



Developments on the Bioactive Compounds and Food Uses of the Tubers: *Colocasia esculenta* (L) Schott (Taro) and *Xanthosoma sagittifolium* (L) Schott (Tannia)

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Authors' contributions

This work was carried out in collaboration between both authors. Author CJM managed the literature searches, and wrote the first draft of the manuscript. Author HOA read and made corrections to the manuscript. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2021/v20i1130380

Editor(s):

(1) Dr. Nelson Pérez Guerra, University of Vigo, Spain.

Reviewers:

(1) Heba A Yassa, Assiut University, Egypt.

(2) Tolulope Ayodeji Olatoye, Forestry Research Institute of Nigeria, Nigeria.

Complete Peer review History, details of the editor(s), Reviewers and additional Reviewers are available here:

<https://www.sdiarticle5.com/review-history/77903>

Review Article

Received 10 October 2021
Accepted 13 December 2021
Published 14 December 2021

ABSTRACT

Two varieties of Cocoyam *Colocasia esculenta* (L) Schott (Taro) and *Xanthosoma sagittifolium* (L) Schott (Tannia) are experiencing renewed interest not only in Africa but also in the rest of the world. They are considered to be cheaper sources of carbohydrates than cereals or other bulbous crops because of their high calorie yield per hectare, low production costs, and relatively low susceptibility to insect and pest infestation. In addition to their nutritional benefits, they contain bioactive compounds such as polyphenols, proteins, mucilage, polysaccharides, lipids and anti-polyphenol antioxidants. These bioactive compounds have been shown to provide consumers with health benefits such as anti-cancer, anti-inflammatory, antioxidant and dyslipemic properties. Interestingly, you don't need to consume the raw tubers or leaves to get these numerous health benefits, as the different parts of the plants which are nutrient-dense, have been used in various food applications such as flour, chips, poi, syrup, weaning foods for babies, local delicacies, and starch production. These products compete favourably with products from other root and tuber crops. Therefore, this article describes various value-added products made from Cocoyam that can be consumed to reap the numerous health benefits associated with consuming Cocoyam.

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Keywords: Cocoyam; bioactive compounds; anti-oxidants; anti-inflammatory; anti-cancer; type-2 diabetes; obesity.

1. INTRODUCTION

1.1 Cocoyam

Cocoyam, a monocot, is an edible aroid in the Araceae family. There are two main varieties in Nigeria: *Colocasia esculenta* (L) Taro, Schott and *Xanthosoma sagittifolium* (L) Schott, Tannia. It is recognized as cheaper carbohydrate sources than grains or other tuber crops [2]. It has high caloric yield per hectare, low production cost [1] and has relatively low susceptibility to insect and pest attack [3]. It has the potential of meeting the fundamental requirement of the body being very rich in nutrients notably carbohydrates, proteins, vitamins and minerals [2]. Due to its high nutrient content, cocoyam is consumed by the rich and poor. The corms of tannia cocoyam are highly superior to taro cocoyam in energy and protein although they contain much less calcium, magnesium, zinc, and trypsin inhibitor than taro cocoyam [4]. Fresh corms of tannia contains 20-30% starch and 1-4% proteins. Nearly all calcium present is in the form of calcium oxalate [5].

1.1.1 Nutritional composition of cocoyam

Cocoyam, like other roots and tubers, contains dietary energy consisting primarily of carbohydrates. It has more carbohydrates than potatoes [6], and about 100g produces 112 calories. It has low protein content 1-2%, like other root crop proteins, which means that sulphur-containing amino acids are relatively small [2]. However, it contains very low fat and protein than in cereals and pulses [2]. The levels of protein are almost the same as that of yam, cassava, potato, and banana [6]. Despite their high starch content, cocoyam has a higher content of protein and amino acids than many other roots and tuber [7]. Table 1 shows the nutritional content of cocoyam. The protein content of cocoyam is higher (1.12% for taro and 1.55% for tannia) than that of other root crops [8].

Cocoyam, contains high-quality Phyto-nutrition profile comprising of dietary fibre, and antioxidants with a moderate quantity of minerals, and vitamins, as well as being gluten-free [9]. Valuable B-complex group of vitamins is also present in cocoyam which includes;

pyridoxine (vitamin B6), folate, riboflavin, pantothenic acid, and thiamine. Also, the corms contain some important minerals like zinc, magnesium, copper, iron, and manganese. Researchers like [10] and [11] studied two major globulins from corms of taro and they observed the existence of two unrelated globulin families during root development; a G2 and G1 protein-which accounts for the total soluble tuber proteins (about 80%).

Cocoyam is a good source of thiamine, riboflavin, phosphorus, and zinc, as well as a source of vitamin B6, vitamin C, and niacin. It contains valuable vitamin B complex groups such as pyridoxine, folate, riboflavin, pantothenic acid and thiamine [12]. Due to its high water content, cocoyam is susceptible to microbial attack and spoilage, which contributes to the short shelf life of the tuber. The leaves are used to feed pigs because of their nutritional value [13]. The leaves are good sources of vitamins A and C and contain a fairer amount of protein than the tubers [14]. Cocoyam's high vitamin B6 content is good for controlling high blood pressure and protecting the heart [15]. Cocoyam contains some fibre that helps regulate gut health, lower cholesterol, and control blood sugar levels [16]. About 100 g of cocoyam pulp provides 4.1 g or 11% of the recommended daily fibre. The presence of slowly digesting complex carbohydrates leads to a gradual rise in blood sugar levels [16].

Cocoyam leaves also contain some phenolic flavonoid pigment antioxidants such as carotene along with vitamin A that help keep mucous membranes and eyesight healthy [17]. Minerals like zinc, magnesium, copper, iron and calcium are supplied by the tubers. The fat and sodium content of this plant is low and when consumed can help prevent hardening of the arteries, which is attributed to the consumption of foods high in cholesterol [12]. Drying can be used to dry aroids into flour for fufu, which is often eaten with soup in Nigeria. In the south-eastern regions of Nigeria, some amounts of tannia are used as a soup thickener when cooked and pounded to make a consistent paste [1]. Young taro leaves are eaten as a vegetable in the South Pacific, also with coconut cream to make a dish called *luau*, and can be eaten with boiled or toasted taro, breadfruit, and banana.

Table 1. Nutritional content of the major edible aroids per 100 g edible portion

Constituent	Taro <i>Colocasia esculenta</i>			Tannia (<i>Xanthosoma sagittifolium</i>)		
	Corms	Leaf	Stalk	Corms	Leaves	Shoots
Major nutrients	Corms	Leaf	Stalk	Corms	Leaves	Shoots
Calories	102	94	24	133	34	33
Protein (g)	1.8	202	0.5	2.0	2.5	3.1
Fat (g)	0.1	0.4	0.2	0.3	1.6	0.6
Carbohydrate (g)	23	21	6	31	5.0	5
Fibre (g)	1.0	0.8	0.9	1.0	2.1	3.2
Calcium (mg)	51	34	49	20	95	49
Phosphorus(mg)	88	62	25	47	388	80
Iron (mg)	1.2	1.2	0.9	1.0	2.0	0.3
Vitamins						
β-carotene equiv. (μg)	Trace	Trace	180	Trace	3300	-
Thiamine (mg)	0.10	0.12	0.02	0.10	-	-
Riboflavin (mg)	0.03	0.04	0.04	0.03	-	-
Niacin (mg)	0.8	1.0	0.4	0.5	-	-
Ascorbic acid(mg)	8.0	8.0	13	10	37	82

Source: [18]

1.2 Starch Content in Cocoyam

The starch content in Cocoyam was given as 70-80% in the dry weight of tubers [19]. Cocoyam starch is considered to be easily digestible and is therefore often used in baby foods in Hawaii and other Pacific islands, as well as in the diet of gluten-allergic and lactose-intolerant children [19]. Cocoyam's starch is also good for those with stomach ulcers, those with pancreatic disease, chronic liver problems, and inflammatory bowel disease, and gallbladder disease [20].

The size of the starch grains varies depending on the variety and ranges from 1.5 to 6.6 μm. The shape of the grains is polygonal. Cocoyam starch contains about 50% less amylose than amylopectin. The cocoyam starch forms a clear and soft paste similar to potato starch. The gelatinization temperature of the starch depends on the variety and ripeness at the time of harvest and is lower with increasing age and ranges from 63-73 °C [19,21]. Cocoyam is grown for its starch, which can be baked, cooked, or made into snacks (chips or fries) to suit the growing city markets [1].

1.3 Protein Content in Cocoyam

Cocoyam contains approximately 11% protein, based on the dry weight of the tubers [22]. This is more than the protein content of yam, cassava or sweet potato [6]. Cocoyam's protein is rich in essential amino acids such as: threonine, leucine, arginine, valine and phenylalanine, and

they are relatively more common in leaves than in tubers [2]. The protein content of the tuber is higher at the circumference of the tuber than in the middle. This suggests that the tubers should be peeled very thinly or cooked with their peels, otherwise a significant amount of protein may be lost during peeling.

Interestingly, cocoyam leaves have been reported to be richer in protein than the tubers. Due to the presence of symbiotic soil bacteria in its root and rhizome parts, cocoyam contains more protein than other root crops [23]. The abundance of these symbiotic bacteria in soils helps cocoyam plants to grow in a variety of environment and environmental conditions [24].

1.4 Lipids Content in Cocoyam

Cocoyam has a very low fat content and consists mainly of cell membrane lipids, which vary greatly between the different varieties. Overall, the fat content of cocoyam tubers is 0.3-0.6% [25,24].

1.5 Crude Fibre Content in Cocoyam

Cocoyam contains fibre. In studies on six varieties in Cameroon and Chad it was found that the crude fibre content in taro fluctuated between 0.3-3.8% [26]. Cocoyam grown in American Samoa had an even wider range of total, soluble and insoluble fibre (5.02-9.01%) [27-29]. Crude fibres are important because they facilitate nutrition, support the micro-supply of components and glucose metabolism, as well as

slow down the process of absorption of undesirable food components such as cholesterol, shorten the intestinal passage, the concentration of total and LDL cholesterol (low density lipoprotein) in the blood, lowers postprandial glucose and insulin levels in the blood, acts as a buffer and reduces excessive acid secretion in the stomach, prevents constipation, increases water absorption of food, can increase food intake stability by changing the structure and density of food, texture, the form of a gel in food and the ability to thicken food [30,29].

1.6 Minerals Content in Cocoyam

Cocoyam contains quite a bit of ash. The ash content of Cocoyam ranges from 3.54-7.78% [14]. Essential minerals play an important role in metabolism and in physio-chemical processes such as maintaining pH and osmotic pressure, muscle contractions and gas transport. These minerals are important components of enzymes and hormones that are crucial for bone formation and vitamin synthesis [6,22].

In addition, cocoyam has been reported to be an excellent source of minerals, including potassium, sodium, magnesium, calcium, phosphorus, Iron, zinc, and copper. Their contents as reported by [22] and [31] is as shown on table 2. A high potassium to sodium ratio is recommended for high blood pressure.

The distribution of the various minerals in the tuber varies depending on the element. Minerals like P, Mg, Zn, Fe, Mn, Cu and Cd are mainly found in the upper part of the tuber, K, P, Mg, Zn, Fe, Cu and Cd are concentrated in the central part, and Ca is concentrated in the lower part and marginal parts of cocoyam tubers [31].

The central part is always the most important from a nutritional point of view, but in order to increase the tuber yield it is necessary to reduce the amount of waste to remove the edge part.

1.7 Bioactive Compounds in Cocoyam

The bioactive compounds contained in taro are mainly tarin, polyphenols, proteins, mucilage, polysaccharides (taro-4-I-polysaccharide, taro-polysaccharides 1 and 2 (TPS-1 / TPS-2)), lipids (monogalactosyldiacylglycerols (MGDGs), and digalactosyldiacylglycerol (DGDGs)), non-polyphenol antioxidants and A-1 / B-2 amylase inhibitors [32,33]. Many of these bioactive principles have already been identified and examined individually, demonstrating their participation in these claimed activities.

1.8 Health Benefits of Consuming Cocoyam

1.8.1 Antioxidant properties

Antioxidants, in appropriate concentrations, have the ability to protect, prevent or retard the oxidation of biomolecules such as nucleic acids (DNA and RNA), proteins and lipids [34]. Phytochemicals found in foods such as fruits, vegetables, grains, and tubers have antioxidant effects and are notable as relevant nutritional intervention programs. The assessment of the total antioxidant capacity (TAC) of foods is useful for improving functional, nutritional quality and maintaining health [35,36]. Many phytochemicals such as flavonoids, tannins, saponins, alkaloids, carotenoids, phenols, vitamins and fatty acids seem to contribute to the overall antioxidant capacity of taro [37-39].

Table 2. Distribution of minerals in cocoyam tuber

SN	MINERALS	AMOUNTS (mg / 100 g)
1	Potassium	2271-4276.06
2	Sodium	82-1521.34
3	Magnesium	118-415.07
4	Calcium	31-132
5	Phosphorus	72.21-340
6	Iron	8.6-610.8
7	Zinc	2.63
8	Copper	1.04

Source: [22,31].

The H-ORAC (Hydroxyl Radical Antioxidant Capacity), ABTS (2,20 -azino-bis [3-ethylbenzothiazoline-6-sulfonic acid] diammonium salt), FRAP (iron reducing antioxidant power) and DPPH (2,20 -diphenyl -1-Picrylhydrazyl radical assay) were used to assess the TAC of taro extracts or taro food derivatives [33]. Research suggests different antioxidants in different amounts in taro and taro derivatives, and these differences could be attributed to several factors, such as (i) genetic background between variants of the same species; (ii) the agricultural cultivation methods used (iii) post-harvest processing, including handling, cutting, peeling, drying, cooking and storage; and (iv) non-standard bioactivity extraction methods [40-42].

Few studies went beyond TAC determination and the characterization of phytochemical groups to identify specific compounds within the above class and in what concentrations they occur in taro [43-45]. The taro matrix represents a complex set of antioxidants, and while they have been identified and measured, it is difficult to predict what role a single compound will play in the human body [33]. Interestingly, taro antioxidants can work in combination to promote synergistic or antagonistic effects [46].

Bioactive compounds such as chlorogenic acid, catechin, epicatechin, epigallocatechin, proanthocyanidins and gallic acid have been identified in Taro by thin layer chromatography (TLC) and high performance liquid chromatography (HPLC) [43]. LC-MS (liquid chromatography-mass spectrometry) was also used to identify the polyphenols represented by 1-O-feruloyl-D-glucoside; 3,5-DiCQ acid; Vitexin; Isovitexin; Cyanidin-3-glucoside; Luteolin-7-O-rutinoside; Vicenin-2; Caffeic acid; Cyanidin-3-rhamnoside; Chlorogenic acid; Quercetin and hyperoxide [47].

Also, polyphenols and other antioxidants contained in taro, in addition to their function as normal radical scavengers, have other molecular and enzymatic mechanisms that are considered complementary for health promotion [33]. Few mechanisms of action describe how polyphenols participate in inflammatory cascades by increasing the release of proinflammatory cytokines. As a result, inflammation can, for example, activate the transcription factor NF- κ B (nuclear factor kappa B) and stimulate the production of TNF-, two critical factors that, if upregulated, can be involved in the development

of cancer [33]. Therefore, polyphenols could help control cancer progression due to their anti-inflammatory effects, including activating antioxidant enzymes, inhibiting prooxidative enzymes, and preventing free radical attacks [48].

2. ANTI-INFLAMMATORY BENEFITS

Taro extracts have also shown anti-inflammatory effects against human and mouse breast cancer cells by increasing the immune response by reducing the release of prostaglandin E2 (PGE2), accompanied by the abolition of the mRNA synthesis of cyclooxygenase-2 (COX-2) modulate and decrease in COX-1 [49]. Tarin downregulation of the COX-2 gene lowered E-series prostaglandins by nearly 70%, particularly PGE2, an inflammatory mediator known to exert pro-tumorigenic effects, and contributes to (i) generating additional mutations in Cancer cells by stimulating the release of ROS; (ii) upregulation of a number of critical molecules such as Bcl-2 that confer resistance to apoptosis, vascular endothelial growth factor (VEGF) involved in angiogenesis, type 2 and 9 matrix metalloproteinases (MMPs) which are invasive, confer the ability to epidermal growth factor receptor (EGFR), which facilitates cell proliferation, extracellular signal-regulated kinase (ERK) and membrane proteases, which are also involved in the invasion; (iii) suppressing the anti-tumour response by downregulating the immune system; (iv) activation of the WNT / catenin pathway, which promotes metastasis and maintains stem cell capabilities; (v) Activation of the phosphatidylinositol-3-kinase / protein kinase B (PI3K / AKT) pathway, which promotes cell proliferation and survival [33]. This would prevent the angiogenesis process, the proliferation, differentiation and migration of cancer cells [49-52].

2.1 Anti-cancer Properties

Crude taro extract inhibits the *in vitro* proliferation of several human breast cancer lines, such as MCF-7, MDA-MB-231 and MCF10A, as well as the murine breast cancer lines 66.1, 410.4 and EpH4 [33]. The antiproliferative effect on mouse cells was accompanied by morphological changes such as cell roundness and a reduction in the protrusion of the feet. Raw taro extract showed antimetastatic effects after intraperitoneal administration before and after the onset of

cancer and exerted therapeutic and protective effects against the colonization of the heart and lungs by breast cancer lines [49]. The anticancer effects promoted by taro extract were ascribed to a lectin (tarin) (PDB id. 5T1X and 5T20) [33]. Lectin is able to reproduce the cancer-inhibiting and antimetastatic effects of the crude extract in *in-vitro* and *in-vivo* tests by inhibiting the proliferation of human hepatoma cells (HepG2 line) as well as lung and heart colonization [49,53].

Tarin, Nano-encapsulated in liposomes improved anticancer activity compared to the free protein against human breast cancer (MDA-MB-231) and glioblastoma (U87 MG) lines, which led to 41 and 65% inhibition, respectively [33]. Nano encapsulated tarin was as effective as cisplatin and temozolomide in controlling glioblastoma cell proliferation. However, the benefit stems from the non-cytotoxicity of either form of tarin, free or Nano encapsulated, at effective concentrations when added to healthy cells [53]. These results indicate that tarin has great potential as supportive cancer therapy [54,53]. In addition, tarin is considered to be a relatively stable protein that maintains its activity over a wide range of pH and temperature, which are mandatory physicochemical properties for candidate molecules for pharmaceutical purposes [55].

Taro components have traditionally been known to enhance the immunological response, which could be an indirect way to reduce cancer risk or control tumorigenesis. Indeed, in mice, tarin has been shown to stimulate *in vitro* and *in vivo* proliferation of bone marrow (BM) and spleen cells while protecting BM progenitor cells from death. B lymphocytes and granulocytic cells were identified among the proliferating cells when taro extract was administered intraperitoneally (1 mg / animal) [33]. In addition, tarin-sensitized splenocytes were stimulated to release IL-2, IL-1b, TNF and INF, which, as already mentioned, are essential cytokines involved in the cancer reaction [56,40,57,58].

Given that tarin is found in the edible part of *C. esculenta*, regular intake of this tubercle could be a useful dietary intervention to strengthen the immune system in healthy individuals or to speed recovery from leukopenia in immunocompromised patients, including those on chemotherapy [33]. Tarin's immunomodulatory potential was demonstrated by administering the purified protein (200 g /

animal) to cyclophosphamide immunosuppressed mice, where BM cells were stimulated to multiply and differentiate into a granulocytic cell line, promoting faster recovery from leukopenia [33]. Tarin also protects the erythroid BM precursors from the cyclophosphamide cytotoxicity [59].

2.2 The Effect of Cocoyam on Type II Diabetes and Obesity

Obesity or overweight is the main risk factor for developing Type II diabetes. Diabetes, obesity, hyperglycaemia, and hypercholesterolemia, occurring together or independently, have been directly linked to cancers of the kidney, bladder, thyroid, ovaries, breast, endometrium, stomach, liver, pancreas, colon, and rectum and associated with leukaemia [33]. A recommended strategy for preventing overweight or obesity is adopting a healthier lifestyle [60,16,61]. Taro can be a strong ally given its mean glycaemic index, as 33% of total taro starch after cooking is made up of slow-digesting starch (SDS) and resistant starch (RS), and high fibre content, two essential properties it has to cope with these metabolic disorders.

Taro meal, offered to streptozotocin (STZ) - induced hyperglycaemic rats, restored glycemia after four weeks of ingestion. Proteinuria and glucosuria, kidney function, relative kidney weights, liver function, glycated haemoglobin, and body obesity associated with type II diabetes were also attenuated after consuming taro. Plasma levels of total cholesterol, VLDL and LDL cholesterol, triacylglycerol, serum pancreatic lipase, atherogenic and coronary risk were all reset and HDL cholesterol levels were increased [37,62,39]. Similar effects were achieved by administering an ethanolic extract from raw taro flour, which reduced glucose tolerance and glycemia in a mouse model [63]. The antihyperglycemic and antihyperlipidemic effects observed herein indicate that taro may have the potential to treat diabetes and obesity. These effects are mainly attributed to bioactive compounds such as flavonoids, alkaloids, saponins, steroids and tannins, but minerals (Mg, Ca, K, P, Fe and Zn) and raw fibre also play a role [37,63].

3. FOOD USES OF COCOYAM

In addition to the rich taste of most forms of cocoyam based foods, they are also valued for their nutritional and medicinal properties. The

bulbs and tubers of taro and tannia can be cooked and crushed on sole or mixed with yam and plantain and eaten as fufu with soup [1]. Tannia's tubers can be processed into various forms of food. They can be boiled, fried, baked, roasted, pounded into a paste or prepared as flour, chips, pepper soup or porridge [4]. In Hawaii, taro is made into packaged food poi, a sour paste made from cooked crushed taro tubers [64]. The grain size is uniquely small, resulting in easy digestibility of starch, estimated at 98.8%. Although taro tubers are low in fat and protein; however, its protein is comparable to or slightly higher than that of yam, cassava and sweet potato [65]. Nutritionally, taros protein is rich in some essential amino acids but poor in isoleucine, tryptophan, and methionine [66-67] reported that a regular meal of taro tubers was a good source of calcium and iron.

Also in the food formulation context, taro and tannia compete favourably with other root and tuber crops and could be even further diversified if appropriate technologies are used to process them. [68] described some recipes based on taro products. Technically, the unique small starch granules (1-4 μ m) of taros seem to be the reason why they are most commonly converted to more consumable forms such as flour, cereal products, poi, powdered drinks, chips, sun-dried slices, grits, and drum-dried flakes. The small starch grains (1-4 μ m) compared to the large grain size of Tannia (17-20 μ m) recommend taro as suitable for several foods, especially as food for potentially allergic infants and people with gastrointestinal diseases [68].

Tannia, is less easily digestible than taro, but richer in minerals with approximately the same protein content. Some special quality features of the aroid starch that are important for industrial use are particle size, dough temperature and amylose content [68]. In comparison, several taro varieties have a particle size of 1-6.5 μ m in mean diameter, compared to rice starch at around 5 μ m, which is the finest of the starches commonly available [69]. Tannia starch, on the other hand, has relatively large grains with an average diameter of 17-20 μ m. Interestingly, since the dough temperature of starch is also important during processing and industrial application, the combination of aroid properties, particularly taros high dough temperatures and particle size, could offer a unique combination [1]. Aroid starch could be used industrially for the production of syrups, cosmetics, gums, packaging films with a modified atmosphere,

fillers / modifiers for plastics and renewable energies [68].

Taro is mainly used as a soup thickener. Such soups, when made with bitter leaves (*Veronia amygdalina*) or *ora* leaves, stock fish, dried fish, pepper, red palm oil, meat, crayfish, salt, fermented *ogiri* (*Ricinus communis*) and eaten with fufu are popular in Nigeria- a treat among the Igbos and Yorubas (South-West and Eastern Nigeria) [1]. Taro can also be kneaded and made into biscuits (*Achicha ede*). The processing of cocoyam (taro) to make *Achicha ede* begins with boiling the tubers for about 12 hours (usually overnight) until they have a brownish colour. The outer skin is then removed and the pulp cut into slices and dried in the Harmattan wind (December to February) for about 4 to 5 days. The dried taro flakes are stored over the fireplace for 3-4 months until they are properly dried and chocolate-coloured. When dried, they can be stored in clay pots for up to 6 months to provide nourishment during lean periods. They are cooked with beans (*Phaseolus spp.*), Cut fermented African oil beans (*Pentaclethra macrophylla*), spices and red palm oil, pepper and salt [70].

The leaves, petioles, runners, and inflorescence of cocoyam are delicacies and are an important source of vitamins, particularly folic acid, in some countries and communities [71]. Tannia leaves, especially the young succulents, are a delicacy among the Efiks of southern Nigeria. They are cooked with grated water yam or grated tubers of tannia, dried fish, periwinkles and various spices and eaten as a delicacy called *Ekwang Nkwukwo* [1]. [72] indicated that these leaves are rich in thiamine and that the thiamine provides a vital nutritional contribution to human nutrition. In Nigeria, tannia chips and flakes are also produced and consumed like the popular potato chips. [73] and [74] reported on the use of taros vitamins (A and B), Ca and phosphorus as a basis for industrial food preparations for babies. In addition, the easy digestibility of taros flour makes it suitable as a food for diabetics, potentially allergic infants and people with gastrointestinal diseases [75]. Taro flour is also classified as superior to cassava, corn or potato starch in the production of polystyrene, polyethylene and polyvinyl plastics.

In addition, [74] reported on its ability to reduce tooth decay in children. Similarly, Onwueme reported in [66] that taro flour was effectively used in bakeries for baking and confectionery

because of its pentosan content, while Griffin and Wang reported the importance of taro starch grain size in [69], which makes it ideal for industrial use in the manufacture of face powders and cosmetics. In Hawaii, dehydrated cooked taro was used as the base for the production of powdered drinks, which is marketed under the name RA-RO-CO as a chocolate-flavoured taro drink with added sugar, cocoa, milk and salt [73]. Other useful applications include use as a nourishing flavour ingredient in ice cream, in syrup and alcohol production, and as a filler for plastics and taro gums. Taro slime has also been reported to be useful in the pharmaceutical, plastic and paper industries [71,75].

4. CONCLUSION

Many root and tuber crops are grown in hot and humid regions around the world for their use as vegetables because most of them contain starch as their main carbohydrate. They are an important part of human nutrition and provide variety. Cocoyam is one of the most important root and tuber plants grown for various purposes. Interestingly, almost all parts of the plant has been used as food and feed formulations, as they are nutrient laden and readily available. Despite their high starch content, cocoyam has a higher content of protein and amino acids than many other roots and tuber. It also contains high-quality Phyto-nutrition profile comprising of dietary fibre, and antioxidants with a moderate quantity of minerals, and vitamins, as well as being gluten-free. It however has a low fat content, making it an ideal food for people on low fat diet. Although neglected and often considered as 'a poor man's food', it is a valuable source of several health-promoting bioactive compounds, such as taro lectin or tarin, bioactive-complex carbohydrates, and natural polyphenols and other antioxidants. In general, these molecules act through individual or synergistic pathways and provide numerous health benefits to their consumers, such as anti-cancer, anti-inflammatory, antioxidant and dyslipemic activities. Interestingly, Cocoyam can be made into more stable foods so that shelf life can be extended and processed into more consumable forms, thereby creating varieties. These include poi (fresh or fermented paste), cocoyam flour, grain base, chips, sun-dried slices, grits, baby weaning foods, and drum-dried flakes. Consumers of cocoyam-based products can rest

assured that they are getting these numerous health benefits associated with cocoyam.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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