Nutritional composition and antioxidative stress properties in boiled tuberous rhizome of Neel Kamal (Nymphaea nouchali Burm. f.)

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Nymphaea nouchali (Burm. f.) is known as Neel Kamal, Utpal, Kumud and Indeevar in India. Its tuberous rhizome is used for the preparation of various vegetable items, curries and pickles, and is also consumed boiled or roasted. It finds application in folk medicine for the treatment of a number of disease conditions. In this research macro- and micronutrients profiling along with phytochemical analysis of the boiled tuberous rhizome of N.nouchali was carried out. Furthermore, antioxidant activities and antioxidative stress potentials of aqueous methanol extract of boiled tuber were also evaluated. Boiled tuber presents a rich source of carbohydrate, protein, fat, fibres, essential amino acids and fatty acids. Simultaneously, vitamins and minerals were also present in ample amounts. The aqueous methanol extract of boiled tuber contains potent antioxidant phytochemicals. In vitro analysis on HEK-293, CHO and NIH 3T3 cell lines reveal that it effectively quashes H2O2 induced oxidative stress and protects DNA against free radical-induced damage. This research demonstrates that N. nouchali tuber can become an economical dietary adjunct and functional food full of macro- and micronutrient that can help fight against oxidative stress originating due to modern lifestyle induced metabolic disorders. This is the first report presenting nutritional composition and antioxidative stress properties in the boiled tuber of N. nouchali.

Keywords: Antioxidant, Antioxidative stress property, DNA damage, Neel kamal, Nutritional composition, Nymphaea nouchali.

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Introduction

The grace and beauty of water lilies (Nymphaea) had impressed mankind for eons for its flower and tuberous rhizome. From ancient time, the tuberous rhizome of Nymphaea species has been the staple food for many savage races and aesthetic food of civilized people1,2. Underprivileged people used tuberous rhizome of Nymphaea nouchali Burm. f. (Syn. Nymphaea stellata Willd., Family Nymphaeaceae) as food and medicine1,3,5.

In India, N. nouchali is known as Neel Kamal, Utpal, Kumud and Indeevar. Henceforth in this article, the tuberous rhizome will be referred to as tuber. In many parts of the world, it is eaten raw, roasted or boiled. In Bangladesh and some Indian states also, different types of vegetable, curries and pickles are prepared with its tuber. In India, wild N. nouchali is used as food4,6 and is considered a rich source of starch, protein and fibres7. In Sri Lanka, it is cultivated in rice-fields during monsoon period to gather edible tubers8. A toxic alkaloid nupharin is reported to occur in the raw tuber of Nymphaea species2. It is reported that the toxic effect of this chemical gets neutralized when the tuber is cooked8. In Assam and West Bengal states of India, the tuber of N. nouchali is called Sheluk. Villagers of these states collect tuber for their own utilization and boil in water adding a pinch of salt whereas flower is sold in the market for monetary gains6.

Tubers of N. nouchali are astringent and tonic in nature and have been used in diarrhoea, colic, dysentery, dyspepsia, and also used as emollient, diuretic, for back and stomach ache in South-East Asia8. Raw tubers have been accorded best medicine for dysentery4 and possess cooling properties2. In Sri-Lankan folk medicine, the tuber is used for cystitis, nephritis, enteritis, fever and in insomnia conditions9. A novel Ca2+-dependent

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lectin with antiproliferative activity has been identified from *N. nouchali* tuber\(^{10}\). The tuber of *N. nouchali* along with refined jaggery and roots of *Lawsonia inermis* ground with rice-washed water is prescribed for diabetic people in India\(^4\). Antihyperglycemic and antihyperlipidemic properties in *N. nouchali* tubers have also been reported recently\(^{11}\).

This research analyzed nutritional contents and phytochemical constituents in the boiled tuber of *N. nouchali*. Furthermore, in order to validate its healthful effect, the antioxidant activities and antioxidative stress properties of its aqueous methanol extract were also carried out.

**Materials and Methods**

**Sample collection and preparation**

Solid tubers of *N. nouchali* were collected from a pond situated near Chebrulu village of East Godavari district in Andhra Pradesh state of India in the month of March 2017. The pond is situated in the forest area. The pond was devoid of any effluents drainage and pollution activities. Its taxonomic identification was carried out by Professor Dr. Ajmeera Ragan (Department of Botany, Kakatiya University-Warangal, Telangana). The voucher specimen with accession number KUW-1924 was deposited in Kakatiya University herbarium, Warangal.

Tubers were washed properly with clean water to remove muds. Whole tubers with scales were water-boiled in cooking-pot covered with a lid on light flame for 10-15 minutes. Tubers were removed from hot water and cooled. Scales covering tubers were removed. Peeled tubers were chopped into pieces and shade dried. Shade-dried tuber pieces were powdered in food grade mixer-grinder and stored away from direct sunlight at room temperature in air-tight lid bottle.

**Nutritional analysis**

Nutritional analysis of boiled tuber powder was carried out at MFPI-Quality Control Laboratory of PJTS Agricultural University, Hyderabad (India).

**Proximate analysis**

Analysis of carbohydrate\(^{12}\), protein\(^{13}\), fat\(^{13}\), fibre\(^{13}\), ash\(^{14}\) and moisture\(^{14}\) contents and acidity value\(^{15}\) was determined following standard methodologies.

**Sugars**

Total as well as reducing sugars present in *N. nouchali* boiled tuber powder was analyzed following Somogyi method\(^{16}\).

**Vitamins**

Vitamins such as riboflavin, thiamine and niacin were quantified by high performance liquid chromatography method (HPLC)\(^{17}\). Ascorbic content was titrated following method as described by Ranganna\(^{18}\).

**Amino acids**

Analysis of amino acids was carried out by (HPLC) applying photodiode array (DAD) and fluorescence detection simultaneously (DAD: 338 10 nm; Ref 390 20 nm, Fluorescence: *Ex* 340 nm, *Em* 450 nm)\(^{19}\).

**Fatty acids**

Gas chromatographic analysis of fatty acid methyl esters (FAME) was performed and relative retention time of FAME peaks was compared with standard samples of fatty acid for their identification.

**Minerals**

Iron, zinc and calcium content in the boiled powder of *N. nouchali* tuber were measured applying inductively coupled plasma optical emission spectrometry (ICP-OES) technique\(^{20}\).

**Phytochemicals**

Aqueous methanol (1:1) extract of powder was prepared as described earlier\(^{11}\) for evaluation of biological activities.

**Total polyphenol**

Total polyphenol content in aqueous methanol extract was measured using Foli-Ciocalteu reagent\(^{11}\). Absorbance at 765 nm was recorded spectrophotometrically and results were expressed as gallic acid equivalence.

**Total Flavonoid**

An equal volume of 2% aluminium chloride was mixed with aqueous methanol extract of tuber to quantify flavonoids content\(^{11}\). Absorbance was recorded at 430 nm spectrophotometrically and results were expressed in terms of rutin equivalence.

**Phytate**

Phytate was extracted from powder with trichloroacetic acid and further precipitated with ferric salt. The iron content of precipitate was determined colourimetrically and phytate content was determined as described by Wheeler & Ferrel\(^{21}\).

**Oxalate**

Total oxalate was extracted by hydrochloric acid (0.25 N, HCl). Titration method using permanganate was applied for the determination of oxalate\(^{22}\).

**Total carotenoids**

The spectrophotometric technique described by Zakaria *et al.*\(^{23}\) was adopted for the determination of total carotenoids in tuber powder.
Lycopene

Lycopene from tuber powder was repeatedly extracted with acetone followed by petroleum ether. Lycopene colour was measured at 503 nm spectrophotometrically.

Antioxidant activity

[2, 2'-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid)] radical cation (ABTS⁺) and 2, 2-diphenyl-1-picylhydrazyl (DPPH) radicals scavenging potentials as a measure of antioxidant activity was determined in the aqueous methanol extract of tuber. Trolox served as the standard antioxidant reference compound.

Antioxidative stress potential in different cell lines

HEK 293 (Human embryonic kidney cells), NIH 3T3 (Mouse embryonic fibroblast) and CHO (Chinese hamster ovary) cells were grown in tissue culture flask in DMEM (Dulbecco modified eagle medium, Sigma) supplemented with 10% fetal bovine serum and 1× antibiotic solution (Sigma) in a CO₂ incubator at 37 °C (5% CO₂ and 90% relative humidity).

Hydrogen peroxide (H₂O₂) induced oxidative stress and effect of aqueous methanol extract on HEK-293, NIH-3T3 and CHO cells

The effect of aqueous methanol extract on H₂O₂ induced oxidative stress on cells was determined by MTT assay. HEK-293, NIH 3T3 and CHO cells (1×10⁶) were seeded in 96 well plates for 24 h. After 24 hours of incubation, cells were treated with different concentrations of extract for 48 h in the presence and absence of 10 μM H₂O₂. After 48 hours of incubation, 10 μL MTT (3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyltetrazolium bromide-Sigma, 5mg/mL) was added to each well and plates were further incubated for 4 hours at 37 °C in dark. Culture medium from each well was carefully removed out and 100 μL of di-methyl sulfoxide (DMSO) was added. Reduced MTT by metabolically viable cell was determined by measuring absorbance at 570 nm spectrophotometrically.

Antioxidative stress potential (AoxP) of test extract was calculated as follows:

$$100-\left\{\left(\frac{A_t}{A_c}\right)-\left(\frac{A_c}{A_c}\right)\right\} \times 100$$

where ‘A_c’ represents absorbance of cells without H₂O₂ treatment and ‘A_t’ represent absorbance of cells treated with H₂O₂ in the presence or absence of extract.

Fluorescence-activated cell sorting (FACS) analysis of H₂O₂ induced oxidative stress in HEK-293 cells and effect of aqueous methanol extract

Quantification of antioxidative stress potential of the extract was evaluated by flow cytometric analysis in HEK-293 cells. HEK-293 cells were treated sham as above and incubated for 48 h in presence or absence of 10 μM H₂O₂. In order to detect H₂O₂ mediated reactive oxygen species (ROS), cells were treated with fluorogenic dye 2’, 7’-dichlorofluorescin diacetate (DCFDA, 2 μM) at 37 °C for 30 minutes and flow cytometric analysis was carried out. Numerical values generated in triplicate for DCF-positive cells were used to quantify antioxidative stress potential of the extract.

Free radical-induced DNA damage and effect of aqueous methanol extract

The method described by Chang et al. was adopted with suitable modifications to assess free radicals induced damage to pUC18 DNA. The reaction was carried out in tris-buffer (pH 7.4) at 37 °C. FeCl₃ and H₂O₂ were used to generate hydroxyl radicals (OH). In an Eppendorf tube, for control test, pUC18 DNA (2 μg) was incubated with 5 μL tris-buffer. In another set, pUC18 DNA (2μg) along with 5 μL of tris-buffer was enacted with FeCl₃ (5 μL) and 10 μL of 30% H₂O₂. The next set was prepared with pUC18 DNA (2 μg), 5 μL of tris- buffer and 5-10 μL of extract (5 mg/mL prepared in tris- buffer) and incubated for 10 minutes at room temperature. FeCl₃ (5 μL) and 10 μL of 30% H₂O₂ were added to induce a free radical reaction. The volume of the reaction mixture was equalized with the addition of tris-buffer. Tubes were incubated at 37 °C for 15 minutes. To the reaction mixture, 3 μL of 6x gel loading dye was added. Electrophoresis was performed on 0.8% agarose gel containing 3 μL Ethidium Bromide (10 mg/mL), at 85 V for 35 minutes. Gels were viewed under transilluminating UV light and photographed (Bio-Rad ChemiDoc™ XRS+ with Image Lab™ Software).

Statistical analysis

The results were analyzed using one way analysis of variance (ANOVA) followed by Tukey’s Multiple comparison test. The criterion for statistical significance was set at $p < 0.05$. Statistical analysis was performed by using GraphPad PRISM Version 5.01 (GraphPad Software Inc. California, USA). Results were expressed as mean±SEM, n=3.

Results and Discussion

Nutritional composition

Table 1 presents profiles of proximate compositions, sugars, vitamins, minerals and phytochemicals analyzed in the boiled tuber of N. nouchali. It is evident from the table that apart
from macronutrients such as carbohydrate, protein, fat and sugars, *N. nouchali* tuber is also a rich source of micronutrients such as ascorbic acid, niacin, riboflavin, thiamin, calcium, iron and zinc. Among non-nutrient factors, polyphenols, flavonoids and carotenoids were amply detected. There are few reports examining the proximate compositions in the dry tuber of *Nymphaea lotus* (L.)27. The nutrient and non-nutrient content in the tuber of *Nymphaea petersiana* are also available in literature28. The protein and fat contents in *N. nouchali* tuber are very much similar to that present in *Nymphaea lotus* however, the moisture and ash contents were two to three time higher in *Nymphaea lotus*26. Analysis of certain nutrient and non-nutrients present in *N. nouchali* of our study are in proximity of the reported literature29. The oxalate content in the boiled tuber of *N. nouchali* was estimated to be 25 mg/100 g (Table 1). It is pertinent to mention here that the oxalate-rich foods present a risk of calcium-oxalate crystals formation and result in the development of kidney stones. At the same time, calcium-rich foods are shown to prevent the development of hyperoxaluria and reduce crystallization of calcium oxalate29. Therefore, the formation of calcium-oxalate crystals due to the consumption of *N. nouchali* tuber may be averted due to the presence of about six times more calcium content in boiled tuber as observed in our analysis (Table 1).

Plant polyphenols30 and carotenoids31 constitute an important class of dietary antioxidants. These phytochemicals have emerged as new generation therapeutics for treatment and management of a number of modern lifestyle induced diseases32. Supplementation of dietary antioxidants in moderation has been shown to reduce markers of oxidative stress in geriatric population34. Result presented in table 1 shows that boiled tuber of *N. nouchali* contains in ample amount these phytochemicals.

Plant foods providing about 12% of the calorific value from protein are categorized as a good source of protein33 and nutritional value of protein is determined by the kind and quantity of amino acids present in proteinaceous diet28. The amino acids composition of boiled *N. nouchali* tuber is presented in Fig. 1. Among nine essential amino acids required to be taken through diet, eight (isoleusine, histidine, leucine, methionine, lysine, phenylalanine, threonine and valine) were identified in the boiled tuber. The essential amino acid tryptophan could not be identified in our analysis (Fig. 1). The co-essential amino acid arginine, cysteine, glycine, proline, and tyrosine except for glutamine were also detected in our analysis. The sulfur amino acids methionine and cystine, and aromatic amino acids phenylalanine and tyrosine were also present in *N. nouchali* tuber (Fig. 1). Presence of a majority of essential and co-essential amino acids in the boiled tuber of *N. nouchali* makes it an important source of amino acids for; they are primarily responsible for maintenance and activity of muscle protein anabolism34.

Availability of essential fatty acids such as linoleic acid (LA, n-6 fatty acid) and linolenic acid (LNA, n-3 fatty acid) through diet is important for the maintenance of health and management of chronic diseases35. Fatty acids profiling of boiled tuber of *N. nouchali* is presented in Fig. 2. Presence of dietary n-3 and n-6 fatty acids balance is an important criterion to maintain the health of cardiovascular system36. The ratio of n-6/n-3 of ~6:1 and LA (~6%) and LNA (0.75%) represent adequate dietary value36. The fatty acid compositions presented in Fig. 2 are in close proximity to this suggestion. Therefore, this food material may become an ideal source of balanced dietary essential fatty acids.

Oleic acid (n-9 fatty acid) has attracted the attention of researchers in the recent past due to its multiple therapeutic applications. Our analysis finds

| Table: 1 Nutritional profile of boiled tuber powder of *N. nouchali* |
|---------------------------------|-----------------|
| **Proximate**                  |                 |
| Carbohydrate                   | 76.5%           |
| Crude Protein                  | 10.76%          |
| Crude Fat                      | 2.40%           |
| Crude Fibers                   | 0.64%           |
| Ash                            | 3.0%            |
| Moisture                       | 9.07%           |
| **Sugars**                     |                 |
| Total Sugars                   | 6.06%           |
| Reducing Sugars                | 1.26%           |
| Acidity                        | 1.18%           |
| **Vitamins**                   |                 |
| Ascorbic Acid                  | 3.12 mg/100g    |
| Riboflavin                     | 1.11 mg/100g    |
| Thiamine                       | 0.05 mg/100g    |
| Niacin                         | 1.45 mg/100g    |
| **Minerals**                   |                 |
| Iron                           | 1.98 mg/100g    |
| Zinc                           | 1.33 mg/100g    |
| Calcium                        | 148.55 mg/100g  |
| **Phytochemicals**             |                 |
| Total Polyphenols              | 0.12 mg/mL Gallic acid equivalent |
| Total Flavonoids               | 50.63 mg/mL Rutin equivalent |
| Total carotenoids              | 115.22 µg/100g  |
| Anthocyanin                    | 0.16%           |
| Lycopene                       | 0.007 µg/100g   |
| Phytate                        | 149.86 mg/100g  |
| Oxalate                        | 24.97 mg/100g   |
that oleic acid is also an important constituent in *N. nouchali* tuber (Fig. 2). Dietary oleic acid offers protection against free radicals induced damage to the cell membrane and resists oxidative stressors better than n-3 or n-6 fatty acids\(^\text{37}\). Diet high in oleic acid is reported beneficial for hypertensive patients and in improving high density lipoprotein cholesterol\(^\text{38}\). Recently, dietary oleic acid has been shown to reduce levels of inflammation arising due to obesity\(^\text{39}\). Furthermore, the failing heart is reported to restore normal functions when perfused with oleic acid\(^\text{40}\). Therefore, *N. nouchali* tuber may become a richer source of dietary oleic acid for the benefit of patients suffering from disorders involving inflammation as a precursor of disease conditions.

**Antioxidative stress capacity**

Evolutionarily, aerobic organisms have been strained with oxidative stress in order to become bioenergetically more competent and efficient\(^\text{41}\). Since oxidative stress is the result of normal metabolic activities, aerobic organisms are equipped with an inbuilt antioxidant defence mechanism. However, under consistent and over strained circumstances, this defence mechanism fails to protect bodily damages induced due to a variety of free radicals arising under oxidative stress conditions. Therefore, easing out of oxidative stress now-a-days has become a core subject to maintain better health. A diet that encompasses antioxidative stress potentials, therefore, offers a better choice for

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**Fig. 2** — Gas Chromatographic analysis of fatty acid methyl esters (FAME) of boiled tuber powder of *N. nouchali*. Peak denotations: 1. Palmitic acid; 2. Stearic acid; 3. Oleic acid; 4. Linolenic acid; 5. A-Linolenic acid; and 6. Cis-13, 16-Docosadienoic acid.
health maintenance and fight against oxidative stress arising due to a disturbance in metabolic activities.

ABTS$^+$ radical cation and DPPH free radical were effectively scavenged by aqueous methanol extract of *N. nouchali* tuber (SC$_{50}$ value 0.24 μg for ABTS$^+$, SC$_{50}$ value 0.29 μg for DPPH). These results show that it has the capacity to fight against oxidative stress in demanding situations. To test this ability of *N. nouchali* extract, we challenged three normal cell lines to H$_2$O$_2$ in order to induce oxidative stress. The percentage of cell viability was measured as an antioxidative stress capacity of extract. Results are presented in Fig. 3. H$_2$O$_2$ differentially induced oxidative stress in different cell lines. Development of oxidative stress due to H$_2$O$_2$ was recorded more in NIH 3T3 (43.31%, viable cells) followed by HEK-293 (66.9%, viable cells) and CHO (78.99%, viable cells) cell lines (Fig. 3). These results demonstrated that preconditioning of cells with *N. nouchali* tuber extract significantly prevented the development of oxidative stress induced by H$_2$O$_2$. It is important to mention here that the degree of protection offered by different concentrations of extract varied in different cell lines. Although, extract significantly ($p <0.01$) reduced H$_2$O$_2$ induced oxidative stress in HEK-293 cells, increasing extract concentration did not offer additional benefits (Fig. 3a). In CHO cell lines, 0.1 μg concentration could not offer significant protection against H$_2$O$_2$ induced oxidative stress however, significant ($p <0.05$) protection was evident when concentration was increased (Fig. 3b). Contrarily, however, tuber extract offered significant ($p <0.001$) protection to NIH 3T3 cells against H$_2$O$_2$ induced oxidative stress, with increasing concentration activity decreased significantly ($p <0.01$) when compared with a lower dose (Fig. 3c). These observations caution that too much of the antioxidant supplementation may not be always beneficial. Clinical studies with antioxidant concentrated food supplements have recently raised such issues and warranted against the use of such supplements.$^{42}$

Antioxidative stress potential of *N. nouchali* boiled tuber extract was further validated applying fluorescence-activated cell sorting (FACS) analysis. DCFDA fluorescence probe was used as an indicator of ROS generation and oxidative stress. Representative FACS diagram and histogram of triplicate analysis is presented in Fig. 4. DCFDA passively diffuses into the cells and gets oxidized by ROS into the fluorescent product known as 2', 7'-dichlorofluorescin (DCF). Right panel shifts (blue) in Fig. 4 depicts DCF-positive cells representing H$_2$O$_2$ induced oxidative stress. It was found that H$_2$O$_2$ treatment generated

![Fig. 3 — Induction of oxidative stress by H$_2$O$_2$ in three different types of normal cell lines and the effect of AqMeOH extract of the boiled tuber of *N. nouchali*. (a) HEK-293 cells, (b) CHO cells, and (c) NIH 3T3 cells. S0.1=0.1 μg of tuber extract, S1.0=1.0 μg of tuber extract and S10.0= 10 μg of tuber extract. Data represent mean±SEM, n=3. One way ANOVA followed by Tukey’s Multiple comparison test was applied to assess the degree of significance within the groups. *$p <0.01$ when compared with S0.1, S1.0 and S10.0. $^p <0.05$ when compared with S1.0 and S10.0. S0.1, S1.0 and S10.0 not significant when compared among themselves. P=ns when compared with H$_2$O$_2$ and S0.1. $^3p <0.001$ when compared with S0.1 S1.0 and S10.0. $^p <0.01$ when compared with S1.0 and S10.0. p=ns (not significant) when compared with S1.0 and S10.0.](image-url)
significantly ($p < 0.0001$) higher level of oxidants when compared with non-$\text{H}_2\text{O}_2$ treated (control) HEK-293 cells. However, preconditioning of cells with *N. nouchali* boiled tuber extract significantly ($p < 0.0001$) mitigated $\text{H}_2\text{O}_2$ induced ROS generation in HEK-293 cells (Fig. 4).

Free radical induced damage to DNA has been linked to the etiology of numerous disease conditions\textsuperscript{43}. Protective agents against oxidative DNA damage have been identified in dietary materials\textsuperscript{44}. We induced hydroxyl radical mediated damage to pUC18 DNA\textsuperscript{25} and found that *N. nouchali* tuber extract was effective in preventing hydroxyl radicals induced damage to DNA (Fig. 5).

Diet and beverages in the modern industrialized world have become highly processed calorie-rich and energy-dense however, they lack micronutrients, vitamins, minerals and essential dietary co-factors in sufficiency\textsuperscript{45}. Micronutrients rescind diet results in the development of metabolic disorders and consequent oxidative stress. Conversely, whole grain based food accompanied with micronutrients and phytochemicals offer better management of metabolic disorders and counter oxidative stress developed beyond optimal physiological control\textsuperscript{46-48}. The amino acids aspartate, glutamate, tyrosine, cysteine, and homocysteine present in *N. nouchali* tuber are not only building blocks of proteins but also serve the purpose of alleviating oxidative stress\textsuperscript{49,50}. Similarly, fatty acids such as oleic acid\textsuperscript{37} and linoleic acid\textsuperscript{51} resist oxidative stress induced damage to biomolecules. These fatty acids are an important constituent of

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**Fig. 4** — Representative diagram of flow cytometric analysis of HEK-293 cells. (a) HEK-293 control cells; (b) HEK-293 cells+$\text{H}_2\text{O}_2$ (10 $\mu$M); and (c) HEK-293 cells + NNTb (1 $\mu$g) +$\text{H}_2\text{O}_2$ (10 $\mu$M). (d) The histogram presents DCF-positive HEK-293 cells representing the induction of oxidative stress induced due to $\text{H}_2\text{O}_2$. Data represent mean±SEM, n=3. One way ANOVA followed by Tukey’s Multiple comparison test was applied to assess the degree of significance within the groups. *$p < 0.0001$ when compared with control cells as well as *N. nouchali* boiled tuber (NNTb).
N. nouchali. Polyphenols, carotenoids and lycopene are well researched antioxidant phytochemicals. They are amply present in N. nouchali tuber. The observed antioxidative stress potentials of tuber extract in our study on different cell lines might be originating due to the presence of these multiple antioxidant property bearing micronutrients and phytochemicals. Apart from antioxidative properties, N. nouchali tuber extract has also been reported recently to bear antihyperglycemic and antihyperlipidic properties. Taken together, this research demonstrates that tuber of N. nouchali can become an economical dietary adjunct of choice to fight metabolic disorders and consequent oxidative stress.

Conclusion

In conclusion, our analysis finds that N. nouchali tuber not only possesses dietary macronutrients in sufficient quantity but also it is a rich source of micronutrients and phytochemicals that demonstrate multiple therapeutic and beneficial health properties. Therefore, promotion and inclusion of its tuberous rhizome in modern dietary milieu may become advantageous in fighting diseases of metabolic disturbances. To the best of our knowledge, this is the first comprehensive report analyzing the nutritional composition and antioxidative stress potentials in the boiled tuber of N. nouchali.

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Conflict of interest

Authors declare no conflict of interest.

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