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Chemical Content and Antioxidant Potential of Aqueous Extract of Irish Potato Tubers Traditionally Used for Ulcer Treatment in Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The study evaluated the chemical contents and antioxidant potential of aqueous extract of Irish potato tubers traditionally used for ulcer treatment in Nigeria.
Methods: Freshly harvested Irish potato tubers were purchased from Aba grocery market, Abia State. They were thoroughly washed in running water, peeled, sliced and dried in an oven at 60ºC to a constant weight. The dried potatoes were milled into fine powder (flour) and extracted using water as the solvent. The proximate, mineral, phytochemical and vitamin contents as well as antioxidant potentials were determined using standard methods.
Results: The results of the proximate analysis showed that the extract contain high percentage of carbohydrate (76.39±4.06%) followed by crude fat (11.43±0.75%) while crude protein (0.82±0.07%) is the least nutritional composition. Magnesium, sodium and iron contents are high in the extract, but calcium and copper were absent. The extract also contain high amounts of phenols (15.54±0.21%), flavonoids (13.03±1.59%), saponins (8.09±0.43%) and alkaloids (4.46±0.91%), but low in antinutrients. Total antioxidant capacity of the extract was 40.16±1.25 mg/AAE/g, with

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vitamins A, C and E contents being 3.56±0.01 mg/100 g, 61.78±12.48 mg/100 g and 20.39±0.11 µg/100 g respectively.
Conclusion: The results of the present study indicate that Irish potato tubers have high phytochemical content and possess antioxidant potential substantiating its use traditionally in the treatment of stomach ulcers.

Keywords: Antioxidant capacity; peptic ulcer; Solanum tuberosum; phytochemical content.

1. INTRODUCTION

Irish potato (*Solanum tuberosum* L.) belongs to the solanaceae family. It is an edible tuber (Fig. 1) that is thought to have originated around Mexico and Chile. The planting stock were believed to have been obtained from Ireland, hence the name Irish potato. Irish potato was introduced into Nigeria in the later part of the 19th century and early 20th century by the Europeans notably the tin miners in the Jos Plateau [1]. Irish potato is grown for food and as a cash crop. It is currently one of the major sources of income among rural farmers in many African communities [2]. Irish potato contains a wealth of health benefits that make it essential as a staple dietary item for the world's population. These health benefits are thought to include its ability to improve digestion, reduce blood cholesterol, boost heart health, protect from polyps, prevent cancer, manage diabetes, strengthen the immune system, reduce signs of aging, protect the skin, increase circulation, reduce blood pressure, maintain fluid balance, reduce insomnia, and boost eye health [3].

Fig. 1. Irish potato tubers [2]

Potatoes have anti-inflammatory properties attributed to the presence of beta-carotene, vitamin C and magnesium. It is equally effective in curing internal and external inflammation. Potatoes have a soothing effect on the stomach and the intestines. They are reported to be rich in B-complex vitamins, vitamin C, beta-carotene and potassium which are very effective in curing stomach ulcers. Moreover, the roughage in potatoes prevents constipation and the resultant acid formation, thereby reducing the chances of ulcers. The anti-inflammatory and soothing properties of potatoes also reduce pain and inflammation associated with ulcers [4]. The pharmacological effects of plants have been variously associated with their chemical composition.

Phytochemicals are biologically active, naturally occurring chemical compounds found in plants, which provide health benefits for humans further than those attributed to macronutrients and micronutrients [5]. They protect plants from diseases, damage and environmental hazards, and contribute to the plant's colour, aroma and flavor [6]. Recently, it has been discovered that these compounds play important roles in human health when ingested into the body. Dietary phytochemicals are ubiquitous in fruits, vegetables, legumes, whole grains, nuts, seeds, fungi, herbs and spices [6]. Phytochemicals can be found in different parts of the plants but vary in concentrations from plant to plant depending on the variety, growth conditions etc. These compounds are mainly plants' secondary metabolites [7,8]. Among these, phenolics have been reported to be the most abundant and structurally diverse plant phytochemicals with antioxidant property [9].

An antioxidant is a substance when present in low concentrations compared to that of an oxidisable substrate, significantly delays or inhibits the oxidation of that substrate [10]. The physiological role of antioxidants, as this definition suggests, is to prevent damage to cellular components arising as a consequence of chemical reactions involving free radicals. In recent years, a substantial body of evidence has developed supporting a key role for free radicals in many fundamental cellular reactions, suggesting that oxidative stress might be important in the pathophysiology of common diseases including ulcers, atherosclerosis, chronic renal failure, and diabetes mellitus [11]. This study sought to evaluate the proximate, mineral, phytochemical, and vitamin contents, as well as the total antioxidant capacity of aqueous extract of Irish potato tubers.

2. MATERIALS AND METHODS

2.1 Collection and Extraction of Plant Materials

Apparently healthy freshly harvested Irish potato tubers were purchased from Aba grocery market, Abia State, Nigeria and were identified by Prof. J. C. Obiefuna of Department of Crop Science, School of Agricultural Technology, Federal University of Technology Owerri, Nigeria. The potatoes were thoroughly washed in running water, peeled, sliced and dried in an oven at 60ºC to constant weight. The dried potatoes were milled into fine powder (flour). Exactly 100 g of the flour was weighed into a 100 mL conical flask and made up with distilled water. This was mixed with magnetic stirrer and allowed to stand for 24 hours at room temperature with intermittent stirring. The extract was filtered through Whatman No. 2 filter paper and residue discarded. The filtrate was evaporated in a rotary evaporator at 35ºC with a yield of 20% extract in the round bottom flask which was preserved for further analysis.

2.2 Determination of Proximate Composition

Proximate composition made up of moisture, ash, crude fibre, crude fat, crude protein and carbohydrate content of the Irish potato tuber extract was determined in triplicate by the methods described in AOAC [12].

2.3 Determination of Mineral Content

The calcium, potassium, sodium, magnesium, copper, iron, manganese and zinc contents of the Irish potato tuber extract were determined with the aid of an atomic absorption spectrophotometer (Alpha 4, Chem. Tech. Analytical, England). Standard solutions of each of the minerals obtained from Sigma Chemicals, USA were also prepared and co-analyzed with the sample extract preparations [13].

2.4 Determination of Phytochemicals

Phenol and tannins contents of the extract were determined by Folin–Ciocalteu method described in [14]. Oxalate content was determined by the method described by AOAC [12]. Alkaloids and cyanogenic glucoside contents were determined using the method described by Onwuka [15]. Saponin quantitative determination was carried out by the method reported by Ejikeme, et al. [16]. Concentration of flavonoid was determined gravimetrically using the method described by Harbone [17].

2.5 Determination of Antioxidant Potential and Vitamin Content

The total antioxidant capacity of the aqueous Irish potato extract was determined according to the method described by Prieto, et al. [18]. Vitamins A and E contents were determined according to the method described by Rutkowski, et al. [19]. Vitamin C content was determined using the method described by Onwuka [15].

2.6 Statistical Analysis

Analyses were done in triplicates, while data generated were calculated using Microsoft Excel (2017 version) and presented as mean ± standard deviations.

3. RESULTS

The result of the proximate analysis of aqueous extract of Irish potato tuber is presented in Table 1. The extract contain high percentage of carbohydrate (76.39±4.06%) and crude fat (11.43±0.75%), while crude protein (0.82± 0.07%) is the least nutritional nutrient.

Table 1. Proximate composition (%) of aqueous extract of Irish potato tuber

Parameter	Composition (%)
Moisture	1.31±0.03
Ash	4.25±0.18
Crude fat	11.43±0.75
Crude fibre	5.80±0.18
Crude protein	0.82±0.07
Carbohydrate	76.39±4.06

Values are presented as mean ± standard deviation of triplicate determinations

Result of the mineral composition of aqueous extract of Irish potato tuber is presented in Table 2. Magnesium (7.21±0.20 mg/kg) was observed to be the dominate mineral in the extract, followed by sodium (4.67±0.49 mg/kg) and iron (3.67±0.81 mg/kg) respectively. Calcium and copper were not detected in the extract.

The content of phenol (15.54±0.21%) and flavonoid (13.03±1.59%) were high in the aqueous extract of Irish potato. Other phytochemical constituents present in the extract

are saponin (8.09±0.43%), alkaloid (4.46± 0.91%), tannin (0.07±0.01%), cyanogenic glucoside (0.02±0.00%), and oxalate (0.01± 0.00%). The result is presented in Table 3.

Table 2. Mineral content (mg/kg) of aqueous extract of Irish potato tuber

Parameter (mg/kg)	Content (mg/kg)
Calcium	0.00±0.00
Potassium	1.47±0.06
Sodium	4.67±0.49
Magnesium	7.21±0.20
Copper	0.00±0.00
Iron	3.67±0.81
Manganese	0.10±0.02
Zinc	0.33±0.09

Values are presented as mean ± standard deviation of triplicate determinations

Table 3. Phytochemical composition of aqueous extract of Irish potato tuber

Phytochemicals	Concentration (%)
Alkaloid	4.46±0.91
Cyanogenic glucoside	0.02±0.00
Flavonoid	13.03±1.59
Oxalate	0.01±0.00
Phenol	15.54±0.21
Saponin	8.09±0.43
Tannin	0.07±0.01

Values are presented as mean ± S.D of triplicate determinations

Table 4. Total antioxidant capacity and antioxidant vitamins content of aqueous extract of Irish potato tuber

Antioxidant content	Concentration
Total antioxidant capacity of the extract (mg/AAE/ g of extract)	40.16±1.25
Vitamin A (mg/100 g)	3.56±0.01
Vitamin C (mg/100 g)	61.78±12.48
Vitamin E (µg/100 g)	20.39±0.11

Values are presented as mean ± S.D of triplicate determinations

The result of the total antioxidant capacity and antioxidant vitamins content of aqueous extract of Irish potato is presented in Table 4. Total antioxidant capacity (40.16±1.25 mg/AAE/g) as well as vitamin C (61.78±12.48 mg/100 g) was of high concentration whereas vitamins E (20.39 ±0.11 mg/100 g) and A (3.56±0.01 mg/100 g) were low.

4. DISCUSSION

Potatoes are the third most important food crop in the world after rice and wheat. They have a more favorable overall nutrient-to-price ratio than many fruits and vegetables and are an affordable source of nutrition worldwide [20]. Irish potato is recommended for use in modern medicine because it is healthy, nutritious and good for those prone to weight gain. It helps the intestines function properly and heals ulcers [21].

The proximate composition of Irish potato is shown in Table 1. Moisture content estimates directly the water content and indirectly the dry matter content of a sample. It is also an index of storage stability of a substance. Substances with moisture content less than 14% can resist microbial growth and thus have better storability [22]. The low moisture content recorded in the Irish potato tuber used in this study indicates that it can resist microbial growth and thus has good storability. Ash content is a measure of the total minerals present within a food. The considerable amount of ash in the Irish potato tuber used in this study might be responsible for the presence of minerals observed in the sample (Table 2). This corresponds to the findings of Lewu, et al. [23] who reported values between 3.93 and 4.58% for ash content of Irish potato. Food substances with low fat content undergoes minimal rancidity during storage and could be stored for longer period without any discolouration or development of off-odour. Crude fibre has been reported to aid digestion of food through peristaltic movement of the bowel [22]. The extract contain considerable amount of crude fat and crude fibre. The carbohydrate content of Irish potato tuber in this study is 76.39%. This confirms that it is a major source of energy. Crude protein was observed to be low (0.82±0.07%) in this study. This is in contrast with 10.34±0.57% reported by Lewu, et al. [23]. This variation in results could be as a result of factors such as difference in crop variety, climatic or soil conditions, as well as storage conditions [24]. Meanwhile, the high protein value reported in [23] casts a shadow of doubt since tubers are generally known to be high in carbohydrates but low in proteins.

This study showed that Irish potato tuber contains important minerals including potassium and sodium. The potassium content was observed to be 1.47±0.06 mg/kg. This is significantly higher than the 0.64–1.16 of potassium reported by Wekesa, et al. [25] for some varieties of Irish potatoes in Kenya. Deficiency of potassium has been reported to be associated with a risk of high blood pressure, heart disease, stroke, arthritis, cancer, digestive

disorders, and infertility. On the other hand, sodium is essential for the control of blood pressure. It is an electrolyte that controls the extracellular amount of fluid in the body and is needed for hydration. In addition, sodium stimulates the muscles and nerves. There is abundant evidence that a reduction in dietary sodium and increase in potassium intake decreases blood pressure, incidence of hypertension, and morbidity and mortality from cardiovascular disease. Excessive sodium intake has been associated with high blood pressure and stiffening of arterial walls and therefore a risk factor for cardiovascular disease. The moderate amount of sodium (4.67±0.49 mg/kg) observed in this study is of significant health importance. This is similar to the 5.06±0.09 mg/kg previously reported by Lewu, et al. [23] for sodium content of Irish potato tubers.

Similarly, the result of the present study showed that Irish potato tuber contained 7.21±0.20 mg/kg magnesium. Magnesium is an active component of several enzyme systems in which thymine pyrophosphate is a cofactor. Oxidative phosphorylation is greatly reduced in the absence of magnesium. Magnesium is also an essential activator for the phosphate-transferring enzymes myokinase, diphosphopyridine nucleotide kinase, and creatine kinase. It also activates pyruvic acid carboxylase, pyruvic acid oxidase, and the condensing enzymes for the reactions of the citric acid cycle. It is also a constituent of bones and teeth [23].

Iron deficiency is the most common micronutrient deficiency in the world. Women of childbearing age are the highest risk group because of menstrual blood losses, pregnancy, and lactation. Iron conveys the capacity to participate in redox reactions to a number of metalloproteins such as haemoglobin, myoglobin, cytochrome enzymes, and many oxidases and oxygenases. It is required for many proteins and enzymes, notably haemoglobin to prevent anemia. Anemia has been shown to be linked to maternal mortality and premature child birth [26]. The results obtained in this study shown that Irish potato tuber contain substantial amounts of iron, thus might be a haematopoietic agent.

Manganese (Mn) is a cofactor of hydrolase, decarboxylase, and transferase enzymes [23]. It is involved in glycoprotein and proteoglycan synthesis and is a component of mitochondrial superoxide dismutase. Manganese is a co-factor in phosphohydrolases and phosphotransferases involved in the synthesis of proteoglycans in cartilage. Mn is a part of enzymes involved in urea formation, pyruvate metabolism and the galactotransferase of connective tissue biosynthesis. Mn activates several important enzyme systems and in this capacity it is required for the synthesis of acid mucopolysaccharides, such as chondroitin sulphate, to form the matrices of bones. Consequently skeletal deformities occur when manganese intake is inadequate [27]. Thus, the observed 0.10±0.02 mg/kg of manganese in Irish potato tuber used in this study is also of a significant health importance.

The concentration of zinc in Irish potato tuber in this study was observed to be 0.33±0.09 mg/kg, while copper and calcium were not detected in the sample. Zinc has been noted to be a very important element for normal body metabolism. Zhang, et al. [28] reported that zinc contributes to host defense mechanism by maintaining the structure and function of the membrane barrier, an activity that is especially important in the gastro-intestine tract, by virtue of the fact that it is continuously exposed to plenty of pathogens and noxious agents. Also, zinc acts as the essential element in the physiology of the digestive system, accelerating the process of wound healing of various types of tissues including gastric ulcer. The gastry may be impaired in conditions of zinc deficiency, depending on the severity of the deficiency. Zinc deficiency may cause enhanced severity of infectious diseases. Thus, zinc supplementation has been linked with reduced incidence of infections, and severity of the symptoms [29]. The presence of zinc in Irish potato tubers might enhance its healing potential against ulcers.

Results of the present study show that Irish potato is rich in phenols, flavonoids and saponin, has mild contents of alkaloid and minute content of antinutrients (cyanogenic glycoside, oxalate and tannins) (Table 3). This is consonance with previous studies that have shown that Irish potatoes are good source of phenolic compounds with several reported bioactivities such as anti-oxidative, cytotoxic and anti-microbial activities [30]. Phenols are recognized as the most abundant antioxidants in human diet. Several unidentified polyphenols were reported to be present in potatoes [31]. The largest proportion comprised of chlorogenic acid, being more than 90% of phenolics. The phenolics are present in both skin and flesh of potatoes, with

the concentration being higher in the skin. The phenols can be recovered from the skin portion, which is discarded as waste during processing and can be used for value addition in different food products [32].

Irish potato tubers are also rich in flavonoids. The flavonoids in order of abundance have been reported to be catechin, epicatechin, erodictyol, kaemeferol and narigenin [33]. Potato peel contains quercetin, a flavonol with antioxidant activity. The antioxidant activity of flavonoids is efficient in trapping hydroxyl ($OH^{\cdot}$), peroxyl ($ROO^{\cdot}$) and alchoxyl ($RO^{\cdot}$) radicals. Flavonols promote gastric mucosa formation, diminish acid mucosal secretion, inhibit the production of pepsinogen and decrease ulcerogenic lesions. They have also been reported to act in the gastrointestinal tract, exhibiting antiplasmodic, anti- secretory, antidiarrhoeal and antiulcer properties. Several studies have linked the potential of some plants' extracts to prevent peptic ulcer due to the presence of flavonoids [34,35,36].

Tannins and saponins were also detected in Irish potato tubers. Tannins are known to "tan" the outermost layer of the mucosa and render it less permeable and more resistant to chemical and mechanical injury or irritation [37]. They form a protective pellicle by promoting precipitation of proteins on ulcers in order to prevent further ulceration development. The pellicle helps in preventing toxic substances absorption and combat the attack of proteolytic enzymes. Similarly, saponins exert protective activities in ulceration by the activation of mucus membrane protective factors. They have been reported to protect the gastric mucosa from acid effects by selectively inhibiting prostaglandin [38]. Detected also are alkaloids, which are bioactive secondary metabolites derived from amino acids biosynthesis or transamination processes. Alkaloids are endowed with diverse biological activities. Among the reported biological effects they present are antitumor, anticholingeric, diuretic, sympathomimetic, antiviral and anti-inflammatory properties. However, there are also reports of its toxic effects to humans [37,38].

The results of the total antioxidant capacity (TAC) of the extract and antioxidant vitamins are shown in Table 4. Repetto and Llesuy [39] reported that the phosphomolybednum assay for total antioxidant determination is a quantitative method to investigate the reduction rate among antioxidants. Total antioxidant capacity is based on the reduction of Mo (vi) to Mo (v) by the extract and subsequent formation of blue-green phosphate Mo (v) complex at acidic pH. TAC of the phosophomlybdenum model evaluates both water soluble and fat-soluble antioxidant capacity. The result shows that aqueous extract of Irish potato has enough antioxidant compounds equivalent to ascorbic acid to effectively reduce the oxidants in the reaction matrix. The reduction of Mo (vi) to Mo (v) by the extract may be due to electron transfer or hydrogen ion transfer by bioactive compounds and antioxidant vitamins present in the extract. Ito, et al. [40] reported that antioxidants have protective role in gastric ulcers and carcinoma.

Antioxidant capacity of ascorbic acid has been used as a reference standard from which plant extracts with potential antioxidant activity are compared [41].The result of this study showed that Irish potato has higher vitamin C content compared to vitamins A and E. Previous data indicate that potatoes rank 5th in terms of dietary source of vitamin C [42]. Vitamins A, C and E are collectively known as the ACE vitamins because of their key importance in biological systems. Vitamin A is fat soluble vitamin whose precursor is beta carotene. Beta carotene is a naturally occurring orange coloured carbon–hydrogen carotenoid abundant in yellow orange fruits and vegetables, and in dark green leafy vegetables. It is the most widely distributed carotenoid in foods. Potatoes are good source of carotenoids which are lipophilic compounds synthesized in plastids from isoprenoids. Diretto, et al. [43] claimed that 50% of the recommended daily allowance of vitamin A can be met by consuming 250 g of carotenoids-enriched genetically engineered potatoes.

Vitamin C (ascorbic acid) is a water soluble antioxidant that directly scavenges reactive oxygen species (ROS) like superoxide, hydroxyl radicals, hydrogen peroxide, singlet oxygen and hypocholorus acid. Vitamin C also guarantees the chain breaking antioxidant action of vitamin E by reducing vitamin E radical to its stable form [44]. In addition, vitamin C is critical for wound healing and tissue repair. Several studies have suggested that its deficiency is associated with an increased risk of peptic ulcer hemorrhage. It has been shown to attenuate aspirin-induced gastric damage and to offer effective gastro protection. Morris [45] suggested that diet rich in vitamin C could play a role in the treatment of peptic ulcer.

Vitamin E (alpha-tocopherol), a lipid – soluble antioxidant scavenges reactive oxygen species (ROS) and functions as a chain breaking antioxidant for peroxidation of membrane lipids. It has been shown to inhibit neutrophils adhesion to endothelial cells and oxygen production in activated neutrophils. Anti-ulcer effects of vitamin E on aspirin and ethanol-induced ulcers have been reported by Fesharki, et al. [46]. The result compares favorably with the report of Andre, et al. [47] who reported that potatoes contain little fat soluble content, thus only minimum amount of tocopherol was found.

5. CONCLUSION

The results of the present study indicate that Irish potato tuber extract has high content of nutritional compounds and minerals, low in antinutrients, and high in phenolic compounds and vitamins accounting for its antioxidant potential. Thus, the traditional use of Irish potato tuber in the treatment of gastrointestinal-associated ulcers could be attributed to the presence of these important properties.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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