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ARTIGO ORIGINAL

Obtaining and characterization of freeze-dried whole taro root (Colocasia esculenta), mucilage and residue as functional food

Obtenção e caracterização do inhame (Colocasia esculenta) integral, mucilagem e resíduo liofilizados como alimento funcional

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Abstract

Taro root (*Colocasia esculenta L.*), a starch based plant widely grown for direct consumption, has been produced for more than 2000 years in regions with a tropical climate. In Brazil, it is a crop grown by small producers, using it for direct consumption. Some industries use the tubers for preparation of baby food; however, there is no industrial processing of taro root. It contains high caloric and protein value and has elements such as phosphorus and potassium and B-complex vitamins; moreover, in popular medicine, it has recognized medicinal properties of detoxification, purification, anti-beriberi properties, etc. The purpose of this study was to determine, characterize and obtain whole taro root flour and its subproducts (mucilage and residue from mucilage extraction) by means of physical-chemical analyses, with a view toward discovering its potential qualities as a functional food. The freeze-dried flours of taro root had considerable proximate composition with lipid values below wheat flour. Starch appeared in the three types of taro root flour at significant levels. The nutritional fiber content was on average 50% greater than the daily requirements of an individual. The minerals Zn, Fe and Mn appeared at levels able to meet significant percentages of the daily needs of children, as well as the vitamin C and β-carotene content. Phytochemical compounds, saponins, anthocyanins and polyphenols were present in all the flours. As a result, we concluded that these taro root flours constitute a viable alternative to production of bakery products based on their starch content. Whole taro root flours and their subproducts may be considered as having potential for functional foods due to their vitamin, mineral, protein and phytochemical content, in addition to their expressive quantity of fiber.
Key-words: chemical composition of foods, taro root flour, nutritional fiber, vitamin C, β-carotene, phytochemicals.

Resumo

A raiz de inhame (*Colocasia esculenta L.*), planta à base de amido amplamente cultivada para consumo direto, é produzida há mais de 2000 anos em regiões com clima tropical. No Brasil, é uma cultura cultivada por pequenos produtores, usando para consumo direto. Algumas indústrias usam os tubérculos para preparar alimentos para bebês; no entanto, não há processamento industrial de raiz de inhame. Contém alto valor calórico e proteico e possui elementos como fósforo e potássio e vitaminas do complexo B; Além disso, na medicina popular, tem reconhecido propriedades medicinais de desintoxicação, purificação, propriedades anti-beribéri, etc. O objetivo deste estudo foi determinar, caracterizar e obter farinha integral de taro e seus subprodutos (mucilagem e resíduos da extração de mucilagem). por meio de análises físico-químicas, com objetivo de descobrir suas qualidades potenciais como alimento funcional. As farinhas liofilizadas da raiz de inhame tinham uma composição com valores lipídicos abaixo da farinha de trigo. O amido apareceu nos três tipos de farinha de raiz de inhame em níveis significativos. O conteúdo de fibra nutricional que eles oferecem foi em média 50% maior do que as necessidades diárias de um indivíduo. Os minerais Zn, Fe e Mn apareceram em níveis capazes de atender percentuais significativos das necessidades diárias

das crianças, bem como o conteúdo de vitamina C e β-caroteno. Compostos fitoquímicos, saponinas, antocianinas e polifenóis estavam presentes em todas as farinhas. Como resultado, pode-se concluir que estas farinhas de raiz de inhame constituem uma alternativa viável à produção de produtos de panificação com base em seu teor de amido. Farinhas de raiz de inhame inteiras e seus subprodutos podem ser considerados como tendo potencial para alimentos funcionais devido ao seu conteúdo vitamínico, mineral, proteico e fitoquímico, além de sua expressiva quantidade de fibra.
Palavras-chave: composição química dos alimentos, farinha de raiz de inhame, fibra nutricional, vitamina C, β-caroteno, fitoquímicos.

Introduction

Taro root (*Colocasia esculenta L.*), belonging to the Araceae family is native to tropical regions of both hemispheres [1]. The group of raw materials consisting of roots, tubers and related products is second in volume of production and in nutritional sustenance in the world, after only cereal crops. Taro root is a starch-based plant widely grown for direct consumption has been produced for more than 2000 years in regions with a tropical and subtropical climate. The mean nutritional chemical composition of taro root is in some cases greater than that of other tubers, consisting of 72 g $100g^{-1}$ of moisture, 23 g $100g^{-1}$ of carbohydrates, 1.7 g $100g^{-1}$ of protein, 0.2 g $100g^{-1}$ of lipids, 35 mg 100 g^{-1} of calcium, 65 mg 100 g^{-1} of phosphorus, 1.2 mg 100 g^{-1} of iron and 4.0g 100^{-1} of dietary fiber [2]. In addition, taro root contains on average 30 mg $100g^{-1}$ of vitamin A, 0.05 to 0.04 mg $100g^{-1}$ of vitamin B1, 0.02 to 0.03 mg $100g^{-1}$ of vitamin B2 and 12 to 35 mg 100g-^{1} of vitamin C. It is considered to be rich in vitamins A, B1, B2, B5, and C, in minerals such as chlorine, silicon, phosphorus, aluminum, iron, manganese, potassium and sodium [3,4]. Starch content is the main quality factor of taro root, which may vary according to fertilization [5], soil conditions, climate, stage of maturity at the time of harvest and plant growing conditions in general.

In medicinal terms, taro root is considered to be a powerful blood purifier and, according to the National Family Expense Study (*Estudo Nacional da Despesa Familiar*) undertaken by the IBGE, it is also recommended for prevention of malaria, dengue fever and yellow fever. It also strengthens the immune system and increases fertility in women due to the presence of a constituent which is quite similar to the female hormone [6]. All parts of the plant may be consumed, the tuber, the leaves and the stems. It is commonly found in supermarkets and may be consumed cooked, as an alternative to potatoes, or in the form of purees and creamy soups. After peeling it is white and has a very firm consistency but after cooking it becomes soft and has a light bluish hue [7] due to its anthocyanin content.

The development of food products based on traditionally grown tropical products with cultural appeal, like taro root, has attracted the interest of rural and industrial producers because it would make an increase in the entire productive chain possible [8].

Taro root is planted throughout the world and, according to estimates from the FAO [9](2001), this year 1,464 thousand ha of taro root were planted, which produced 8,868 thousand tons. In this scenario, Africa holds sway, being responsible for more than 75% of taro root produced. Three countries of that continent alone – Ghana, Ivory Coast and Nigeria – are responsible for 67% of taro root [9].

On the consumption side, rich countries of the so-called First World stand out, among them Japan and the United States, which concentrate around 80% of imports. The mean imported volume in the period from 1995 to 2000 stood at 194 thousand tons, with financial operations in the order of US$ 165.6 million in transactions involving 60 countries [9].

Brazil´s involvement in this international market is very limited (it is not represented in world production), not taking advantage of its immense edaphoclimatic capacity for exploitation of these crops and the innumerable business possibilities that would come from structured chains of production. Although there are records of growing of *Colocasia* in Brazil from the beginning of colonization, expressive development of this agribusiness is not observed in national territory.

Domestic production of taro root occurs in south central Brazil, especially in the state of Rio de Janeiro but the exported volume of this product, in 2001, reached little more than four thousand tons, in other words, less than 2% of domestic production [9,10].

According to Lima [11], yams (taro) have various potential uses in addition to their use “in natura” and as a substrate for the pharmaceutical industry. Through the lack of greater knowledge in respect to tubers, especially taro, under all aspects, their industrial use, beyond food purposes, is very restricted. In Brazil, tubers do not have other channels of application beyond domestic consumption and animal feed. It is estimated that less than 5% of Brazilian production is utilized for purposes other than direct human consumption and feed production [12].

According to Lima [11], bakery, confectioner's shop and pastry shop products, ice cream and frozen products, as well as frozen, breaded, ready to use products, may have improved characteristics through the use of taro root flours, which serve as functional ingredients since they contain protein, gum or mucilage.

In the literature, it is possible to find data on preparation of flours from taro root, which taro root has in abundance, mainly in Africa and the Caribbean, where there is a market for this product for preparation of yam (taro) puree, a very popular food [13].

Taro root flour may be added to wheat flour for making bread, or it may be used in various dishes, sweet or salty. That is because the consumption of bakery products constitutes an alternative source of vitamins, minerals and proteins [14].

Lima [11] describes that in addition to the various industrial possibilities for bread production based on the use of mixed flours, taro root mucilage has emulsifying power that lends a great deal of softness to bread, increasing its shelf life.

According to Fonseca [15], the use of freeze-dried taro root in natura and the mucilage of taro root *in natura* as an additive in manufacturing bread loaves is viable.

The purpose of this study was to obtain and characterize freeze-dried whole taro root flour and its subproducts, mucilage and residue from extraction of taro root mucilage, by means of physical-chemical analyses, aiming to discover its potential as a functional food.

Material and methods

The experiment was conducted for the preparation and production of whole taro root flours and its subproducts, mucilage and residue from extraction of taro root mucilage, here denominated II, MII, RII – whole taro root, mucilage of whole taro root and residue of whole taro root, respectively.

The taro root was obtained from a local fruit and vegetable market and, so as to obtain the study samples, the tubers obtained were separated, selected and sanitized in sodium hypochlorite (200 mg L^{-1}) according to the organogram of project execution (Figure 1). After that, the following flours were obtained – whole taro root – FTI, taro root mucilage - FMT and residue from extraction of taro root mucilage - FRT, all of them lyophilized/freeze-dried.

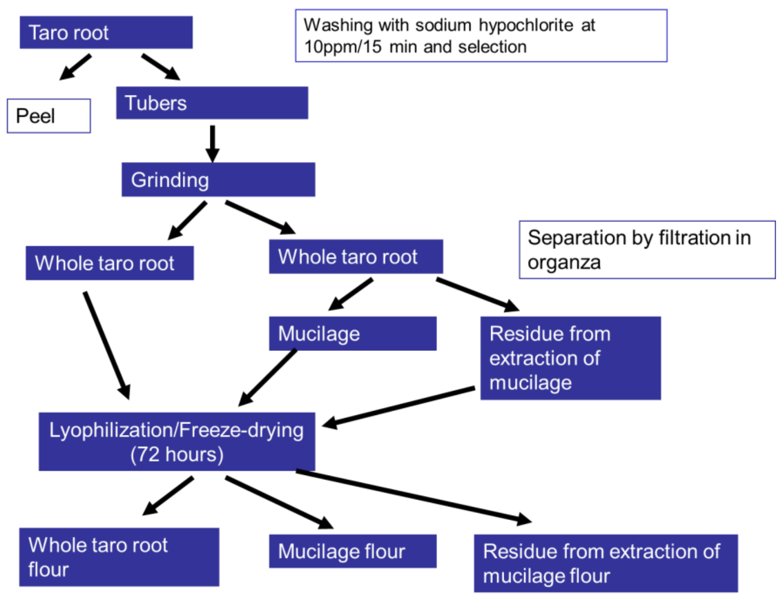

Figure 1 - *Organogram of project execution for obtaining freeze-dried flours of whole taro root, of taro root mucilage and of residue from extraction of taro root mucilage.*

Taro root and its derivative products are rich in water content and, so as to preserve nutritional properties, the choice was made for freeze-drying to obtain the flours. Freeze-drying occurred in an Edwards apparatus, model L4KR, Series 163, for 72 hours or until constant weight, with the material frozen in a freezer (- 18º C ± x ºC) for 24 hours in Petri dishes covered with plastic film. Before the mucilage proceeded to the lyophilizer, the layer of plastic film covering the Petri dish was perforated with around 70 holes by a 0.2mm diameter needle.

Analyses performed on the freeze-dried flours were: moisture (laboratory oven at 105ºC), ether extract by Soxhlet extraction, ash, crude protein by the micro-Kjeldahl method determined according to the methodology proposed by the AOAC [16], crude fiber through the gravimetric method by Van de Kamer & Van Ginkel [17], dietary fiber by gelatinization in termamyl according to the AOAC [18]. Fractional glucose was determined by difference [18], the caloric value by Atwater conversion, according to the methodology of Osborne & Voogt [19], pH in digital pH meter and titratable acidity (AT) according to Cecchi [20], total reducing and non-reducing sugars carried out by Somogy adapted by Nelson [21], vitamin C by the colorimetric method [22], the minerals Ca, Mg, Mn, Cu, Zn, Fe, P, S, and K by Malavolta *et al.* [23], the β-carotene where the extract was read at absorbance in spectrophotometer in accordance with Nagata & Yamashita [24], saponin by standard curve in different concentrations of digitonin (Baccou, Lambert e Sauvaire [25], anthocyanin by Lees & Francis [26], polyphenols by colorimetry using standard curve by tannic acid and Folin-Dennis reagent (reagente o Folin-Dennis) [27] and starch by the standards of the Instituto Adolfo Lutz [28]. Descriptive statistics was performed in five replicates, obtaining the mean and standard deviation by means of the software SISVAR 4.03 [29].

Results and discussion

Yield of freeze-dried taro root flours

The taro root tubers in natura yielded 79.30% pulp and 20.69% peel. The yield of the taro root pulp consisted of 11.62% of dry matter (DM) and 88.38% moisture. The yield in mucilage and residue was 53.68% of whole mucilage (19.69% DM and 80.31% moisture) and for residue, a yield of 46.32% (24.20% DM and 76.00% moisture) was found.

Characterization of freeze-dried taro root flours

The mean proximate composition and the caloric value of the freeze-dried taro root flours are shown in Table I.

Table I - *Mean proximate composition plus standard deviation (moisture, ether extract (E.E.), crude protein, ash, fractional glucose) and the caloric value of the flours of whole taro root (FTI), mucilage (FMT) and residue (FRT).*

Composition (g $100g^{-1}$; bi)	(FTI)	(FMT)	(FRT)
Moisture (bu)[2]	5.37± 0.13	2.35 ± 0.11	4.38 ± 0.08
E.E.[3]	0.48 ± 0.11	0.58 ± 0.11	0.81 ± 0.07
Crude protein[3]	4.75 ± 0.20	6.96 ± 0.10	6.59 ± 0.08
Crude fiber[3]	0.32 ± 0.30	0.31 ± 0.09	3.38 ± 0.24
Fractional glucose[3]	86.64 ± 0.29	86.31 ± 0.3	81.60 ± 0.37
Ash[3]	2.43 ± 0.35	3.50 ± 0.23	3.21± 0.24
Caloric value (kcal/100g)	369.91 ± 0.17	378.25 ± 0.16	360.06 ± 0.18

[1]Mean of 5 observations; [2]bu = wet basis; [3]bi = whole basis

The taro root mucilage flour had the lowest moisture content, followed by flour from the residue from extraction of taro root mucilage and finally whole taro root flour. But the moisture content of all the three flours are within the standards established by Anvisa [30], which determines that the moisture content of flour should be at most 14%. Fonseca [15], working with freeze-dried taro root mucilage found 4.36g $100g^{-1}$ of moisture (bu), whereas Leonel *et al.* [8] in their study with whole taro root flour dried in a laboratory oven found moisture of 6.2g $100g^{-1}$, both with values greater than those found in this study. Even with the product undergoing freeze-drying, a percentage of moisture in both flour fractions (whole taro root, mucilage and residue) was still observed and the same occurred in the study of Fonseca [15], who also freeze-dried the mucilage and still found moisture. This occurrence may be explained because data that determine the time of freeze-drying were not found in the literature; thus, the principle of the time necessary for obtaining constant weight was followed.

In regard to the mean content of ether extract, low values were found in the flours studied. As ether extract is not soluble in water, when separation of the residue and mucilage was made, it remained concentrated in the residue. In all the three flours (FTI, FMT and FRT), the lipid content remained below that found in the wheat flour analyzed by Couto [31]. The data found in the taro root flours were similar to those found by Leonel *et al.* [8] in their study of yam flour dried in a laboratory oven, and that of Fonseca [15] who worked with mucilage flour. Heredia Zárate, Vieira e Minuzzi [32], for their part, working with five yam clones and use in home bread baking found 0.71g.100g^{-1} of ether extract in yam flour and 1.0g.100g^{-1} in wheat flour.

The crude protein values found in taro root flours and subproducts (mucilage and residue) were similar to what Fonseca [15] found in freeze-dried taro root mucilage. Heredia Zárate, Vieira e Minuzzi [32], for their part, in laboratory oven dried taro root flour found protein content of 9.04 g 100g^{-1} in dry basis. Leonel *et al.* [8] found 5.81 g 100g^{-1} of crude protein in yam flour in dry basis. Legislation determines that the minimum protein content in wheat flour must be 11g 100g^{-1} (bs) [33].

Comparing taro root residue flour (FRT), the crude fiber content was greater than that found by El-Dash *et al.* [34] in whole corn meal (1.2 g 100g^{-1}) and in whole soy flour (3.3 g 100g^{-1}). But what is most interesting in nutritional terms is the dietary fiber content, which will be discussed further on.

The glucose values found in the present study are greater than those found by Couto [31](2007) in wheat flour (85.29 g 100g^{-1}), when compared to freeze-dried whole taro root flour and mucilage; however, the glucose content in the taro root residue flour was below that of wheat flour.

According to Brillouet *et al.* [35] and Ketiku & Oyenuga [36], the stage of maturity is one of the factors that decisively affect the characteristics of horticulture products. Therefore, the proximate composition varies in accordance with the physiological stage of the tubers.

One important quality attribute of food products is determined by the durability, color, odor, and flavor and they may or should be related to the acid and organic acid content present in the food. In Table II are shown the values obtained for pH, titrable acidity (AT) (mEq NaOH 100g^{-1}), starch and sugars of the freeze-dried flours of whole taro root (FTI), taro root mucilage (FMT) and residue from extraction of taro root mucilage (FRT).

Table II - *Mean values1 of pH, titrable acidity (meq NaOH 100g^{-1}), starch and sugars of the freeze-dried flours of whole taro root (FTI), mucilage (FMT) and residue (FRT) in wet basis.*

Freeze-dried flours	pH	Acidity (meq NaOH 100g^{-1})	Starch g 100g^{-1}	Total sugars (reducing and non-reducing) (g 100g^{-1})
FTI	5.96 ± 0.08	8.41 ± 0.18	53.15± 0.27	0.85 ± 0.01
FMT	6.67 ± 0.04	7.25 ± 0.05	53.85 ± 0.28	0.73 ± 0.01
FRT	5.96 ± 0.08	9.95 ± 0.20	53.40 ± 0.37	0.61 ± 0.01

[1]Mean of 5 observations.

The greatest value of pH found was in the freeze-dried flour of taro root mucilage when compared to the others (whole taro root and taro root residue), but it was in the mucilage flour that the lowest values of titrable acidity were found and in the taro root residue flour, the highest value. But all three types of freeze-dried taro root flour are not in accordance with legislation [37] which determines that the flours of tubers may contain at most 2.0 mL of NaOH/100g (AT). The data of this study are greater than those found in the literature for wheat flour, which is the fundamental base for production of bakery products. The starch content in the flours of taro root and its subproducts, mucilage and residue from extraction of mucilage, were very similar; however, it was the flour of the residue from extraction of mucilage that showed the lowest content of total sugars.

In regard to the total sugar content (reducing and non-reducing), greater concentration appeared in whole taro root flour; these data are less than those found by Leonel e Cereda [38] who found sugars of around 1.19% in wet basis in dehydrated tubers.

Other constituent components of plants are total sugars, starch, vitamins, and minerals; they mainly make up the nutritional and technological value of the plants. In Table III are shown the vitamin and mineral values of the freeze-dried flours of whole taro root (FTI), mucilage (FMT) and residue (FRT).

The mineral and vitamin contents are considered an important quality attribute of the foods because the food that contains considerable values of vitamins and minerals is considered to be a "good" food. Mixed flours are currently being widely studied for the purpose of verifying the aggregation of nutritional value, especially to bakery products, which have higher *per capita* consumption in Brazil.

Table III - *Mean values[1] of macro and micronutrients (mg kg^{-1}) in whole basis and of vitamins (Vit. C and β-carotene) (mg $100g^{-1}$) in whole basis.*

Nutrients	Freeze-dried	flours	
	FTI	FMT	FRT
P	0.19 ± 0.006	0.34 ± 0.005	0.25 ± 0.005
K	1.89 ± 0.14	1.97 ± 0.04	1.91 ± 0.09
Ca	0.04 ± 0.005	0.02 ± 0.01	0.03 ± 0.001
Mg	0.07 ± 0.005	0.11 ± 0.01	0.08 ± 0.006
S	0.03 ± 0.01	0.06 ± 0.01	0.04 ± 0.011
....			
B	2.76 ± 0.21	2.16 ± 1.20	5.65 ± 1.7
Cu	4.4 ± 0.86	4.46 ± 0.81	4.6 ± 2
Mn	15.02 ± 1.01	43.36 ± 2.23	31.7 ± 1.3
Zn	22.53 ± 0.75	37.06 ± 0.75	25.433 ± 0.46
Fe	21. 0 ± 1.48	28.6 ± 0.65	27.833 ± 3.1
....			
Vitamin C	3.19 ± 0.029	2.7 ± 0.074	2.35 ± 0.15
β-carotene	2.49 ± 0.0346	2.52 ± 0.17	2.42 ± 0.07

[1]Mean of 5 observations.

The mean contents of micronutrients were significant since Brazilian legislation recognizes and determines the addition of micronutrients, like Fe, to wheat and corn flours [39] with a view toward decreasing the incidence of anemias in children and pregnant women; thus, bakery products with the addition of flours that have reasonable contents of this mineral become significant. The Fe content found in the flours of whole taro root, mucilage, and residue from extraction of taro root mucilage suggests fulfilling on average 42.97%, 21.49% and 8.56% of the daily allowances of the children, adolescent and adult classes according to the RDA [40] respectively. However, it was mucilage flour and flour of residue from extraction of mucilage that offered the greatest percentage of iron, capable of offering the pre-school child (3 to 6 years old) 47.6% of the daily allowance of iron [40].

Zn and Mn appeared with considerable contents in freeze-dried flours of whole taro root, mucilage and residue from extraction of taro root mucilage showing that they are capable of meeting on average 94.33%, 35.38% and 25.72% of the daily allowances of Zn for children, adolescents and adults respectively, but it was flour of taro root mucilage and flour of residue from extraction of taro root which presented the greatest percentages of Zn when compared to the daily allowance of this mineral [40 for children; that is, 100g of use of these flours suggests meeting 123.33% (mucilage flour) and 84.66% (flour of residue from extraction of taro root mucilage) of the needs of a child, because the recommended daily allowance according to the DRIs [41] is 3-5 mg day^{-1} for children, 8-11 mg dia^{-1} for adolescents and 11-13 mg dia^{-1} for adults. The mean content of Mn found in the flours of whole taro root, mucilage and residue from extraction of taro root mucilage, suggest offers of 3.74%, 1.24% and 0.93% of the daily needs of children, adolescents and adults respectively according to the DRI´s [41]. It was mucilage flour and residue from mucilage extraction flour that suggested offer of the greatest percentages of 5.41% and 3.96% Mn respectively when compared to the needs of a child [41].

Vitamin C and β-carotene, for their part, appeared in greater quantities; vitamin C in the whole taro root flour and beta-carotene in mucilage flour. These vitamins are considered antioxidants and for that reason, all the flours may be considered as sources because in accordance with the daily recommendation of the DRIs [42] for vitamin C, the taro root flours and their subproducts, mucilage and residue, showed an offer of this vitamin capable of meeting 21.3%, 18% and 15.66% in the flours respectively when compared to the need of this vitamin for children, which is 15-25 mg day^{-1}; the recommendation of β -carotene is 3.6 to 4.89 mg day^{-1}

for children from 3 to 6 years old [42], and in regard to β -carotene content, all the taro root flours suggest meeting more than 60% of the daily recommendations for pre-school children.

Dietary fiber is now one of the nutritional components most analyzed and studied by the scientific community because its activity in the human body is already well known and approved. The dietary fiber content of the freeze-dried flours of whole taro root (FTI), mucilage (FMT) and residue (FRT) are shown in Table IV.

Table IV - *Mean contents1of soluble, insoluble and dietary fiber of taro root flours (FTI, FMT, FRT) g 100 g^{-1}.*

Sample	Soluble F.	Insoluble F.	Dietary F.
FTI	1.97±0.15	11.16±0.57	13.12±0.47
FMT	2.03±0.26	8.21±1.87	10.24±1.69
FRT	1.96±0.52	17.44±0.62	19.40±0.19

[1]Mean of 3 observations

The recommendation of dietary fiber is from 20 to 30g day^{-1}, with 25% of soluble fiber, which represents 6g day^{-1} [43]. The mean contents of freeze-dried flours of whole taro root, mucilage and residue presented considerable values of dietary fiber in whole materials, with residue flour presenting the greatest quantities; however, it was in mucilage flour that soluble fiber showed the greatest concentration, precisely through being soluble. The freeze-dried flours of whole taro root, mucilage and residue from extraction of taro root appear to meet 65.6%, 51.2% and 97.0% respectively of the daily dietary fiber allowance (g $100g^{-1}$) of an adult. Heredia Zárate, Vieira e Minuzzi [32] working with whole yam flour found fiber content of 22.0 g $100g^{-1}$ of dry matter, data similar to those found in the present study. The authors furthermore commented that through these results, it may be supposed that taro root is a good dietary alternative for vegetables. Various nutrients are considered as functional and the mean contents of anthocyanins, saponins and polyphenols (tannins) analyzed in the freeze-dried flours of whole taro root, mucilage and residue are shown in Table V.

Table V - *Mean values[1] of polyphenols (tannins), saponins and anthocyanins in the freeze-dried flours of whole taro root (FTI), mucilage (FMT) and residue (FRT).*

Flours (mg $100g^{-1}$)	Polyphenols (Tannins)	Saponin	Anthocyanins
FTI	317.64 ± 1.22	122.87 ± 0.0926	0.26 ± 0.003
FMT	450.20 ± 8.65	138.90 ± 0.7235	0.72 ± 0.003
FRT	402.25 ± 2.36	101.71 ± 1.32	0.04 ± 0.002

[1]Mean of 3 observations

According to Schneider [44], Ruiz [45] and Staszewski & Haenszel [46], taro root contains saponin steroids, principally of the diosgenin group (dioscin, dioscorin and others), and Olayemi e Ajaiyeoba [47] studying Dioscorea extract in mice, having confirmed the presence of saponins, described in his biological essay that actually this species of tuber has saponin contents, confirming anti-inflammatory action. The freeze-dried flours of taro root have saponin contents, with the greatest saponin content appearing in the mucilage flour; however, it is good to observe that all three flours showed the presence of saponins.

The polyphenol content (by tannic acid) in the freeze-dried flours of taro root appeared in greatest quantity in the mucilage flour. The beneficial effects on health attributed to the polyphenols seem to result from its antioxidant and free radical scavenging properties, according to Katalinic *et al*. [48]. Melo *et al.* [49], in their study, consider for verification of content of polyphenols, carotenoids and flavonoids in normally consumed fruits and vegetables, that a content > 200 mg $100g^{-1}$ of sample is considered high content, medium content is 100-200 mg 100g and low content is less than 100 mg $100g^{-1}$. Thus, freeze-dried flours of taro root may be considered as having high polyphenol content.

Anthocyanins are present in taro root tubers [50]. The flours have low concentrations of anthocyanin content, when compared to the concentrations obtained from red wines, which range from 30 to 750 mg per 100 g of ripe fruit, which is considered to be an excellent source of this phytochemical [51]. There are approximately 400 different anthocyanins, and, according to Malacrida [52] malvidin-3,5-diglucoside is the type present in grapes, wine, beans and taro root. But it was freeze-dried flour of taro root mucilage that showed the greatest contents of this phytochemical.

In spite of not finding the minimum and maximum content of phytochemical compounds like anthocyanins, saponins and polyphenols (tannins) in the literature, it could be seen that in all three types of flour, these compounds appeared in significant quantities. But it was the taro root mucilage flour that showed the greatest contents.

Conclusion

The flours of whole taro root and its subproducts, mucilage and residue, showed high percentage content of minerals and vitamins, suggesting that some, as in the case of Fe, Zn, vitamin C and β-carotene, were able to offer near or over 25% of the recommended daily allowances, with mucilage flour in most cases being the greatest holder of these nutrients.

The starch contents were significant in both the taro root flours and their subproducts, mucilage and residue, as well as the dietary fiber content; these flours can thus be called sources of fiber.

Taro root mucilage flour showed the greatest contents of the phytochemicals analyzed.

It may also be concluded that whole taro root flour and its subproducts can be considered as having potential for functional food since they have vitamin, mineral, protein and phytochemical content, as well as an expressive quantity of fiber.

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