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Research Article

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Investigation of Solvent Efficiency in Extraction of Bioactive Constituents from Peels, Leaves and Tubers of Sweet Potato

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Abstract

The effectiveness of solvents in extracting phytochemicals from leaves, peels and tubers of sweet potato was studied with a view of knowing the best solvent for extraction as well as establishing the availability of bioactive constituents in different parts of sweet potato. The peels, leaves and tubers of sweet potato were obtained, cut, air-dried, ground, sieved with 40 mm mesh and separately extracted using six different solvents (acetone, ethyl acetate, methanol, ethanol, water and chloroform) at ratio 1:10 for 72 h. The extracts obtained using six different solvents on peels, leaves and tubers of sweet potato were screened for phytochemicals. It was observed that all the three parts of sweet potato considered were rich in phytochemicals, although the peels and tubers contained relatively higher bioactive constituents than that available in the leaves. The extraction efficiency of the solvents in obtaining bioactive constituents from leaves, peels and tubers of sweet potato is highest in ethanol, followed by methanol, acetone and ethyl acetate while the least were in chloroform and water.

Keywords: Sweet Potato, Bioactive Constituents, Solvents, Solvent-Efficiency.

Introduction

In recent times, the use of plant extracts as preservatives have become very important because of the increase in demand by consumers for safer and less harmful preservatives in food products due to the adverse effects of unnatural preservatives. The helpful effects of plant products are primarily attributed to their phytochemical composition [1]. Tens of thousands of phytochemicals have been identified, and researchers speculate that there are likely many more they haven't yet discovered in the foods we eat [2].

Phytochemicals are defined as bioactive nutrient or plant chemicals found in fruits, vegetables, grains and other plant foods that may provide desirable health benefits beyond basic nutrition to reduce the risk of major chronic diseases In recent years the term 'phytochemical' has been used to distinguish plant chemicals that do not meet the classical definition of 'essential nutrients' [3]. Phytochemicals have great antioxidant potentials and are of great interest due to their beneficial effects on health of human being [4]. and they give immense health benefits to the consumers [5]. Phytochemicals impart plants with colour, aroma, flavor and protection from infection and predators. The phytochemicals may stimulate the immune system, slow the growth rate of cancer cells, and prevent DNA damage that can lead to cancer and other diseases [6]. Phytochemicals found in medicinal plants are alkaloids, tannins, saponins, flavonoids, phenols, steroids, carotenoids, etc., and they have several disease prevention activities [7]. These plant-derived chemical compounds play important preventive activities such as anti-inflammatory, antidiabetic, antiaging, antimicrobial, antiparasitic, antidepressant, anticancer, antioxidant, and wound healing [8]. They also have great role in stress tolerance of plants and accumulation of many important bioactive compounds in fruits and vegetables [9].

Sweet potato (Ipomoea batatas (L) Lam.) is a member of convolvulaceae. It is a dicotyledonous perennial plant grown for its edible storage roots[10]. Sweet potatoes grow very well in tropical and subtropical climates and they are very sensitive to cold weather where there is sufficient water to support their growth. They grow best at temperatures in excess of 25 oC in well-draining, loamy soil with a pH of 5.6-6.6 [10]. Sweet potato should be planted in

full sun and require plenty space as the vines will spread over the large areas. The crop is sensitive to drought at the tuber initiation stage 50-60 days after planting, and it is not tolerant to water-logging, as it may cause tuber rots and reduce growth of storage roots if aeration is poor [11]. This is an extremely versatile and delicious vegetable that possesses high nutritional value. It is also a valuable medicinal plant having anti-cancer, antidiabetic and anti-inflammatory activities Because of its high nutritional content and wide adaptability to marginal lands in areas ranging from the tropics to temperate zones. Ipomoea batatas is native to tropical America. It is a creeping plant with gnarled stems and adventitious roots. The stem is green or purple, pubscent, 1-2 to 8 m long. The tuberous root can have different shapes and colours depending on the variety grown. The skin and flesh can be white, yellow or orange (because it contains carotene). The leaves can also differ in cultivars [12], and even in the same plant, the leaf stalk is 5-20 inches long, the leaf blades are a variable of about 5-13 centimeteres long [13]. They can be pale green or dark green in colour. Potato peel waste can be utilised as a natural source of antioxidants that otherwise may create disposal-related problems leading to environmental pollution [14]. Nutritional composition of different potato varieties includes carbohydrate, protein, dietary fibre, vitamins, minerals, phenolic compounds, carotenoids, organic acids and glycoalkaloids have been documented [15]. However, there is limited or no literature on the use of different solvents in verifying possible extractable phytochemical from the leaves, peels and tuber of sweet potatoes. Hence this research work centers on the use of ethanol, methanol, acetone, ethyl acetate, chloroform and water to obtain extracts from the leaves, peels and tuber of sweet potatoes as well as to screen the different solvent extracts for phytochemicals with the objective to rank the parts of the plant and the solvent extracts in terms of richest in bioactive ingredients.

Materials and Methods

Source of Materials

The peels, leaves and tubers of sweet potato were collected from a compound of a building at Ajagbale Street, Oka, Ondo City, Ondo State, Nigeria. All chemicals used were of analytical grade with the highest purity available (<99.5%) and procured from Sigma Aldrich, USA.

Preparation and extraction of peels, leaves and tubers of sweet potato

Peels, leaves and tubers of sweet potato were cut into smaller pieces for easy air-drying. The dried samples were ground separately using electric blending machine (Solitarire Mixer Grinder VTCL Heavy Duty 750 Watts) and each part was sieved with 40 mm mesh size. The powdered samples were divided into portions, packed in air tight containers labelled appropriately prior to extraction. 20 g of each sample was extracted separately with 200 mL of each solvent (acetone, chloroform, ethyl acetate, ethanol, methanol and water) for 72 h during which it was intermittently shaken on a shaking orbit machine. The resulting mixture was filtered through a 0.45 µm nylon membrane filter. The extracts were desolventised to dryness under reduced pressure at 40 oC by a rotary evaporator (BUCHI Rotavapor, Model R-124, Germany). The dry extracts were stored in a refrigerator (4 0C) prior to analysis [16, 17].

Phytochemical screening of solvent-extracts of peels, leaves and tubers of sweet potato The phytochemicals were qualitatively determined using standard methods described by Trease and Evans, 1989; Evans, 2002 and Sofowora, 2008.

Test for Tannin

About 0.2 g of the extract was taken and 2 mL of 10 % ferric chloride was added. Color changes into blue black which indicates the presence of tannin.

Test for Alkaloid (Wagner's test)
About 0.2 g of the extract was hydrolyzed by 1% hydrochloric acid; six drops of Wagner's reagent were added. Color changes into brown red/orange precipitate which indicates the presence of alkaloid.

Test for Saponin

About 0.2 g of the extract was added with 5 mL of distilled water, it was shaken for 30 seconds and the presence of foam indicates presence of saponin.

Test for Terpenoid (Salkowski test)

About 3 mL of chloroform was added to about 0.2 g of the extract and then concentrated sulphuric acid was added from sides of the test tube. The presence of reddish brown color appears at the interface indicates the presence of terpenoids in extract.

Test for Cardiac Glycoside (Keller - Killiani test)

About 0.2 g of the extract was taken and then 1 mL of glacial acetic acid was added and 1 mL of 10% ferric chloride was added, then 1 mL concentrated sulphuric acid was added from the sides of test tube. Formation of green/blue precipitate indicates the presence of cardiac glycoside.

Test for Steroid (Lierbermann-Burchardt test)To about 0.2 g of the extract, 1 mL chloroform was added, 3 mL acetic anhydride was added from sides of the test tube, and then two drops of concentrated sulphuric acid was added. The appearance of dark green color confirms the presence of steroids.

Test for Flavonoid

About 0.2 g of the extract was taken; dilute sodium hydroxide was added to create intense yellow color, which on addition of concentrated hydrochloric acid turns into colorless which indicates the presence of flavonoids.

Test for Reducing Sugars (Fehling's test)

About 0.2 g of the extract was shaken with distilled water and filtered. The filtrate was boiled with drops of Fehling solution A and B for few minutes. An orange red precipitate indicates the pres-

ence of reducing sugar.

Test for Phlobatannin

About 0.2 g of the extract was added with distilled water then shaken and filtered, then 2 mL of 2% hydrochloric acid was added and boiled. Red colored developed which indicate the presence of phlobatannin.

Test for Phenol

2 mL of distill water followed by few drops of 10% ferric chloride was added to about 0.2 g of the extract. Formation of blue or green color occurred which indicates the presence of phenol.

Test for Volatile Oil

0.1 mL dilute sodium hydroxide and small quantity of dilute hydrochloric acid was added to about 0.5 g of the extract and the solution was shaken. White precipitate was formed which indicates the presence of volatile oil.

Test for Quinone

To about 0.2 g of the extract, 1 mL of concentrated sulphuric acid was added. Formation of red color indicates presence of quinone.

Results and Discussion

Table 1: Qualitative phytochemical screening of solvent extracts of sweet potato peels

	Solvent extracts					
Phytochemical	**Acetone**	**chloroform**	**Ethanol**	**Ethyl acetate**	**Methanol**	**Water**
Alkaloid	+	+	+	+	+	+
Flavonoid	+	-	+	+	+	+
Saponin	-	-	+	-	-	+
Cardiac glycoside	-	-	-	-	-	-
Reducing Sugar	+	-	+	+	-	+
Tannin	+	-	+	+	+	-
Quinone	-	-	-	-	-	-
Volatile oil	+	-	-	-	+	-
Phenol	+	-	+	+	+	-
Terpenoid	+	+	+	+	+	+
Phlobatannin	-	-	-	-	-	-
Steroid	-	-	-	-	-	-
%Phytochemical extractable	58.33	16.67	58.33	50.00	50.00	41.67

KEY: (+) =Present (-) =Absent

Qualitative phytochemical screening of solvent extracts of sweet potato peels is depicted in Table 1. The presence of alkaloid and terpernoid were observed in all the solvent extracts of sweet potato peels. Flavonoid was present in all the solvent extracts except for chloroform extract. It was only ethanol and water extracts of sweet potato peel contained saponin. Cardiac glycoside, quinone, phlobatannin and steroid were not present in all the solvent extract of sweet potato peels. Reducing sugar was absent in chloroform and methanol extracts but it was detected in other solvent extracts. Tannin and phenol was detected in ethanol, ethyl acetate, acetone and methanol extracts. Volatile oil was present only in acetone and methanol extracts. In general overview of solvent efficiency of all the twelve phytochemicals considered in sweet potato peels, it was established that acetone and ethanol were able to extract 58.33%, ethyl acetate and methanol extracted 50.00% each, water extracted 41.67% while chloroform extracted 16.67%. Acetone and ethanol extracts of sweet potato peels showed the highest presence of phytochemicals while chloroform extract had the least presence of phytochemicals

Table 2: Qualitative phytochemical screening of solvent extracts on sweet potato leaves.

Solvent Extracts						
Phytochemical	**Acetone**	**Chloroform**	**Ethanol**	**Ethyl acetate**	**Methanol**	**Water**
Alkaloid	+	+	+	+	+	+
Flavonoid	+	-	+	+	+	-
Saponin	+	-	+	+	+	-
Cardiac glycoside	+	+	+	-	+	-
Reducing sugar	-	+	+	-	-	+
Tannin	-	-	-	-	-	-
Quinone	-	-	-	-	-	-
Volatile oil	-	-	-	-	-	-
Phenol	+	-	+	+	-	-
Terpenoid	-	-	-	-	-	+
Phlobatannin	-	-	-	-	-	-
Steroid	+	+	+	+	+	-
%Phytochemical extractable	50.00	33.33	58.33	41.66	41.66	25.00

KEY: (+) =Present (-) =Absent

Qualitative phytochemical screening of solvent extracts on sweet potato leaves is shown in Table 2. Alkaloid was detected in all the solvent extracts of sweet potato leaves. All the solvents except chloroform and water extracted flavonoid and saponin from the sweet potato leaves. Cardiac glycoside was present in acetone, chloroform, ethanol and methanol extracts of sweet potato leaves. Chloroform, ethanol and water extracts of sweet potato leaves contained reducing sugar. Tannin, quinone volatile oil and phlobatannin were conspicuously not detected in all the solvent extracts. Phenol was found in acetone, ethanol and ethyl acetate extracts of the plant sample. Only water extracts among all the solvent extracts contained terpenoids. There was presence of steroids in all the solvent extracts except water extract. Considering the efficiency of the solvents to extract bioactive constituents form sweet potato leaves, it was found that out of the twelve bioactive constituents screened, ethanol extract had 58.33%, acetone extract had 50.00%, ethyl acetate and methanol extracts had 41.66% each, chloroform extract had 33.33% and water extract had 25.00%. The ethanol extract of sweet potato peel ranked highest while the water extract ranked least in phytochemical constituents.

Table 3: Qualitative phytochemical screening of solvent extracts of sweet potato tubers.

Solvent Extracts						
Phytochemical	**Acetone**	**Chloroform**	**Ethanol**	**Ethyl acetate**	**Methanol**	**Water**
Alkaloid	+	+	+	+	+	+
Flavonoid	+	-	+	+	+	-
Saponin	-	-	-	-	-	+
Cardiac glycoside	-	-	-	-	-	-
Reducing sugar	-	+	+	-	+	-
Tannin	+	-	+	+	+	-
Quinone	-	+	+	-	-	-
Volatile oil	+	-	+	+	-	-
Phenol	-	-	+	+	+	-
Terpenoid	-	+	+	+	+	+
Phlobatannin	-	-	-	-	-	-
Steroid	-	+	-	-	+	-
%Phytochemical extractable	33.33	41.67	66.67	50.00	58.33	25.00

KEY: (+) =Present (-) =Absent

The qualitative phytochemical screening of solvent extracts of sweet potato tubers is presented in Table 3. The acetone extract of the sweet potato tubers exhibited the presence of alkaloid, flavonoid, tannin and volatile oil. Chloroform extract showed the presence of alkaloid, reducing sugar, terpenoid, quinone and steroid. There were presence of alkaloid, flavonoid, reducing sugar, tannin, quinone, volatile oil, phenol, terpenoid in ethanol extract of sweet potato tubers. Ethyl acetate extract contained alkaloid, flavonoid, tannin, volatile oil, phenol and terpenoid out of the twelve phytochemical constituents considered. Methanol extract showed the presence of alkaloid, flavonoid, reducing sugar, tannin, phenol, terpenoid and steroid. In water extract, alkaloids, saponin and terpenoid were the phytochemicals detected. The overview of solvent efficiency in extracting phytochemical constituents from sweet potato tubers showed that ethanol extract had 66.67%, methanol extract had 58.33%, ethyl acetate extract had 50.00%., chloroform extract had 41.67%, acetone extract had 33.33% and water extract had 25.00%. Ethanol extract of sweet potato tubers contained highest number of phytochemicals while methanol extract, ethyl acetate extract, chloroform extract, acetone extract and water extract rated the second, third, fourth, fifth and sixth respectively.

Considering the number of bioactive constituents identified in Table 1 to Table 3, there was noticeable absence of phlobatannin in all the solvent extracts of peels, leaves and tubers of sweet potato. It was observed that all the three parts of sweet potato considered are relatively rich in phytochemicals. The sweet potato peels and tubers had the same number (thirty three (33)) of identified phytochemicals in all the solvent extracts and it was thirty (30) phytochemicals identified in all the solvent extracts in the sweet potato leaves. In other hand, considering the solvents used for extraction of phytochemicals in peels, leaves and tubers of sweet potato, it was noted that ethanol extracted twenty two (22) phytochemicals, methanol extracted eighteen (18), acetone and ethyl acetate extracted seventeen (17) each while chloroform and water extracted eleven (11) each in all the three parts of sweet potato examined.

Conclusion

Nature and types of solvents used for extraction of bioactive ingredients is an important factor to be considered. Ethanol, methanol, acetone and ethyl acetate served as better solvents than water and chloroform in obtaining bioactive components from the peels, tubers and leaves of sweet potato. Peels and tubers of sweet potato are relatively richer in phytochemicals than the leaves of sweet potato. Further research can be conducted in utilizing the ethanol, methanol, acetone and ethyl acetate extracts of peels, tubers and leaves of sweet potato as antioxidants or preservatives in both refined and crude edible oils; and their antioxidant activities can be compared with the antioxidant activities of synthetic antioxidants (such as butylated hydroxyl toluene (BHT), butylated hydroxyl anisole (BHA), propyl gallate (PG) etc.) in edible oils.

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