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Review Article

Nutritional & Anti Nutritional Quality of Taro (*Colocasia Esculenta*); A Review

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Abstract

Taro *(Colocasia esculenta)* is one of the most nutritious and easily digestible food. Like many other root crops, taro corms are rich in carbohydrates in the form of starch and it contain low amount of fat and protein. Taro was originated from humid tropical rainforest regions of Southeast Asia including India. In Ethiopia Taro is one of the most important source of food as well as source of income to the farmer. It has a great potential to supply high quality food and one of the cheapest source of energy. From its starch contents, 98.8% is digestible. Taro exhibits an approximate protein content of 11% when assessed on a dry weight basis. Taro contains minimum amount of fat content. The lipid content of taro root fluctuates between 0.3% and 0.6%. Vitamin C and the vitamin B complex, like niacin, riboflavin, and thiamin are found in Taro corm and leaves. Taro contains bioactive molecules which are effective against cancer and cancer related risk factors Taro also contains Anti-nutrients such as oxalate, phytate, tannin, lectins Saponins. These anti-oxidants are harmful for human health. The anti-oxidants like oxalate will be removed from the taro corm by boiling because oxalates are soluble in water.

Keywords

Anti-nutritional, Colocasia Esculenta, Mineral, Oxalate, Proximate, Tannin, Taro

1. Introduction

Root and tuber crops are cultivated globally and hold significant economic and nutritional value in the Pacific Islands. Approximately 40-50% of dietary energy is derived from taro, cassava, sweet potato, and yams. These root crops serve as crucial sources of both energy and essential nutrients. Furthermore, they are recognized as rich sources of dietary fiber, calcium, iron, vitamins, and minerals. Innovations in food technology facilitate contemporary techniques for food preservation. Engaging in food processing to ensure a consistent and prolonged supply presents a judicious alternative. It is indeed imperative to advance the development of instant foods that are both nutritious and composed of readily available natural ingredients [1].

Staple crops play an important role in food in many developing countries including Ethiopia. This crops include tubers such as, Taro, Yam, Cassava, and Potato [2]**.** *Reports shows that* next to cereal starchy root and tuber crops are used as a global sources of carbohydrate [3]. There are many wild plants used as food in most developed countries. Peoples used these edible plants for medicine, food and other purposes. Their roots, stems, leaves, flowers, fruits or seeds are available for human being for food consumption [4].

The word "Taro" is used to refer *Colocasia esculenta (L.) Schott*. It belongs to the genus *Colocasia* in the subfamily

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Colocasiaideae of the *monocotyledonous* plant family Araceae. Taro is recognized as likely the most ancient cultivated crop on the planet and has been cultivated one of the most significant root and tuber crops globally and it is mostly grown in tropical regions of Asia [5]. Although all parts of the cocoa plant are edible, it is grown primarily for its roots, called corms [5]. The most important feature of taro is its flexibility, its good adaptability, resistance to different diseases and ability to produce high amount of yields in different areas especially on tropical environments [6]. Taro is one of the most nutritious and easily digestible foods. Like many other root crops, Taro corms are rich in carbohydrates in the form of starch and it contain low amount of fat protein [7].

In Ethiopia farmers consciously plant different cultivars of Taro within their farmland for home consumption. In Wolaita, for instance, farmers have identified about eight Taro cultivars locally named as Gerezua, Shishia (Yeda), Yiteria, Molia, Tawayia, Gessa, Dolka and Yeda, on the bases of variations in morphological, phonologic, agronomic and quality traits, its fitness into cropping systems and medicinal values [8]. The reported data of agricultural sample survey of the central statistical agency (CSA) indicated that, area coverage, production, and productivity of Taro are increasing from time to time. It ranked 3rd followed by Potato and Sweet potato in terms of area coverage and 2nd in terms of production and productivity next to Sweet potato among the major root crops grown in major growing regions of the country [9]. Jimma agricultural research center released Denu and Kiyaq and Areka research center also released onevariety called Boloso-1 for North-Bench woreda of Bench-Sheko zone and BenishanguleGumuz region respectively. This varieties have better potential in production than the local varieties [9].

2. Origin of Taro

Taro was originated from humid tropical rainforest regions of Southeast Asia including India. scholars conclude that it is not possible to determine a single center for origin of Taro [10]. Taro is heavily used in Caribbean, Hawaii, the Solomons, American Samoa, Western Samoa, the Philippines, Fiji, Sri Lanka, India, Nigeria, Indonesia, New Hebrides, Tonga, Niue, Papua New Guinea, and Egypt [11]. However, in Ethiopia Taro is one of the important food source as well as income source to the farmer. It has a great potential to supply high quality food and one of the cheapest source of energy. The total area of cultivation of Taro in Ethiopia is 26,506.36 ha out of which 20,100.48 ha cultivated in SNNPR (including the new regions south Ethiopia region and southwest Ethiopia peoples' region) 6,147.87 ha in Oromia, 231.84 ha in Gambela and 9.36 ha in BenishanguleGumuz region. In Wolita Zone, the total area under taro cultivation is 4,202.46 ha [10]. In Ethiopia, the local name for Taro is Boyna (a language of Wolaita tribe which is located in Southern Nation Nationality People's Region) and Godere (in Amharic-National language of Ethiopia) [5].

In Jimma Agricultural Research Center (JARC) there are 100 accessions of Taro [12] from this accessions 2 varieties, namely; Denu and Kiyaq, were released to the farmers [9]. Tewodros and Tilahun from mizan-tepi University and Desta and Merga from Assosa Agricultural Research Center were evaluated the performance of the three varieties namely; Denu, Kiyaq and Boloso-1 and both were suggested that from the three varieties Boloso-1 has better performance than the other varieties based on number of leaf per plant, plant diameter, corm diameter, cormel number per plant, and total yield [9, 13].

3. Nutrition and Other Importance of Taro

Taro is one of the most nutritious and easily digestible foods. Like many other root crops, Taro corms contain high carbohydrate as a starch, but low fat and protein compositions. From its starch contents, 98.8% digestible, a quality attributed to its granule size, which is a tenth that of Potato, making it ideal for people with digestive difficulties. The corm is an excellent source of potassium (higher than banana), and fiber. It is also a good source of calcium and iron [7].

Based on the extraction method used Taro is used as a source of about 3-19% mucilage and 70 - 80% starch. Chemical composition of Taro mucilage consists carbohydrates (glucose, galactose, mannose, xylose, and arabinose) and proteins (major amino acids, e.g., leucine, isoleucine, cysteine, tryptophan, and lysine). The presence of this radicals of completely or partially hydrophobic amino acids can improve the emulsifying properties of Taro mucilage. Mucilage can be used in food, pharmaceutical, and several other fields of research as a matrix and a thickening, binding, emulsifying, or foaming agent. Moreover, mucilage can be extracted from several living organisms and has excellent functional properties, such as water-holding, oil-holding, and swelling capacities. It also used as a fat replacer or reducer, dye remover, coating agent, and antioxidating agent [14]. Taro is a good source of calcium for children who cannot take milk as a result of lactose intolerance and it is gluten-free so it is suitable for people with gluten intolerance. The starch grains are highly digestible (99%) because of their small in size. Taro is used as an ornamental plant. Its peels and wastes can be used as animal feed, it can be used to produce biofuel and biodegradable plastics, and it's corm can be used to prepare nutrient media for nematode growth [15]. Taro contains nutrients which are used to boost the immune system and help human body to resist disease such as; thiamin, riboflavin, iron, phosphorus, zinc, potassium, copper, manganese and vitamins [16]. Taro has been utilized for treatment of various ailments such as asthma, arthritis, diarrhea, internal hemorrhage, neurological disorders, and skin disorders and also its juice is widely used for treatment of body ache and baldness [17].

Taro corms contain valuable bioactive molecules which are effective against cancer and cancer-related risk factors, such as carcinogens and biological agents, several pathophysiological conditions, including oxidative stress and inflammation, for controlling metabolic dysfunctions and boosting the immunological response. This all are achieved by Taro health-influencing compounds displaying antitumoral, antimutagenic, immunomodulatory, anti-inflammatory, antioxidant, antihyperglycemic, and anti-hyperlipidemic activities. Taro bioactivities are attributed to the combination of tarin, taro-4-I polysaccharide, taro polysaccharides 1 and 2 (TPS-1 and TPS-2), A-1/B-2 α-amylase inhibitors, monogalactosyldiacylglycerols (MGDGs), digalactosyldiacylglycerols (DGDGs), polyphenols, and nonphenolic antioxidants. Most of these compounds have been purified and successfully challenged in vitro and in vivo, proving their involvement in the aforementioned activities [18].

Although the roots are the most widely consumed and important parts of the plant, the leaves, and rhizomes of Taro are eaten depending on the cultivar and the culture. In Asia/ Pacific regions, for instance, the leaves are usually boiled and prepared in various ways. Taro can be consumed as boiled, baked, roasted or fried and in conjunction with fish, and coconut preparations [19]. The average length of a Taro root is 76.197 mm [20].

Figure 1. *Taro (Godere) leaves and corms.*

Due to its small particle size Taro starch has numerous application in production of food products such as noodles, bread and cookies. And also because of its easily digested starch it is widely used in the production of infant foods [21]. Taro starch is also good for peptic ulcer patients, patients with pancreatic disease, chronic liver problems and inflammatory bowel disease and gall bladder disease [22].

3.1. Starch

Taro corm has been documented to contain 70–80% starch on a dry weight basis, characterized by its diminutive granules. Due to its small granule size, Taro exhibits a high level of digestibility, rendering it suitable for the formulation of infant nutrition products in Hawaii and various Pacific islands [23]. Its minimal granule size renders Taro an appropriate dietary option for individuals with cereal allergies as well as for children exhibiting sensitivity to milk; additionally, it finds utility in various industrial applications. Taro possesses a hypoallergenic profile, indicative of a low propensity to induce allergic responses, and the starch derived from Taro is devoid of gluten. [10]. Furthermore, Taro starch is beneficial for individuals suffering from peptic ulcers, pancreatic disorders, chronic liver ailments, inflammatory bowel disease, and gallbladder conditions [10, 23]. Taro starch possesses approximately 50% less amylose and a comparatively elevated amylopectin content in relation to other cereals. The ratio of amylose to amylopectin is 1:7. Taro starch generates a translucent and pliable paste akin to that of potato starch [10]. The predominant sugar found in taro is sucrose; however, fructose, maltose, glucose, and raffinose are also identified. The most significant organic acid in taro is malic acid (60%), succeeded by citric acid (25%) and oxalic acid (15%) [10, 23].

3.2. Moisture

Given that taro is classified as a root vegetable, it possesses a significant moisture content, which constitutes approximately two-thirds of the overall mass of the unprocessed produce. The moisture content in taro is influenced by various factors, including the specific variety, environmental growth conditions, and the timing of the harvest. Typically, the moisture content in taro fluctuates between 60% and 83%. [10, 23]

3.3. Protein

Taro exhibits an approximate protein content of 11% when assessed on a dry weight basis. This surpasses the protein levels found in yam, cassava, or sweet potato. The protein composition is particularly abundant in essential amino acids, including threonine, leucine, arginine, valine, and phenylalanine. Among the essential amino acids, methionine, lysine, cystine, phenylalanine, and leucine are significantly more prevalent in the leaf relative to the corm. The protein concentration within the corm is greater at the periphery compared to the central region. This indicates that meticulous care must be exercised during the peeling of the corm; otherwise, a considerable proportion of the protein may be forfeited during this process. With respect to the leaf, analogous to other higher plants, the taro leaf exhibits a substantial protein content. It comprises approximately 23% protein on a dry weight basis [10]. Taro possesses a higher protein concentration than other root crops, attributable to the presence of symbiotic soil bacteria within the root and rhizome regions of the plant. These bacteria are capable of fixing atmospheric nitrogen, thereby enhancing nitrogen availability in both the corm and leaf. The free-living nature of these soil bacteria further facilitates the growth of the taro crop across diverse environmental and ecological conditions [10, 23].

3.4. Fat

Similar to numerous other root and tuber crops, the lipid content in taro is notably minimal, predominantly consisting of the membrane lipids, and exhibits variability among different cultivars. Typically, the lipid content of taro root fluctuates between 0.3% and 0.6% [10].

3.5. Crude Fiber

Taro encompasses both dietary and non-dietary fiber. The data reported by the Food and Agriculture Organization (FAO) in 1999 indicates that the crude fiber content of taro varies between 0.3% and 3.8%. Crude fiber possesses numerous advantageous functional characteristics. These characteristics include the facilitation of digestive processes, the enhancement of micro-nutrient delivery and glucose metabolism, as well as the retardation of the re-absorption of undesirable dietary components such as cholesterol, the reduction of intestinal transit duration, the lowering of total and low-density lipoprotein (LDL) cholesterol levels in the bloodstream, the diminishment of postprandial blood glucose and insulin concentrations, the buffering of excessive gastric acid, the prevention of constipation, the augmentation of water retention capacity in food, the enhancement of food stability through structural and density modification, the improvement of food texture, the promotion of gel formation within food, and the thickening capacity of food products [10].

3.6. Total Ash

Taro exhibits a considerable concentration of ash. Consequently, it can be deduced that it possesses substantial mineral constituents. The ash content of taro varies between 3.54% and 7.78% [10, 23].

3.7. Mineral

Taro constitutes a substantial reservoir of essential minerals, encompassing iron (8.66-10.8 mg/100g), calcium (31-132 mg/100g), sodium (82-1521.34 mg/100g), magnesium (118-415.07 mg/100g), phosphorus (72.21-340 mg/100g), zinc (2.63 mg/100g), copper (1.04 mg/100g), and serves as an exceptional source of potassium (2271-4276.06 mg/100g) [10].

3.8. Vitamins

Vitamin C and the vitamin B complex, encompassing niacin, riboflavin, and thiamin, are crucial components of the human diet and are found in substantial quantities in the corms and leaves of taro. Similar to other root vegetables and tubers, taro exhibits a deficiency in many vitamins; however, it possesses noteworthy levels of dietary fiber. The cooked leaves of taro are rich in beta-carotene, iron, and folic acid, which serve to mitigate the risk of anemia. [10].

Basalingappa et al. [23] reported nutrition values of Taro root recommended dietary allowances (RDA) in comparison to the USDA national nutrient data base (Table 1).

Table 1. *Nutrition value of Taro root RDA [23].*

Principle	Nutritional value per 100g	
	Nutrient value	Percentage of RAD
Energy	112 kcal	6
Carbohydrate	26.46 g	20
Protein	1.50 g	3
Total Fat	0.20 g	<1
Cholesterol	0 g	0
Dietary fiber	4.1 g	0
Vitamins		
Folates	22 µg	5.5
Niacin	0.600 mg	4
Pantothenic acid	0.303 mg	6
Pyridoxine	0.283 mg	23
Riboflavin	0.025 mg	2
Thiamin	0.095 mg	8
Vitamin A	76 IU	2.5
Vitamin C	4.5 mg	7
Vitamin E	2.38 mg	20
Vitamin K	1 µg	1
Electrolytes		
Sodium	11 mg	<1
Potassium	591 mg	12.5
Minerals		
Calcium	43 mg	4
Copper	0.172 mg	19
Iron	0.55 mg	7
Magnesium	33 mg	8

Principle	Nutritional value per 100g	
	Nutrient value	**Percentage of RAD**
Manganese	0.383 mg	1.5
Selenium	0.7 µg	1
Zinc	0.23 mg	2

4. Anti-nutrients

Nutrition is important when plants or vegetables are utilized as a source of food, but there are toxic factors which influence the nutrients present in the plant or vegetables. This toxic factors are called anti-nutrients [24]. Anti-nutrients are chemical compounds found in plant which are considered as harmful to health due to their potential to limit the bioavailability of essential nutrients [25]. They are found in plants and protect them as a defense mechanism and they assist in other biological functions. They reduce nutrients such as minerals vitamins and proteins [24].

Antinutritional factors are compounds or substances of natural or synthetic origin that inhibit the absorption of nutrients and reduce nutrient intake, digestion, and utilization of nutrients and may cause other effects. The major anti-nutrients found in plant-based foods are toxic amino acids, saponins, cyanogenic glycosides, tannins, phytic acid, gossypol, oxalates, goitrogens, lectins (phytohaemagglutinins), protease inhibitors, chlorogenic acid and amylase inhibitor [26]. Certain cultivars may demonstrate elevated levels of calcium oxalate, which is recognized as an anti-nutritional constituent that imparts a pungent flavor to the tuberous structures, induces dermal irritation, and may inhibit calcium bio availability. Consequently, it is advisable to consume taro primarily post-cooking to mitigate these unfavorable consequences [18].

4.1. Tannins

Tannins are water soluble phenolic compounds that are capable of forming complexes with metals ions and macro-molecules like proteins and polysaccharides. They can affect the nutritional value of food products by chelating metals like iron and zinc and by reducing the absorption of these nutrients as well as by forming complexes with protein thereby inhibiting their digestion and absorption [24]. And they have the ability to precipitate proteins from aqueous solutions [27]. They are astringent, bitter plant polyphenols that either bind and precipitate or shrink proteins and various other organic compounds including amino acids and alkaloids [28]. Tannin-protein complexes may cause digestive enzymes inactivation and protein digestibility reduction caused by protein substrate and ionizable iron interaction. Tannins impairing the digestion of various nutrients and preventing the body from absorbing beneficial bioavailable substances [26]. Tannin is classified as hydrolysable and condensed tannin [28]. The major anti-nutritional effect of tannins is it interferes with the digestibility of dietary protein and this is due the binding of the tannins to the protein to form substrates that are resistant to digestive enzymes (indigestible complexes) or a direct binding to these enzymes themselves. Tannin form complexes with divalent metals and reduce mineral absorption and the diets with high tannin content causes weight [29].

4.2. Oxalates

Oxalates are anti-nutrient compounds present in vegetables and plant foods. These compounds are a strong organic acid and they have the ability to form water-soluble salts by binding to minerals such as sodium or potassium, as well as water-insoluble salts by binding to calcium, iron or zinc [25]. Calcium oxalate can have an effect on human nutrition and health by accumulating kidney stone. Peoples with enteric and primary hyperoxaluria have to lower their oxalate intake. Even small amount of oxalate causes burning in the eyes, ears, mouth, and throat and taking in large amount causes abdominal pain, muscle weakness, nausea, and diarrhea [26]. Soluble oxalates have a greater impact on bioavailability and the risk of stone formation than insoluble oxalate. The presence of compounds such as magnesium and potassium in oxalate rich foods have a role in reducing risk of kidney stone [25].

Organic materials are usually decomposed by wet digestion with boiling oxidizing acids or acid mixtures, eventually producing carbon dioxide, water, and other volatile compounds that are expelled, leaving behind salts or acids of the inorganic components of the samples. Wet digestion can be done on a hot plate in an open container, but better results can be achieved in Kjeldahl flasks or specially designed containers [30]. Wet processing is more popular due to its speed of tissue processing [31]. Traditionally, acid digestion is done by heating waste with a suitable acid in an open system. Technologies such as microwave-assisted cracking and pressure bomb cracking have improved over time, resulting in faster and greater metal recovery [31]. The two best methods for separating samples are treatment with hydrochloric acid, hydrofluoric acid, nitric acid, sulfuric acid, or perfluoric acid (or various combinations thereof) [30].

4.3. Saponins

Saponins are amphipathic, non-volatile secondary metabolites that exhibit a broad distribution in the biosphere, predominantly residing within the plant kingdom. Saponins consist of aglycones (lipophilic cores) which are classified as neutral, triterpenoid, or alkaloidal steroids, accompanied by one or more glycosidic chains contingent upon their structural framework. Saponins primarily compromise cellular membranes, potentially obstructing the assimilation of nutrients by rumen microbiota and subsequently impairing nutritional digestibility and overall animal productivity [32]. Saponins are secondary metabolites of botanical origin, identified in over one hundred families of both wild and domesticated flora that fall under the classification of the Magnoliophyta division [33].

4.4. Phytates

Phytates, or phytic acids, are naturally occurring compounds within the realm of the plant kingdom. Phytate is scientifically designated as myo-inositol-1, 2, 3, 4, 5, 6-hexakis di-hydrogen phosphate, and it is present in various food sources at concentrations ranging from 0.1% to 6.0%. Phytic acid represents a secondary metabolite that is predominantly concentrated in plant seeds, particularly within legumes, peanuts, cereals, and oilseeds, and is typically found across all plant-derived food products. Phytic acid is characterized by a generally negatively charged molecular structure, which facilitates the binding with positively charged metal ions such as zinc, iron, magnesium, and calcium, thereby forming complexes that diminish the bioavailability of these essential ions through reduced absorption rates [33].

4.5. Lectins

Lectins represent a category of glycoproteins that exhibit the capability to bind to carbohydrates, thereby facilitating their adhesion to erythrocytes and resulting in agglutination. These compounds, classified as anti-nutrients, are predominantly present in alimentary sources that are ingested in their unprocessed states. Lectins adversely affect the assimilation of nutrients by interacting with intestinal epithelial cells, while additionally inflicting damage upon the intestinal lining, consequently permitting the translocation of bacterial populations into the circulatory system [33].

5. Conclusion

Root and tuber crops are cultivated globally and hold significant economic and nutritional value in the Pacific Islands and these root crops serve as crucial sources of both energy and essential nutrients. Furthermore they used as a sources of dietary fiber, calcium, iron, vitamins, and minerals. Taro is one of the root crop which is mostly cultivated in tropical regions. It is the most nutritious root crop and it is used as staple food in rural areas. Taro contains high carbohydrate content and low fat and protein content. It is easily digestible, so due to this property of taro it is used for production of infant foods and it has a great contribution for peoples with digestive difficulties. 85%-87% Taro starch is digestible.

Abbreviations

CSA	Central Statistical Agency
DGDG	Digalactosyldiacylglycerols
FAO	Food and Agriculture Organization
LDL	Low-Density Lipoprotein
JARC	Jimma Agricultural Research Center
MGDG	Monogalactosyldiacylglycerols
RDA	Recommended Dietary Allowance
SNNPR	South Nation Nationality People Region
TPS	Taro Polysaccharides
TWI	Tolerable Weekly Intakes
USDA	United States Department of Agriculture

Author Contributions

Meseret Nigussie is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares o conflicts of interest.

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