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POSSIBLE USE OF MANIHOT SCULENTA LEAVES AS FOOD

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ABSTRACT

Several nutritional problems are seen in developing countries, and a countless number of people are affected by chronic undernutrition. Plants such as Cassava (Manihot esculenta) work as a staple food source for over 800 million people around the world. The aerial part of cassava can be used in animal feed, and in human food in the preparation of typical dishes of the Northern (Amazonian region) and Northeastern regions of Brazil. Besides the presence of cyanide compounds, cassava leaves may represent a source of proteins, vitamins, and minerals; it has a low cost of production, and it is widely adapted to Brazilian conditions. For these reasons, this study aims to review the main aspects of this vegetal waist and evaluate its potential as a safe food source. Databases such as MEDLINE/Pubmed, Scielo and Google Scholar were consulted. Cassava leaves stand out for being a good protein source but contain toxic cyanogenic compounds. Nevertheless, that are efficient techniques that can reduce the amount of these compounds making than a food alternative for the low-income population in several countries. Cassava leaves can also be used as a therapeutic approach for hypertension, diarrhea, fever, spasms, and fever. However, for this use to be safe, further studies are required to show the adequate detoxification of these leaves making them safe for human consumption.

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INTRODUCTION

Several nutritional problems are seen in developing countries, and it is estimated that over 800 million people are affected by chronic under nutrition, and more than 1.5 billion people exhibit micronutrient deficiencies (Fongar, Gödecke, Qaim, 2019). Protein deficiencies have been one of the main factors of human malnutrition and can lead to irreversible physical and mental disorders (Grajeda *et al*, 2019; Kraemer, van Zutphen, 2019; Hoffman *et al*, 2019; Streit, 2018). There are foods, such as cassava (*Manihot esculenta* Crantz), that are accessible to low-income populations in developing countries. This plant is a perennial tropical crop native to South America, which grows widely in 105 subtropical and tropical areas with an estimated production of 292 million tons. Furthermore, cassava works as a staple food source for over 800 million people (Selvaraj *et al*, 2019; Faostat, 2017; Achidi, Ajayi, Bokanga, & Maziya-Dixon, 2005). In tropical areas, cassava is in the third position, after maize and rice, in the provision of calorie intake, and it is a primary food source in approximately ten percent of the worldwide population. It represents as tarch-rich plant that is capable of raising in poor soils and shows strong adaptability. Africa, America, and Asia are the top three regions for cassava production totaling a total production of over 276 million tons. Furthermore, cassava is a cheap and non-grain crop in several countries such as China (Ibrahim, Opabode, 2019; Lin *et al*, 2019; Ceballos *et al*, 2011; Ray *et al*, 2015; Ospina, Ceballos, 2012). Varieties of cassava are usually different from othersdue to the morphological characteristics such as the color of petioles, stems, tubers, and leaves. Commonly, the bitter varieties possess dark stems and leaves, and the sweet varieties show light-green stem and leaves (Oni, 2011). Cassava is mainly known for its roots, and the leaves are eaten as a vegetable in some countries as a source of protein and valuable nutrients. However, the consumption is nearly 0.5 to 0.7 million tons per year, which is far less than the consumption of the roots. This low consumption is due to the high cyanogenic potential of the leaves, which may cause severe illness or death if consumed without proper detoxification (Latif, Muller, 2015). The aerial part of cassava can be used in animal feed, in which leaves and branches are used in the form of silage, hay, or even fresh, and in human food in the preparation of typical dishes of the Northern (Amazonian region) and Northeastern regions of Brazil (Cardoso, Souza, Gameiro, 2006). Cassava leaves may represent a source of proteins, vitamins, and some minerals; has a low cost of production and the widely adapted to Brazilian conditions. Due to these reasons, the aim of this study is to review the main aspects of this vegetal waist and evaluate its potential as a safe food source.

METHODS

Databases such as MEDLINE/Pubmed, Scielo, and Google Scholar were consulted.

RESULTS AND DISCUSSION

The databases consulted showed numerous studies with cassava roots. However, when it comes to leaves, the number of studies is much smaller. The major problem with using this plant residue is the presence of cyanide derivatives.

Cassava Leaves: There are many studies on cassava regarding its richness in nutritional elements, including the root stem and leaf, but its potential richness has been underused in most of the countries that grow it (Montagnac, 2009). Cassava leaves stand out for being a good protein source, have low production cost because they are considered residues of a subsistence crop, and do not compete with the main product. According toa study, the protein content of the leaves generally ranges from 20 to 30%. It is also known that the proteins in cassava leaf have good quality, that is, a good profile of essential amino acids, such as lysine. However, the leaves are deficient in some sulfur amino acids, especially methionine (Carvalho, 1987). The leaves are rich in iron, zinc, manganese, magnesium, and calcium; moreover, vitamins B1, B2, C, and carotenoids are also present. Antinutritional factors can also be found in the leaves such as cyanide, polyphenols (tannins), nitrate, oxalic acid, hemagglutinin, saponins, and trypsin inhibitors (Eggum, 1970; Adewusi and Bradbury, 1993; Wobeto *et al*., 2006). These substances may cause toxic effects depending on the amount consumed or may have benefits depending on the substance and / or circumstance. Studies performed with cassava leaves show that the drying form of the leaves, the age of the plant, and the cultivar itself have a deep influence on both nutrient and antinutrient content (Corrêa, 2000; Corrêa *et al*., 2004; Wobeto, 2003).

Cyanide Quantification in the Leaves: Cultivars of cassava are commonly designated as sweet, with low cyanide content or bitter, with high cyanide content, depending on the amount of the cyanogenic glucosides linamarin and lotaustralin found in the plant parts. The enzymatic hydrolysis of these compounds releases free-hydrocyanic acid (HCN) and cyanohydrin (Mbah *et al*, 2019). Cyanogenic glucosides are present in the leaf, stem, root peel, and root parenchyma (peeled root). The leaves show a cyanogenic content 5 to 20 times higher than that of the peeled root. Cyanide amountsvary from 53 to 1300 mg HCN equivalents/kg (Wobeto *et al*., 2007) in the leaves, and from 10 to 500 mg HCN equivalents/kg in the peeled root (Mbah et a, 2019; Consumption of 50 to 100 mg/day of cyanide has been associated with acute poisoning and has been reported to be lethal for adults (Montagnac *et al*., 2009). Other studies have shown that hydrogen cyanide (HCN) in this plant can vary from 1 to 2000 mg/kg of dry matter depending on the plant age, cultivar, soil, and environmental conditions. Some studies have been carried out regarding the degradation of cyanide compounds, mainly in cassava roots by-products (Nambisan, 2011; Cardoso, Sousa, & Gameiro, 2006; Achid *et al*., 2005; Wobeto *et al*., 2004), since the roots are the main product of industrial cassava chain. However, few studies concerning the degradation of HCN in the leaves are available in the literature, and most of them are usually related to agronomic aspects, such as leaf aging (Simão *et al*., 2013; Corrêa *et al*., 2004). Cyanide is the most relevant toxic factor restricting the consumption of cassava roots and leaves; indeed, this is the main reason why cassava is not commonly consumed in Western countries (Latif *et al*, 2019; Montagnac *et al*., 2009). The cyanogenic glucosides are toxic to humans and can lead to severe health disorders. The leaves contain potentially toxic levels of cyanogenic glucosides in the form of linamarin (95% of total cyanogen content) and lotaustralin (5%). Linamarin is present in all cassava tissues (Balagopalan *et al*., 1988; Bokanga, 1994, 1994a) and is synthesized from the amino acid valine. In particular, the bitter varieties exhibit a cyanide level exceeding the Food and Agriculture Organization/World Health Organization (1991) recommendation of 10 mg/kg DW, which makes this plant acutely toxic for humans.Furthermore, the young leaves contain higher levels of cyanogenic compounds than older, and the presence of these compounds differs among varieties, and for the same variety increases with the increase of drought due to water stress on the plant (Cardoso *et al*., 2005; Nambisan, Sundaresan, 1994).

Corrêa *et al*. (2002) evaluated the effect of the drying temperature of cassava leaves on the hydrocyanic acid release and observed that the drying in the shade led to a great release of this acid, due to the action of the linamarase that occurs bu virtue of tissues are damaged. In this situation, the enzyme and glycoside come into contact (in normal conditions are stored in separate cell compartments),resulting in the hydrocyanic acid that is highly volatile at room temperature and is dissipated in the air, reducing its concentration significantly in the raw material. Methods involving grating and crushing (tissue disintegration) are usually very efficient in cyanide removal because they completely break plant cells and allow direct contact between the enzyme linamarase (also named β-Dglucosidase) and linamarin, resulting in the conversion into HCN, which either dissolve in water or is released into the air. After cleavage, glucose and α-hydroxynitriles are produced, with the latter, at pH above 4.0 and temperatures above 30ºC, being catalyzed by a hydroxynitrile bond, transformed into HCN and as its corresponding ketones (Chisté *et al*., 2010; Cardoso *et al*.2005; Oke, 1994). Heap fermentation retains half the cyanide of sun-drying. Boiling in water is relatively efficient in cyanide removing (50%) mainly because lignase is inactivated at the boiling temperature (100ºC). It is still much more efficient than baking, steaming, or frying (15 to 20% of cyanogen removal) (Bradbury, Denton, 2014; Padmaja *et al*., 1993; Essers, 1994).

Dewatering after fermentation and/or grating seems to be the most efficient treatment in cyanides removal (70– 95%) since either free or residual cyanides can be reduced (Hahan, 1988). Although efficient processing techniques to remove cyanide have been developed, some derived foodstuffs still have final cyanide content much above the Food and Agriculture Organizationof the United Nations and the World Health Organization safe recommendation of 10 ppm. Latif *et al* (2019) evaluated the cyanide content after the treatment with temperature (55 °C for 6 hr), enzymes, sodium bicarbonate, and ultrasonic treatments over 80%, and showed that the treatment with sodium bicarbonate was the most effective. Adindu *et al* (2003) reported that cassava flour, *fufu*, *gari*, and *tapioca* (typical cassava root products) from Nigerian markets contained cyanide up to 30 ppm, which is above the safe value. In East Africa, higher values are also observed (Cardoso *et al*., 2005). Indeed, Mlingi and Bainbridge (1994) reported values of cyanide concentrations in *makiopa* and *chinyanya* (sun-dried flours) to be above 130 ppm in Tanzania. According to Cereda, Vilpoux (2003), an alternative for improving the utilization of cassava leaves is protein extraction and its direct utilization, thus eliminating the antinutritional and toxic products. One way to improve the protein quality of the leaves would be to produce a protein concentrate that would remove fiber and reduce undesirable polyphenols, allowing better digestibility.

Possible Health Benefits of Cassava Leaves: Literature shows cases of acute poisoning following the consumption of a cassava-based meal. Commonly the symptoms include nausea, dizziness, headache, abdominal pain, and diarrhea (Penãs, 2015). On the other hand, as shown above, there are several techniques that reduce the concentration of cyanide compounds in cassava plants or products, making the leaves also usable for human consumption. Besides the potential use of cassava leaves in food, few studies have evaluated the health effects of this residue. The leaves have been cited for their possible medicinal potential to treat diarrhea, headache, fever, and rheumatism. In some countries, they are used in the treatment of sores, ringworm, and conjunctivitis. Other studies showed that they are efficient in the treatment of irritable bowel syndrome, aches, hypertension, cancerous affections, and tumors. Furthermore, cassava leaves can be used asdysentery, diuretic, demulcent, antiseptic, marasmus, flu, spasms and prostatitis (Bahekar, Kale, 2016; Abd Aziz *et al*, 2011; Tsumbu *et al*, 2011; Miladiyah I, Dayi F, Desrini, 2011). Saponins present in the leaves mayproduce complexes with steroids and phospholipids of the intestinal mucosa cell membrane and can also result in hypolipidemic effect by binding to bile acids and cholesterol and preventing the absorption of these fats (Rao & Kendall, 1986).

Tannins are considered anti-nutrients due to the decrease inprotein digestibility. Still, these polyphenols also work as potent antioxidants and may be related to the prevention of cardiovascular diseases and indirectly reduce the depletion of antioxidant vitamins (Mizutani *et al*, 2019; Russo *et al*, 2019; Ditano *et al*, 2019). Tsumbu *et al* (2011) revealed the first insights into the anti-radical and antioxidant effects of cassava leaves in a model of lipid peroxidation and cellular inflammation-like pattern. In this model, the extract of the leaves significantly reduced the production of advanced lipid peroxidation mediators such as ethylene and lipid hydroperoxides. Beyond that, the extract of the leaves inhibited the formation of transient free radicals. Bahekar, Kale (2016) suggested that cassava leaves can be considered as a potential source of antioxidants. Other authors showed that the leaves present α-carotene, vitamin A, ascorbic acid, anthocyanins, ascorbic acid, and other antioxidant compounds such as scopolin, coumarin, kaempferol-3-O-rutinoside, isovanillin, rutinp-coumaric acid, and ficusol. These compounds may show 2,2-diphenylpicrylhydrazyl scavenging capacity (Suresh *et al*, 2011; Al-Rofaai *et al*, 2012; Okeke *et al* 2007; Gomez *et al*, 2004). Fabri *et al* (2015) showed that the leaves of another species of cassava (Manihot multifidi) also showed 1,1-diphenyl-2-picrylhydrazyl scavenging property, and can be in the treatment of fungal infections. James *et al* (2019) showed that cassava leaves are used by women to augment milk production or supply in Sierra Leone.

Conclusion

Our literature review has shown that cassava leaves can be used as a food alternative besides being a source of good quality protein, vitamins, minerals, and antioxidants, and for therapeutic purposes for the low-income population in several countries. However, for this use to be safe, further studies are required to show the adequate detoxification of these leaves making them safe for human consumption.

Conflict of Interests: The authors declare no conflict of interest.

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