process. Korean journal food science technology, **48**(1): 15-19.
12. Duan, Y., Jin, D. H., Kim, H. S., Seong, J. H., Lee, Y. G., Kim, D. S. and Jang, S. H. (2015). Analysis of total phenol, flavonoid content and antioxidant activity of various extraction solvents extracts from onion (Allium cepa L.) peels. Journal of Korean Oil and Chemical Society, **32**(3): 418– 426.
13. Ebrahimzadeh, M. A., Seyed, M. N., Seyed, F. N., Fatemeh B. and Ahmad, R. B. (2009). Antioxidant and free radical scavenging activity of H. officinalis, L.angustifolius, V. odorata, B. hyrcana and C. speciosum. Pakistan. Journal of Pharmaceutical Science **23**(1): 29-34.
14. Food and Agricultural Organization (FAO), (2021). FAOSTAT. http://www.fao.org/faostat/en/#data (cited on September 12, 2023).
15. Griffiths, G., Trueman, L., Crowther, T., Thomas, B. and Smith, B. (2002). Onions—A global benefit to health. Phytotherapy Research, **16**(7): 603– 615.
16. Guyton, C., and Hall, J. E., (2006). Textbook of medical physiology. Elseveir publisher, Philadelphia, India. **11**: 113-115.
17. Ihekoronye, A. I. and Ngoddy, P. O. (1985). Integrated Food Science and Technology for the Tropics. Macmillan Publishers Ltd. London and Oxford, Pp. 262-276. Irkin, R., andKorukluoglu, M. (2007). Control of Aspergillusnigerwith garlic, onion and leek extracts. African Journal of Biotechnology, **6**,

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue IV April 2024

384–387.
18. Ijeoma, W.C., Enemali, M.O., Asogwa, K. K., Onwukeme, C.A. and Nwodo, N.M. (2023). The
19. Effect of Processing on the Antioxidant Activities of Purple Onions (Allium Cepa L.), Bulb. The Bioscientist Journal. **11** (2): 194 – 207.
20. Khandagale, K. and Gawande, S. (2019). Genetics of bulb colour variation andflavonoids in onion. The Journal of Horticultural Science and Biotechnology,**94** (4), 522–532.
21. Lee, E. J., Rezenom, Y. H., Russell, D. H., Patil, B. S. and Yoo, K. S. (2012). Elucidation of chemical structures of pink-red pigments responsible for 'pinking' in macerated onion (Allium cepa L.) using HPLC–DAD and tandem mass spectrometry. Food Chemistry, **131** (3): 852–861.
22. Lichtenstein, A. H., Appel, L. J., Brands, M., Carnethon, M., Daniels, S., M., Franch, H. A., Franklin, B., Kris-Etherton, P., Harris, W. S., Howard, B., Karanja, N., Lefevre, M., Rudel, L., Sacks, F., Van Horn, L., Winston, M. and Wylie-Rosett, J. (2006). Summary of American heart association diet and lifestyle recommendations revision, Arteriosclerosis, Thrombosis and Vascular Biology, **26**: 2186-2191.
23. Liu, X., Xia, B., Hu, L.T., Ni, Z. J., Thakur, K. and Wei, Z. J. (2020). Maillard conjugates and their potential in food and nutritional industries: A review. Food Frontiers, **1**(4): 382– 397.
24. Marrelli, M., Amodeo, V., Statti, G. and Conforti, F. (2019). Biological properties and bioactive components of Allium cepaL.: Focus on potential benefits in the treatment of obesity and related comorbidities. Molecules(Basel, Switzerland), **24**(1), 119.
25. Mills, C. F. (1981). Biochemical roles of trace elements. Prognosis Clinical Biology Resources,**77**: 179-188.
26. Nieman, D. C., Batterworth, D. E. and Nieman, C. N. (1992). Nutrition, Dubugue, USA: Wmc. Brown Publish Pp 237-312.
27. Pareek, S., Sagar, N. A., Sharma, S. and Kumar, V. (2017). Onion (Allium cepa Fruit L) and Vegetable Phytochemicals: Chemistry and Human Health. 2nd ed. Hoboken, NJ: Wiley Blackwell. Pp. 1145-1162.
28. Pengjiao, T., Huiying, H., Xiya, Z., Mingqing, C., and Xiqing, W. (2023). Effects of Temperature and Moisture levels on Vitamin A in Total Mixed Ration Silage. Fermentation 9 (7), 614
29. Putnik, P., Gabrić, D., Roohinejad, S., Barba, F. J., Granato, D., Mallikarjunan, K. and Kovaćević, D. B. (2019). An overview of organosulfur compounds from Allium spp.: From processing and preservation to evaluation of their bioavailability, antimicrobial, and anti-inflammatory properties. Food Chemistry, **276**: 680– 691.
30. Robert, K. M., Daryl, K. G., Peter, A. M. and Victor, W. R. (2003). Harper's Illustrated Biochemistry. In Benders and Mayes Vitamins and Minerals, Lange Medical Books/McGraw-Hill, Medical Publishing Division, New York, 496.
31. Sagar, N. A., Pareek, S. and Gonzalez-Aguilar, G. A. (2020). Quantification of flavonoids, total phenols and antioxidant properties of onion skin: A comparative study of fifteen Indian cultivars. Journal of Food Science and Technology, **57**: 2423– 2432.
32. Sahar, R., Mehdi, R., and Sayed, A. (2016). Evaluation of seven different drying treatments in respect to total flavonoid, phenolic, vitamin C content, chlorophyll, antioxidant activity and color of green tea (*Camellia sinensis* or *C. assamica*) leaves. Journal of food science technology, 53(1): 721–729.
33. Saupi, N., Zakaria, M. H. and Bujang, J. S. (2009). Analytic chemical composition and mineral content of yellow velvet leaf (LimnocharisflavaL. Buchenau)'s edible parts. Journal Applied Science, **9**(16):2969–2974.
34. Thomas, R. A. and Krishnakumari, S. (2015). Proximate analysis and mineral composition of Myristicafragrans seeds. Journal of Pharmacognosy and Phytochemistry, **3**(6): 39-42
35. Vance, C. P., Uhde-Stone, C. and Allan, D. L. (2003). Phosphorous acquisition and use: critical adaptations by plants for securing a nonrenewable resource, New Phytologist, **157**: 432–449.
36. WHO, (2012). Guideline: potassium intake for adults and children. World Health Organization: Geneva.