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Research Application Summary

Nutraceutical and antimicrobial properties of baobab pulp and leaves: A review

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Abstract

Baobab is an important in Africa for its medicinal and nutritional properties. The different parts of the tree (bark, leaves and pulp) are used for different purposes. Despite the health benefits properties of the baobab pulp and leaves, few studies were related to their nutraceutical properties. The present review aimed to point out some nutraceutical properties of these parts of the fruit and their potential health benefits. Different terms related to baobab and functional properties were used on selected research's engines and the data related to this review were collected from 28 articles. The review revealed the richness of the baobab leaf in glycosides, saponins, steroids and flavonoids; its extract has an inhibitory activity on some pathogenic microorganisms. Bioactive compounds such as procyanidin B2, vitamin C, gallic acid and epicatechin were found in the pulp. The pulp contains alkaloids, glycosides, steroids, coumarins, flavonoids, saponins, carbohydrates; in the family of glycosides were identified in the pulp, three phenylethanoid glycosides, four hydroxycinnamic acid glycosides and six iridoid glycosides. The efficiency of baobab pulp extract on the total blood cholesterol content and blood glucose content through the experiences made on rats and human patients was evidenced. Baobab pulp can be used against diabetes and obesity whose prevalences are increasing. The review revealed the inhibitory effect of the leaf extract on pathogenic microorganisms as *Aspergillus flavus*, *Staphylicoccus aureus*, *Escherichia coli*, and *Salmonella typhi*. Further studies should examine antimicrobial properties in food storage, and on the identification of molecules responsible of the anti-diabetic and anti-cholesterolemic effects of the baobab pulp.

Keywords. Diabetes, functional properties, microorganisms, nutritional, obesity

Résumé

Le baobab est important en Afrique pour ses propriétés médicinales et nutritionnelles. Les différentes parties de l'arbre (écorce, feuilles et pulpe) sont utilisées à des fins différentes. Malgré les propriétés bénéfiques pour la santé de la pulpe et des feuilles de baobab, peu d'études ont porté sur leurs propriétés neutraceutiques. La présente revue visait à souligner certaines propriétés nutraceutiques de ces parties du fruit et leurs avantages potentiels pour la santé. Différents termes liés au baobab et aux propriétés fonctionnelles ont été utilisés dans les moteurs de recherche et les données ont été recueillies à partir de 28 articles. La revue a révélé la richesse de la feuille de baobab en terme des glycosides, les saponines, les stéroïdes et les flavonoïdes; son extrait a une activité inhibitrice sur certains microorganismes pathogènes. Des composés bioactifs tels que la procyanidine B2, la vitamine C, l'acide gallique et l'épicatéchin ont été trouvés dans la pulpe. La pulpe contient des alcaloïdes, des glycosides, des stéroïdes, des coumarines, des flavonoïdes, des saponines, des glucides; dans la famille des glycosides ont été identifiés dans la pulpe, trois glycosides phényléthanoïdes, quatre

glycosides d'acide hydroxycinnamique et six glycosides iridoïdes. L'efficacité de l'extrait de pulpe de baobab sur la teneur totale en cholestérol sanguin et la teneur en glucose sanguin à travers les expériences faites sur des rats et des patients humains a été démontrée. La pulpe du baobab peut être utilisée contre le diabète et l'obésité dont la prévalence augmente. La revue a révélé l'effet inhibiteur de l'extrait de feuille sur les microorganismes pathogènes comme *Aspergillus flavus*, *Staphylicoccus aureus*, *Escherichia coli* et *Salmonella typhi*. D'autres études devraient examiner les propriétés antimicrobiennes dans l'entreposage des aliments et l'identification des molécules responsables des effets anti-diabétiques et anti-cholestérolémiques de la pulpe de baobab.

Mots clés: Diabète, propriétés fonctionnelles, microorganismes, nutrition, obésité

Introduction

From the family of Bombacaceae, around of 20 genera and 180 species, *Adansonia digitata* L. is found widespread throughout the hot, drier areas of tropical Africa (Gurashi *et al*., 2016). It is well appreciated its therapeutic and nutritional value. The pulp represents an excellent source of antioxidant, due to the vitamin C content, round ten times higher than in oranges (Kamatou *et al*., 2011). Researches conducted on baobab parts revealed that crude protein, crude lipids and carbohydrates ranged from 2.5 to 17 g/100g dw, 0.2 to 15.5 g/100g dw, 46.6 to 87.7 g/100 g dm, respectively, for baobab pulp, 10.1 to 15 g/100g dw, 4.0 to 6.3 g/100g dw, 40.2 to 69.0 g/100g dw, respectively, for baobab leaves (Chadare *et al*., 2009; Assogbadjo *et al*., 2012) .

In the past decades, the tree gained interest from several pharmaceutical companies and researchers due to its different therapeutic, nutritious and cosmetic properties. Indeed, fruits, seeds, leaves and bark contribute to the livelihood of many Africa tribes as a source of food, fiber and medicine (Wickens, 1982; Codjia *et al*., 2001; Sidibe and Williams, 2002; Chadare *et al*., 2009; Buchmann *et al*., 2009; De Caluwe *et al*., 2010) . Traditionally, more than three hundred uses were documented in Benin, Cameroon, Central African Republic, Kenya, Malawi, Mali, Senegal, South Africa and Zimbabwe (Buchmann *et al*., 2010). A strong demand for baobab and its derived products exist particularly in Sudan where 60 to 75% of consumers appreciate baobab products due to its nutritional value (Adam, 2017). It is therefore, important to understand the different properties of the baobab tree and its health benefits to mankind. The increasing demand for health promoting ingredients is attracting interest from beverages industries and the fast-growing food market. Functional beverages are sold as fortified water, tea, diary or juices often claiming nutrition, energy, anti-aging or relaxing effects (Gruenwald, 2009). They thus appear to constitute an opportunity for next generations in food industries. New wmerging interest in Africa in the last years has been the establishment of baobab as a commercial crop with an economic importance (Ibrahima *et al*., 2013). Currently, baobab parts are used for multiple medicinal purposes due to antioxidant, prebiotic-like, anti-inflammatory, analgesic, antipyretic, anti-diarrhoea and anti-dysentery activities (Kaboré *et al*., 2011). These therapeutic properties were described by many authors but their nutraceutical components were hardly assessed. The present review aimed at contributing to filling that gap by documenting nutraceutical properties of baobab pulp and leaves, and their effects on diabetes and obesity.

Methodology

The literature search was done by using the following search terms: "baobab derived products", "functional and nutraceutical of baobab pulp", "functional and nutraceutical properties of baobab leaves", "Medicinal properties of baobab pulp/leaf", "antimicrobial properties of baobab pulp and leaves" "Obesity status" and "Diabetes status". The research's engines used were "Google scholar", "Web of Science", "Scopus" and "Agora". In all, 162 articles were reviewed and 28 articles were used in the writing of the present short review.

Results and discussion

Obesity and diabetes. The WHO estimates that there are about 180 million obese adults, and in addition, at least twice as many adults are overweight, with a Body Mass Index (BMI) of 25.0 to 29.9 (Bjorntorp, 2002). The world obesity prevalence doubled in recent decades and this disease was associated with lower contents of specific antioxidants in food; these antioxidants play a role in the development of obesity linked to diseases such as cardiovascular diseases (Hosseini *et al*., 2016). The prevalence of overweight and obesity among women is increasing in developing countries as well. Indeed, the number of obese persons doubled in Kenya, Benin, Niger, Rwanda, Côte d'Ivoire and Uganda, while it tripled in Zambia, Burkina Faso, Mali, Malawi and Tanzania from 1993 to 2014 (Amugsi *et al*., 2017). Obesity was identified as an important risk factor for beginning and progression of multiple neurological disorders as Parkinson's disease and Alzheimer's disease These metabolic changes alter the synaptic plasticity of the neurons and lead to neural death, affecting the normal physiology of central nervous system (Bhat *et al*., 2017).

The human population worldwide appears to be in the midst of an epidemic of diabetes (Tiwari and Rao, 2002). The global prevalence of diabetes currently exceeds 400 million and is projected to increase to more than 600 million affected persons by the year 2035 and developing countries will account for the greater proportion of the projected increase in diabetes prevalence (Dagogo-Jack, 2017).

The nutraceuticals. The word "Nutraceutical" combines the words "Nutrition" and "Pharmaceutical"; it is a food or food product that supply health and medical advantages, including the prevention and cure of diseases (Ujjaliya *et al*., 2018). A nutraceutical is also defined as any substance considered as a food or part of a food which supply medical or health benefits including the prevention or cure of disease. It includes isolated nutrients, dietary supplements, diets and dietary plans, genetically engineered foods, herbal products and processed foods such as cereals soups and beverages (Wrick, 2005). The term Nutraceuticals is also used to describe bioactive natural compounds that have health promoting or disease preventing properties (Elliott and Ong, 2002). Many food nutrients are nutraceuticals. They belong to the group of carbohydrates, lipids, proteins, minerals, fibers and Vitamins.

Nutraceutical compounds in Baobab pulp. Many studies described the potential or reported health benefits of the pulp consumption on human body. Thirteen components were reported for the first time in baobab pulp: four hydroxycinnamic acid glycosides, six iridoid glycosides and three phenylethanoid glycosides. The four hydroxycinnamic acid glycosides (HAGs) are: 1-O-(E)-feruloyl-β-D-glucose, 1-O-(E)-caffeoyl-β-D-glucose, 6-O-(E)-caffeoyl-β-D-glucose, 6-O-(E)-caffeoyl--D-glucose. The six iridoid glycosides are: specioside, verminoside, 6-O-(E)-feruloylcatalpol, 6-O-p-coumaroylajugol, 6-O-(E)-caffeoylajugol, 6-O-(E)feruloylajugol. The three phenylethanoid glycosides are: martynoside, acteoside and isoacteoside. Hydroxycinnamic acid glycosides, iridoid glycosides and phenylethanoid glycosides were found to be the main components in baobab fruit pulp (Li *et al*., 2017). The iridoid glycosides and phenylethanoid glycosides which were revealed to have antioxidant, anti-inflammatory, antimicrobial and antiviral effects (Li *et al*., 2017). Some chemical families were found in the baobab pulp extract; they are: Tannins, Terpenoids, Alkaloids, Coumarins and Sterols (Zeitoun *et al*., 2016). The same compounds were found in the ethanolic extract of dried baobab pulp; they are the alkaloids, the glycosides, the steroids, the flavonoids, the saponins, the carbohydrates, the gums and the mucilage (Saravanaraj *et al*., 2017). Bioactive compounds were found in baobab pulp and include procyanidin B2 (533 ± 22.6 mg/100 g FW), vitamin C (AA + DHA) (466 ± 2.5 mg/100 g FW), gallic acid (68.5 ± 12.4 mg/100 g FW) and (-) epicatechin (43.0 ± 3.0 mg/100 g FW) (Tembo *et al*., 2017).

Nutraceutical compounds in Baobab leaves. Usually presented in dry form, baobab leaves are used in the preparation of soup known as "miyan kuka" in Northern Nigeria (Ogbaga *et al*., 2017), "Yatirankounti" sauce, "Touwoundou" sauce and "Kouimkoundi" sauce" in Benin (Chadare *et al*., 2008). The leaves are reported to possess nutritional and medicinal benefits and have been used for those purposes in Africa and Asia; however, research on the detailed constituents of the dry leaves are scarce (Ogbaga *et al*., 2017).

The evaluation of the presence of some phytochemicals in aqueous extract of baobab leaves revealed that the leaves are rich in phytochemicals such as glycosides, saponins, steroids and flavonoids while alkaloids, tannins and resins are absent (Abiona *et al*., 2015)

Anti-microbial properties of baobab pulp and leaves. Baobab leaves have anti-microbial properties on certain microorganisms (Abiona *et al*., 2015). The use of baobab pulp aqueous extract showed inhibitory effect on pathogenic microorganisms, at different doses (Table 1). Baobab leaf extract showed a significant effect on *Staphylococcus aureus*, at a little dose (12.5 mg/ml); it also revealed inhibitory effect on *Escherichia coli* at a dose of 50mg/mL and *Salmonella typhi* at a dose of 100 mg/ml. *Escherichia coli* and *S. typhi* are considered as target pathogenic microorganisms in many food products such as juice, nectar and milk. Baobab leaves extracts could possibly be used to prevent stomach aches and typhoid fever respectively due the inhibitory actions on *E. coli* and *S. typhi*.

Table 1. Effect of baobab leaves extract on some microorganisms

Microorganisms	Doses (mg of dried leaf/ml of the solution)				
	12.5	25	50	100	200
Staphylococcus aureus,	+	+	+	+	+
Escherichia coli,			+	+	+
Bacillus subtilis,		+	+	+	+
Pseudomonas aeruginosa,				+	+
Salmonella typhi,				+	+
Candida albicans,			+	+	+
Aspergillus niger,			+	+	+
Rhizopus stolomifer,				+	+
Penicillum rotatumat			+	+	+

+ indicates an inhibition of microorganism

Source: Abiona *et al*. (2015)

Baobab pulp has inhibitory effect on moulds. The use of baobab fruits extract on the vegetative growth and aflatoxin secretion by *Aspergillus flavus* (SQU21) and *Aspergillus parasiticus* (CBS921.7) strains, at different concentrations (1.5, 3, 5 and 7% w/v) revealed an inhibition on the total aflatoxin secretion of up to 20.4-68.5% for *Aspergillus flavus* and 11.9-69.1% for *Aspergillus parasiticus*; whereas the inhibition of aflatoxin B1 production ranged between 29.9-79.2% and 13-68% for the two strains, respectively. This indicates the antifungal activity and inhibitory property of baobab on the growth and aflatoxin production by the two toxigenic strains (El-Nagerabi *et al*., 2013).

Effect of the baobab pulp extract on the body

Anti-diabetic effect. The use of the ethanolic extract on streptozotocin-induced diabetes rats revealed a significant effect on the blood glucose content. The experiment evidence obtained indicates that

ethanolic extract of *Adansonia digitata* L. fruits possess antidiabetic properties which suggests the presence of biologically active components which deserve further investigation and elucidation (Saravanaraj *et al*., 2017). Another similar experience on diabetic rats which were administrated baobab pulp extract showed, at doses lower than 5000 mg/kg, significant decrease in blood glucose level were observed when compared to the control after two weeks of treatment with the extract (Muhammad *et al*., 2016). It involves a hypoglycemic activity of the extract which might be due to the presence of various bioactive compounds in baobab pulp.

Anti-obesity effect. Research conducted at Soba Hospital, Sudan, assessed the effects of *Adansonia digitata* pulp on serum lipids among a human population of hyperlipidemic patients. The findings showed a significant reduction of the levels of total cholesterol (49.06 %) and triglycerides (57.44%) in the intervention group compared to the control (Gadour *et al*., 2017). The intervention group were administrated with atorvastatin tablets combined with baobab pulp, while the control group received tablets of atorvastatin only. The results suggests a combined effect of baobab pulp and atorvastatin's tablets. Another study on rats, revealed the effect the baobab pulp on the total cholesterol (Alhassan *et al*., 2016). Indeed, Hyperlipidemia was induced in rats via feeding on high lipid diet for three weeks. The rats received different doses of baobab pulp (1.25 g/kg, 2.5 g/kg and 3.75 g/kg). The experience revealed a significant increase in the high-density lipoprotein (HDL) content observed with 1.25 g/kg, 2.50 g/kg and 3.75 g/kg. The findings indicate that baobab fruit pulp aqueous extract possess anti-hyperlipidemic activity.

Conclusion

The multi-purposes tree, *Adansonia digitata* has several chemical properties explaining the different benefits. Its nutritional value is well investigated while its medicinal value still needs to be investigated more. The present short review indicate the presence of phytochemicals or bioactive compound families in baobab pulp and leaves. Some research have shown a significant effect of pulp on diabetes and total cholesterol in rat and in human beings. Further studies should focus on the identification of molecules which are responsible for the anti-diabetic and anti-cholesterolemic effects of the baobab pulp.

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