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Nutritional and Pharmacological Properties of *Tamarindus Indica L*

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Abstract

Vegetables of a different nature from cereals are important foods for the populations of West Africa and significantly enter their daily diet especially during periods of wheat famine. These populations have discovered not only the nutritional value of different local vegetables and fruits, but also the therapeutic power, for which many species are used in folk medicine with positive results. *Tamarindus Indica L.* is a large tree of the Cesalpinaceae family, Leguminose order, originating in the tropical areas of East Africa, of great utility because all its parts are used: the fruit, the seeds, the leaves are important in nutrition and medicine, the wood of the tree is very hard, resistant, is not attacked by insects, and is highly valued in furniture joinery, paneling, mill shovels, for the skeleton of boats, for golf clubs, for handles of knives etc. In folk medicine *Tamarindus indica* preparations are used in fever and as laxatives; in combination with lemon juice, honey, and spices they are considered an effective digestive and antiscorbutic. The pulp is applied on the inflammation, rheumatism, insolation, in poisoning, in cases of overdose and even in leprosy.

Keywords: Tamarindus; Pulp; Seeds; Jellose; Food; Drug

Introduction

Tamarindus Indica L. is a large tree of the Cesalpinaceae family, Leguminosae order, originating in the tropical areas of eastern Africa, India and many tropical countries. The stem branched from the base, can reach 12-25m in height, with very dense foliage that does not allow the sunlight to filter through, so that no other plants grow at its foot. The leaves are alternate, composed of 7 to 12 pairs of leaflets, of light green color, the flowers are yellow-orange, often striped or spotted of purple-red [1]. The fruits ripen in winter and have a brown bark, while the immature ones have the color of greenish bark: they are pendulous pods, with a woody coat, slightly curved, 5 to 15cm long, containing from 4 to 7 seeds for each pod. When the fruits are ripe, they are filled with a yellowish or brown pulp, fibrous, edible, with an acid but pleasant taste; the seeds become hard and shiny; the bark of the pod becomes fragile, the pulp narrows and the bark can be easily broken by hand [2,3]. The fruit pulp must be adequately prepared through a purification process, first dissolving it in boiling water, then filtering and concentrating the obtained liquid in a bain-marie. This concentrate is used both for the preparation of beverages with refreshing properties and for therapeutic uses [4]. For a long time, exactly until 1943, the tamarind seeds did not constitute a source of food. Only during periods of famine, Indian tribes mixed roasted and shelled seeds with other cereal flour and were also used for animal feed. Currently it has been shown that the almond composition of tamarind seeds is very similar to cereal seeds and is an excellent source of food [5].

Chemical Composition

The fruit pulp contains water, carbohydrates, proteins, organic acids: tartaric, malic, citric, succinic; vitamins: A, B_1, B_2, B_3, B_5, B_6, C, K, minerals: calcium, potassium, phosphorus, magnesium, sodium and selenium; volatile aromas, -sitosterol; a bitter principle, the Tamaridine, with fungicidal activity on the cultures of *Aspergillus niger* and of *Candida albicans* and antibacterial on Staphylococcus aureus, *Escherichia coli*, *Pseudomonas savastanoi*; 100g of tamarind pulp bring 239kcal. From the tamarind pulp, which is the richest source of natural tartaric acid, a refreshing drink is prepared for feverish states and at the same time purifying for its slight laxative action [6-9]. Tamarind seeds have been considered waste materials and have been little used for a long time compared to the tamarind pulp industry. A small percentage of the seed, in the form of tamarind kernel powder, was used in the textile, paper and jute industries. In 1942 two Indian scientists, TP Ghose and S. Krishna, announced that the decorticated seeds contained 46 to 48% of a gelling substance [10]. In fact, by grinding the tamarind seeds, a reddish-brown powder was obtained which water

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provided a soluble polysaccharide known as tamarind gum or Jellose. This polysaccharide, identified as xiloglucan, consists of the skeleton of D-glucan bound in β (1, 4) with residues of xylose, arabinose and galactose; it is completely soluble in water; it is stable in the acid pH range; reacts positively with an iodine solution [11-14]. Furthermore, no toxicity, environmental persistence or harmful effects on human health, crops or livestock were found, as xiloglucan is omnipresent in the plant cell walls of all vegetation. In humans, it is known that xiloglucan is a fiber that increases viscosity in the small intestine and is fermented by symbiotic bacteria in the colon; the similarity with cellulose shows the easy degradability of xiloglucan by cellulase enzymes [15]. In addition to polysaccharide, tamarind seed contains protein, lipids, mineral salts and tannins, the latter mainly present in the external coating [16]. Seed proteins are represented by albumins and globulins and the amino acids present are both branched chains with a high biological value such as leucine, isoleucine and valine, both sulphurous as methionine and cysteine [17]. Pentose sugars make up about 20% of soluble sugars and the main ones are mannose and glucose; in addition to a small amount of inositol [18]. The young seeds contain amber oil with a sweet taste: the palmitic, oleic, linoleic and eicosanoic fatty acids are the main components of the oil which also contains stigmasterol, sitosterol and carotenoids [19,20]. The organic extracts of the epicarp of the seed have a strong antioxidant activity, evidenced by the reaction with thiobarbituric acid, due to the presence of hydroxybenzoates, catechins, proanthocyanidins, as well as flavonoids such as taxifolin, apigenin, eriodictyol, luteolin and naringin. Although it is a waste product of processing, the epicarp of the seed, rich in polyphenols, could be considered as a low-cost source for the preparation of supplements, with protective effects on the reduction of oxidative damage caused by lipid peroxidation, to which they are attributed degenerative processes of age, mutagenesis, carcinogenesis and arteriosclerosis [21,22].

Tamarind and Feeding

Tamarind is an important source of low-cost nutrients, especially proteins, so it is a much consumed food in areas of the world where protein malnutrition is a widespread problem. All parts of the tamarind, from the fiber-rich pod, to the protein-rich and flavonoid seeds and pulp, have a high nutritional importance. According to the World Health Organization tamarind can be considered a source of all essential amino acids, with the exception of tryptophan: as a food it is rich in nutrients, fibers and phenolic compounds with antioxidant action such as catechins, procyanidins; contains also organic acids as tartaric acid, succinic and malic. The pulp is an important ingredient and is used in marinades, vindaloos, curry, chutney and Worcestershire sauce; it is also used in beverages and in refreshing pastry preparations. In the kitchen the pulp is widely used to flavor different dishes: from potatoes, to rice, to Sambhar, an Indian vegetable and lentil soup; from the pulp it is also possible to prepare a nutritious and thirst-quenching drink, simply by shaking the pulp in water with or without adding carbon dioxide. From the pulp of the fruits a jam is also prepared, which, consumed as such, is suitable for children and for weakened people. In Indian recipes the pulp is mainly used as an acidulant. Tamarind leaves and flowers are also used: both are characterized by a marked sour taste, the former are added to spicy soups, main courses, salads [23]. The preparations are often of handicraft or home origin and some products, such as tamarind lollipops, have been the subject of alarms from the FDA due to their lead content or insect contaminants. The whole ground seeds provide a powder with high nutritional value but have been used in a limited way, only as emergency food: they can be roasted, or kept soaked in water to remove the peel, then boiled or fried, or ground to obtain flour or extract starch. In Thailand, roasted seeds are ground and used as coffee substitutes or adulterants. The flour is widely used as feed of some animal species, including ruminants and pigs, which are able to digest its starch complex [24,25]. In chickens feeding tests, in fact, the results do not they were satisfactory: the chicks fed with tamarind diets showed a greater weight gain and a greater water retention compared to the control; in addition, the weight of some organs, pancreas and intestines also increased, showing a state of suffering for the liver and kidneys, attributed to the indigestible nature of the polysaccharide, rather than to the tannin content, or perhaps to the presence of other toxins [26-28]. Tamarind seed extracts show a strong antioxidant potential, reducing lipid peroxidation *in vitro*, and antimicrobial activity; therefore the seed can be used as a fortifying food due to its ability to provide nutritional value and low-cost nutraceutical [29-31]. A study was undertaken to evaluate the effect of tamarind seed powder on the physico-chemical properties, on the phytonutrient content, on the antioxidant and sensory properties of some enriched food products, such as bread, biscuits, and fruit juices. These foods have been chosen for the great diffusion among consumers of all ages; the biscuits also contain fats that possess ideal sensory characteristics to mask the astringent taste and flavor of tamarind seeds, which is not very attractive to most consumers; the fruit contains pectin in addition to a very tasty taste, which can mask astringency without altering the antioxidant effect of tamarind seeds. The addition of seed ground to cereal flour also affects the hardness, freshness and thickness of the biscuits, while the flavor and taste have not been influenced. Both in bread and in biscuits the addition of seed flour is acceptable up to 15% [32-34]. Today the industries are interested in the development of nutraceutical products from waste products including seeds, peels, stems, stems and leaves of plants, generated by the food and agricultural processing industries, because they contain a considerable quantity of phenols, flavonoids, anthocyanins, vitamin C and carotenoids and can be used as economic sources of natural antioxidants for pharmaceutical, cosmetic and food applications [35-37]. The polysaccharides extracted from the dough obtained from the tamarind kernel were found to be an excellent medium for the production of lipids and penicillin *via* the bacterial route and the tamarind gum which is used as a thickener and stabilizer in many foods, due to its ability to form gels even in cold water, in the form of film, can be used successfully to increase the conservation time of the fish [39-45].

Pharmacological Properties

Tamarind has long been used in traditional medicine by local populations for many diseases, without documented scientific evidence; modern research is in agreement on the therapeutic efficacy of this plant [46]. The fruit pulp has a laxative action due to the presence of malic and tartaric acid; it helps with abdominal pain and diarrhea; it is digestive, also acting on bile secretion and preventing liver disease [47-49]. The indigenous people of Mauritius mix salt with pulp and use this poultice to treat rheumatism; Bengalis use tamarind pulp to treat dysentery. The leaves are used as decoctions for the antihelminthic action and to fight malarial fever; the root decoction is used to cure asthma; leaves and roots are used as wound healing [50-53]. The methanolic extract of tamarind has antileismanial activity and antibiotic activity, while the aqueous extract has hypoglycemic activity [54-58]. Tamaridina bitter substance identified in the pulp has antibacterial and molluscicidal activity [59-63]. The potassium of which the pulp is rich acts by regulating arterial pressure [64]. The fiber-rich seed helps to regulate the intestinal function and lower the level of cholesterol in the blood [65-67]. The pericarp of the seeds is rich in polyphenols with very marked antioxidant activity: the flavonoids taxifolin, eriodictiol, luteolin, naringenin and apigenin, in fact, are important agents in the prevention of cancer diseases. An extract of the pericarp of the seed has also shown anti-arthritic activity, counteracting bone degeneration and degeneration of articular cartilage by inhibiting the proteolytic enzymes [68]. The polysaccharide extracted from the seed is used both in the food sector and in the pharmaceutical and cosmetic sectors. In the medical field it is used as an ointment stabilizer, thickener, binder, emulsifier, tablet coating agent; excipient for prolonged release drugs in oral, buccal, ocular and nano-manufacturing drug delivery systems, having been highlighted both the absence of carcinogenicity, the biocompatibility, the high capacity to retain drugs, the high thermal stability. Being a natural polysaccharide, it is easily biodegradable, well tolerated by patients and does not pollute the environment [69-73]. The polysaccharide for its mucomimetic, mucoadhesive and pseudoplastic characteristics has been used for the treatment of dry eye, a pathology that affects those who use contact lenses daily. Its molecular structure is similar to the corneal and conjunctival mucin, a glycoprotein that performs the task of protecting the ocular surface from the mechanical stress induced by the lens and constantly wetting it. To avoid undesirable effects such as itching and tearing, various companies have produced contact lenses by adding hyaluronic acid, and hydrophilic molecule, in their polymer matrix, which improves hydration at the lens-eye interface. Research carried out by comparing the polysaccharide activity of tamarind seeds with hyaluronic acid showed improvement in the stability of the tear film and symptoms such as ocular burning, photophobia and foreign body sensation; maximum tolerability [74-78]. The ocular solutions obtained from the polysaccharide have proved to be very effective, allowing for their viscosity and mucus adhesiveness to remain on the ocular surface for a longer time. These products require a lower frequency of daily instillations and greater protection of the corneal epithelium; they increase the healing rate of corneal wounds; they have a protective effect against sunlight and allow topical administration of prolonged-release antibiotics in the treatment of ocular, infectious diseases, such as bacterial keratitis, caused by Pseudomonas aeruginosa and Staphylococcus aureus [79]. In the cosmetic sector, an ethanol extract from the pericarp of the tamarind seeds was incorporated into a milky-based lotion and the antioxidant and anti-inflammatory activity was evaluated for an anti-wrinkle product [80]. Several patents have been obtained for the preparation of tamarind-based solutions useful in the prevention of dental caries or gelatinous products suitable for the stability of dentures [81,82]. An in vitro release study was also performed, using chitosan-coated liposomes in which a lyophilized tamarind extract was incorporated to evaluate the release rate of the alpha hydroxy acids of which the extract is rich. The application on a skin cell culture showed that in the coated liposomes the release rate of alpha hydroxy acids was lower than that of uncoated liposomes, but of greater quantity. Therefore, this system could be useful to increase the potential of tamarind alpha hydroxy acids on the stimulation of human keratinocyte proliferation which was twice as high as the tamarind extract solution [83].

Conclusions

Tamarindus indica L. is an important source of food in tropical regions, but currently waste products such as seed bark are little used. The plant contains in the leaves, seeds, roots, pulp and flowers a great variety of bioactive substances that have beneficial effects on human health and the possibility of application in various industrial sectors. Above all the seeds have great importance for the richness of antioxidant substances that counteract the formation of free radicals and play an important role for the body's health in the prevention of cardiovascular and cancer diseases. Furthermore, the residues from the processing of the seeds, which represent a zero-cost waste, could be used as a preservative to increase the suitability time of packaged foods, interfering with lipid peroxidation.

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