Nutritional and functional properties of *Hyphaene thebaica* L. flour: a critical treatise and review

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**ABSTRACT**

The importance of plant secondary metabolites in food and their possible impacts on human health are the subjects of a steadily developing number of studies. Furthermore, as consumers become more conscious of diet-related issues, they desire natural ingredients that are anticipated to be safe and health-promoting; as a result, doum flour might be regarded as an excellent source of functional compounds. *Hyphaene thebaica* L. is a palm plant species with eatable ovoid fruits and a woody texture that is endemic to upper Egypt. It is one of the world’s most significant and valuable plants. Doum flour is considered to contain higher moisture content, crude fiber, ash content, protein, fat, and vitamins, especially niacin, folic acid, pyridoxine, riboflavin, and thiamin. Previous findings showed that doum flour has high functional and nutritional qualities and may be used for a variety of key applications in the food sector. Doum nuts contain antioxidants as well as metabolites like tannins, saponins, steroids, glycosides, terpenes, and terpenoids. The results of different studies have indicated that doum flour is effective in various health maladies. This review highlights the anti-inflammatory, antioxidant, antibacterial, anticancer, nutritional content, fertility activity, the rheological, and pharmacological ability of *Hyphaene thebaica* L. flour extracts and their significant phyto-constituents such as polyphenol, essential-oil, and flavonoid components.

**Introduction**

*Hyphaene thebaica* L. (doum plant) is a desert tree endemic to Egypt, Sub-Saharan Africa, and West India. In Sudan, it is named the doum, or gingerbread tree, that reaches a length of 6–9 feet and has branched stems with 65–75 centimeter lengthy fan-shaped leaves. It is considered one of the world’s most beneficial plants. The palm’s wood is utilized for building and the production of numerous household objects, while the leaves are utilized to produce mats, parcel binders, and notebook paper Siddeeq et al.\(^1\). The oval, apple-sized bright orange fruit has a reddish shell, a dense, spongy, delicious, fibers rich fruit flesh with a gingerbread-like flavor, and a big kernel. The fruit’s coating is edible and may be crushed into a powder or sliced into pieces; the powder is generally dried and used as a flavoring ingredient in foods. Doum flour has a vast quantity of important minerals like potassium, sodium, calcium, magnesium, as well as phosphorus, according to different research. Doum flour also provides vitamin B complex, carbs, and fibers, all of which are beneficial to one’s health. Several investigations have found that doum flour extracts are rich in phenolic and flavonoid compounds, and have substantial antioxidant and antibacterial properties Seleem et al.\(^2\). Various research has

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demonstrated that high-dietary fiber consumption is linked with various health advantages, including a lower risk of cardiovascular disease, diabetes mellitus, obesity, and certain types of cancer, and also customer health improvement through a decrease in triglycerides and fat. Doum flour has also been shown to have strong antibacterial properties against both Grams positive and Grams negative microorganisms reported by Glew et al. 

Trace minerals and major minerals are two types of essential minerals. Both types of minerals are essential; however, trace minerals are required in lesser quantities than macro-minerals. The quantity of nutrients required in the body is not an evaluation of their significance. Trace minerals appear to have biological activities as a constituent of prosthetic groups and as co-factors for enzymes. Due to their extremely low needs and the abundant distribution of these minerals in foods, deficiency symptoms for some critical trace elements were not recognized till now. Vitamins are chemical compounds that are available in trace quantities in foods and are required for metabolism. Vitamins are assembled not because they are structurally linked or have identical physiological roles, but because, as their names indicate, they are essential nutrients in the food and were all identified in association with disorders caused by their shortage. Different researchers have used doum flour in food items based on the following reason reported by Aboshora et al. 

Doum is a valuable fruit that contains necessary nutrients and functional characteristics that may be used in a variety of methods. The pulp of the doum-flour is an excellent supplier of fructose, glucose, fibers, antioxidants, and other useful substances like carbohydrates and minerals, particularly potassium (K which is responsible for the maintenance of blood pressure). The purpose of this review was to look at the nutritional, biological and rheological characteristics of doum flour.

**Nutritional composition of doum flour’s**

Doum flour has a high level of protein ranging from 2.86 to 5.01%, a large amount of lysine and cysteine in raw protein ranging from 4.09 to 4.16% and 0.2 to 1.62%, respectively, a few amino acid threonines, raw lipid ranging from 1.2 to 8.4%, crude fiber ranging from 52.26 to 66.5%, the most essential carbohydrates constituent mannose ranging from 13 to 75.9%, and the occurrence of calcium, tannic acid, terpenoids, steroids, glycosides, flavonoids, terpenes, and terpenoids were identified in minimum to moderate amounts in the doum flour. Aamer et al. studied several processes that may increase the antioxidant properties found in doum flour and which may play an essential nutritional role in the diets of children and adults in some of the world’s poorest countries (Sub-Saharan Africa, India, and Egypt). Nutritional composition of doum flour was shown in Table 1.

| Components          | Values | References |
|---------------------|--------|------------|
| Moisture            | 10.15% | 8          |
| Crude fiber         | 14.08% | 9          |
| Ash                 | 9.57%  | 8          |
| Nitrogen free extract | 72.72% | 10         |
| Total sugars        | 43.70% | 11         |
| Antioxidant activity| 45.86% | 12         |
| Niacin (B3)         | 20.08% | 13         |
| Folic acid (B9)     | 3.02%  | 11         |
| Pyridoxine (B6)     | 10.07% | 8          |
| Thiamin (B1)        | 5.00%  | 13         |
| Riboflavin (B2)     | 4.22%  | 8          |
| Total fats          | 0.91%  | 14         |
**Fatty acid**

The concentrations of six distinct fatty acids were observed in epicarp, pulp, and crushed samples of doum fruit. Palmitic acid was detected in abundance in doum flour samples. Epicarp had the maximum value, followed by crushed sample and pulp, with palmitic acid ranging from 75.10% to 34.14% Lokuruka et al. Arachidic acid was not observed in the epicarp but was discovered in small amounts in pulp (3.76%) and crushed samples (2.69%). Concerning other samples, the epicarp sample had the maximum level of steric-acid (8.57%) reported by Hsu et al. The pulp also contained a high concentration of unsaturated fatty acids, mainly oleic-acid (C18:1 trans-9) at 25.66% as well as linoleic-acid (C18:2 cis-9–12) at 21.39%, according to the data. Linolenic (C18:3 cis-9, 12, 15) was observed only in pulp samples among the unsaturated fatty acids (3.28%). Saturated fatty acids, monounsaturated, and polyunsaturated fatty acids were shown to differ significantly among doum flour samples, according to statistical data Admassu et al. The pulp sample had the maximum level of monounsaturated fats, followed by the crushed sample and the epicarp. The polyunsaturated fatty acid/saturated fatty acid ratio is usually used to measure the fat’s nutritional content. Chang et al. tested the influences of monounsaturated fatty acids on plasma and liver fat contents in mice, as well as the proportion of polyunsaturated and monounsaturated fatty acids to saturated fatty acids.

**Phenolic content**

Several investigations reported various total-soluble phenols concentrations in doum, ranging from 45.08–64.90 milligrams GAE DW. The maximum values were found in crushed doum fruit flour extracts, which ranged from 116.26 to 139.48 milligrams GAE/g DW Aboshora et al. Fruits and veggies have a significant polyphenol content, which contributes to their bioactivity. Vanillic acid, sinapic acid, chlorogenic acid, catechin, methoxy-cinnamic acid, p-hydroxybenzoic acid, 3,4 di hydroxycinnamic acid, caffeic acid, 2-hydroxycinnamic acid, Epicatechin, and cinnamic acid were the most prevalent phenolic chemicals found in doum. In compared to domestic fruits, doum-pulps have increased caffeic-acid concentrations studied by Sultana et al. It has been studied that the extracts of doum flour possess antioxidant properties; this is owing to a significant quantity of water-soluble phenolic-content in the fruits Aamer et al. Concentrations of different phenolic components in doum fruit flour were shown in Table 2.

**Flavonoids content**

The flavonoid concentration of various doum fruit flour extracts ranged from 24.04-milligram rutin/g DW to 47.17-milligram rutin/g DW. The total flavonoids (milligram/gram) within quercetin-equivalent of *H. thebaica* flour was 46.28 milligram/gram DW, according to similar reports Mohamed et al. Dilute doum fruit preparations were subjected to HPLC analysis, which revealed

| Table 2. Concentrations of different phenolic components in doum fruit flour. |
|-----------------------------|----------------|------------------|------------------|
| Compounds                   | Retention time (min) | mg/100 g levels | References       |
| Catechin                    | 9.823            | 5.99             | 8                |
| 3-OH tyrosol                | 8.413            | 3.54             | 23               |
| Caffeic                     | 10.595           | 1.00             | 16               |
| Iso-Ferulic                 | 12.773           | 1.43             | 13               |
| Alpha-coumaric              | 13.840           | 0.54             | 11               |
| Coumarin                    | 15.087           | 0.33             | 16               |
| Cinnamic                    | 15.820           | 0.23             | 23               |
| E-Vanillic                  | 13.232           | 6.61             | 8                |
| Chlorogenic                 | 9.410            | 3.59             | 8                |
| Ellagic                     | 13.692           | 0.98             | 23               |
11 flavonoid components. The flavonoids quercetin, hesperetin, naringin, and rutin have the maximum concentrations reported by Aamer et al.\textsuperscript{[18]} Concentration of flavonoid components in doum fruit flour were shown in Table 3.

### Functional characteristics of doum flour

#### Antioxidant properties

Doum is a poly-phenolic compound-rich traditional beverage popular in Egypt. Various researchers have found that doum fruit flour extracts contain significant concentrations of flavonoid and phenolic compounds, which function as antioxidants and antibacterials, reducing the negative oxidative stress and preventing illness caused by infectious microbes.\textsuperscript{[19]} Plants’ phenolics are well known for their ability to scavenge reactive radicals. The polyphenols’ antioxidant characteristics are linked to the existence of functional groups within ring and circular structure of atoms, as well as connected double bonds.\textsuperscript{[20]} The factors that contribute to the synthesis of oxygen radicals and the physiological response to oxygen radicals are depicted in Figure 1.

The antioxidant properties were enhanced when the amount and ingestion of doum flour were increased, indicating that the effectiveness of its antioxidant and antibacterial activities would have several beneficial advantages.\textsuperscript{[13]} 2,2-Diphenyl-1-Picrylhydrazyl is a sustainable diamagnetic molecule that has gained an extra electron studied by.\textsuperscript{[22,23]} The reduction in absorption at 517 nanometers caused by antioxidants was used to identify DPPH. The effectiveness of the phenolic components in the doum fruit extracts to donate hydrogen improves the DPPH scavenging property Kolla et al.\textsuperscript{[24]} When utilizing DPPH to evaluate the antioxidant properties of doum flour extracts, the water-soluble extract had 343.4 moles of dpph equivalents/g DW while the lipid-soluble extract had 42.67 moles of dpph equivalents/g DW Salih et al.\textsuperscript{[25]} Similarly, doum flour extracts had IC50 values varying from 1 07.6–172.7 grams/ml. These results were different from those of,\textsuperscript{[26]} who reported that aquatic doum flour extract had 50% antioxidant action IC50 at a concentration of 1000 micrograms/ml and that the 1500 micrograms/ml extract had 80% antioxidant characteristic. Moreover, the doum leaf ethanolic extract in water was shown to be an effective scavenger of oxygen free radicals Eldahshan et al.\textsuperscript{[27]} Recent studies show a strong connection between phenolic concentration and antioxidant properties, demonstrating that total phenolic compounds might have a substantial effect on antioxidant properties. Fe\textsuperscript{2+} is a transition metal that is required for the functioning of numerous enzymes and several essential proteins involved in cellular metabolism, O\textsubscript{2} transportation, and redox mechanisms within the human body Aboshora et al.\textsuperscript{[6]} Nonetheless, as a transition element, it includes one or more lone pairs of electrons, allowing them to interact in a single electron transfer mechanism. As a result, it is a powerful catalyst for autoxidation processes, such as the Fenton-reaction, which produces OH\textsuperscript{−} from H\textsubscript{2}O\textsubscript{2}, and the degradation of alkyl-peroxides into alkoxyl and reactive species Lloyd et al.\textsuperscript{[28]} Transition element chelation can produce low oxidation-reduction potential complexes, which is an important antioxidant activity owing to this characteristic, and evaluating Fe\textsuperscript{2+} chelation is one approach for assessing this function.\textsuperscript{[29]} The process is dependent on an antioxidant’s interaction with Fe\textsuperscript{2+} in correlation to ferrozine; the test is impacted by both antioxidant level and binding potential, and only substantial Fe\textsuperscript{2+} antioxidant

### Table 3. Concentration of flavonoid components in doum fruit flour.

| Compounds   | Retention time (min) | mg/100 g levels | References |
|-------------|----------------------|-----------------|------------|
| 7-hydroxy-flavone | 18.150              | 0.02            | 25         |
| Naringin    | 12.925               | 1.11            | 26         |
| Apigenin    | 17.283               | 0.04            | 8          |
| Rutin       | 12.925               | 0.96            | 16         |
| Quercetin   | 15.590               | 0.29            | 25         |
| Kaempferol  | 16.790               | 0.04            | 26         |
| Hesperidin  | 13.033               | 1.35            | 8          |
| Quercitrin  | 13.962               | 0.79            | 23         |
chelators are identified. Because they tended to chelate iron ions, numerous plant phenolics have been classified as antioxidants using this test. El-Beltagi et al.\textsuperscript{[21]} found that alcohol and aqueous extracts of \textit{H. thebaica} fruits had antioxidant properties of 28.93 ± 0.23%, and 31.91 ± 0.14%, correspondingly. Because of the significant amount of water-soluble polyphenols in doum flour, extracts exhibited antioxidant action. Mohamed et al.\textsuperscript{[13]} The percentage of iron scavenging ability of \textit{H. thebaica} alcohol extracts was determined to be 24.3% at 200 grams per milliliter. When the content of the extract was raised, the antioxidant properties rose as well. The Fe$^{2+}$ chelating impact was seen in a concentration-dependent approach by Hsu et al.\textsuperscript{[10]} When employing the FRAP test, the antioxidant properties of doum flour extract were 13.57 micromoles of total phenolic equivalents/grams DW in aqueous extract and 7.69 micromoles of total phenolic equivalents/grams DW in the lipid-soluble extract. These studies are consistent with prior research that demonstrated doum fruit flour to have Fe$^{2+}$ chelating activity. Hsu et al.\textsuperscript{[10]} The superoxide ion is injurious to the host because it is a precursor of the hydroxide radicals in the reaction of Fenton and functions allylic hydrogen extractor in lipid oxidation. The superoxide radicals were measured using the nitro blue tetrazolium/phenazine-methosulphate//β-NADH method. Antioxidant properties can be induced with an antioxidant by transferring hydrogen or electrons to a radical or through direct interaction with it. Doum flour has a low action against superoxide, with 0.02 millimoles of Gallic acid equivalents per gram of extract, according to this experiment. Furthermore, the significant suppression percent of superoxide formation was found to be 63.22% at a dosage of 300 micrograms per milliliter of \textit{H. thebaica}. Doum flour extract is an effective superoxide radical scavenger produced in an in vivo PMS system, with an effectiveness equivalent to quercetin. In previous research, antioxidant action/IC50 Inhibitory levels of doum parts are determined using various approaches also discussed in Table 4.

\textbf{Figure 1.} The factors that contribute to the synthesis of oxygen radicals and the physiological response to oxygen radicals are depicted in this diagram. Source El-Beltagi et al.\textsuperscript{[21]}
Anticancer properties

Reactive oxygen species may interact with biological molecules and cause significant damage to genetic material, proteins, and lipids, all of which are linked to aging, aging-related disorders, and cancer. In the last phases of cancer growth, polyphenols play a critical role. The unbalance between free radicals and antioxidants, which favors the oxidants and may cause damage to normal cells, is known as oxidative stress. The methanolic extracts of *H. thebaica* peel have strong cytotoxicity and free radical scavenging versus human cancers, but no cytotoxic consequence on human normal immortal fibroblast cells. Antioxidants play a critical function in the mitigation of the production of oxygen radicals species, which are responsible for a variety of damaging oxidative reactions. Antioxidants can come from either an artificial or natural origin. In the last phases of cancer growth, antioxidants play a significant role. A549 (carcinoma of a lung) and MCF-7 (Adenocarcinoma of the breast) cells were found to be cytotoxic to *H. thebaica* extract (87% and 89%, respectively). Researchers reported that *H. thebaica* flour extract exhibited antioxidant and anticancer properties in the prevention of severe myeloid leukemia. Additionally, Soares et al. reported that incubating tumor cells with doum extract greatly decreased their survivability and that the number of dead cells grew exponentially with higher extract concentrations. At a concentration of 2 grams per mL, the extract decreased survivability from 98 to 83% (17% death). In comparison to the control, the extract produced 50% damaged cells at 3 grams per mL (2% death). Doum flour extract reduced survivability from 98 to 60% (61% mortality at 4 g/mL and 92% mortality at 8 g/mL). This anticancer action might be attributed to doum flour extract’s antioxidant properties. This is because they have a lot of liquid phenolic compounds.

A potential cancer chemo-preventive candidate is a plant extract that combines antioxidant and anticancer actions while remaining safe for healthy cells. The theory behind it is that antioxidants will decrease, if not eliminate, DNA alterations and adducts induced by free radicals in the cytosol, hence preventing the development of abnormalities that lead to cancer. The antitumor action will help to eliminate any newly produced neoplastic cells that aren’t clinically evident early on. On the other hand, these tumor cytotoxic medicines, on the other hand, should have little or no complications because they are intended to be taken for a long period to avoid cancer formation.

Anti-inflammatory properties

Irritable bowel illnesses are divided into two categories: Crohn’s disease and ulcerative colitis. Glucocorticoids and sulfasalazine are two commonly prescribed medicines for the treatment of IBD. Antibiotics, monoclonal antibodies, and immune suppressants are commonly used in severe illness situations. These medications cause negative effects and are ineffective in curing IBD patients El-Beltagi et al. In several studies Cross et al. antioxidants are beneficial in acute colitis. The effectiveness of several herbal medications on animal models of irritable bowel syndrome (IBS) has previously been described, with antioxidant capacity being the principal mechanism against IBS reported by Ko et al. *H. thebaica* is considered to have anti-inflammatory as well as antioxidant activities, demonstrating its relevance in the treatment of practically produced IBS. It significantly improved experimentally caused IBS, which might be due to its antioxidant and anti-inflammatory characteristics Shalaby et al. Previous research discovered that doum flour extract reduced the mass and volume of tumor components in inflammation. This might be because of the influence of anti-
proliferative polyphenols, coumarins, and saponins in doum flour extract Koganov et al.\textsuperscript{[37]} As a result, this could be its anti-inflammatory mode of function. Coumarin and flavonoid derivatives have also been identified as protective ingredients for preventing and treating intestinal inflammatory reactions caused by various biochemical indications of experimental colitis Witaicenis et al.\textsuperscript{[38]} Moreover, doum flour supplementation within food has a potential anti-inflammatory effect in reducing the problems associated with renal failure. Similarly, the anti-inflammatory state of animals administered with cyclosporine and enriched with doum flour showed a considerable improvement in renal function when analyzed to animals treated only with cyclosporine Shalaby et al.\textsuperscript{[39]} Doum’s anti-inflammatory action may be attributed to its saponin component, which protects against reactive oxygen species and inhibits serum transforming growth factor-ß1 production. As a result, doum flour treatment reduces reactive oxygen species and kidney interstitial-fibrosis in rats Xie et al.\textsuperscript{[40]} The substantial increase in white blood cells (WBCs) generated by \textit{H. thebaica} raw mesocarp extract might be attributed to the activation of stem cells from bone marrow to make these cells, that is an indicator of immune system function demonstrated by some plants, as reported by other studies. The availability of phytochemicals like reducing sugars and glycosides may be the cause of leukocytosis Mohajeri et al.\textsuperscript{[41]} Flavanols preserve both hematopoietic committed bone marrow and produced blood cells against oxygen reactive species damage, hence boosting leucocytic production Ugochukwu et al.\textsuperscript{[42]} Polyphe- nol conjugates, oxygenated triglycerides, and sphingolipids present in flour are thought to contribute to the anti-inflammatory activity of \textit{H. thebaica} Esmaeil et al.\textsuperscript{[43]}

\textbf{Antimicrobial properties}

Aqueous extracts of doum flour and methanol had greater antibacterial action versus gram-negative bacteria and gram-positive bacteria, except for \textit{Listeria monocytogenes}, where just a little inhibition was seen Mohamed et al.\textsuperscript{[13]} Furthermore, the ethyl-acetate extract of doum flour was effective against 5 harmful bacteria, including \textit{Klebsiella pneumonia}, \textit{Pseudomonas aeruginosa}, \textit{Escherichia coli}, \textit{Bacillus subtilis}, and \textit{Staphylococcus aureus}, whereas the methanolic extracts were effective versus \textit{Klebsiella pneumonia} and \textit{Pseudomonas aeruginosa}. The development of \textit{Penicillium sp.} was significantly inhibited by a high quantity of methanol extracts Dosumu et al. \textit{H. thebaica} flour extracts decreased Erwinia carotovora development and produced inhibitory zones up to 38 millimeters in size Moawad et al. All doum flour extracts demonstrated significant action against \textit{Salmonella typhi} and \textit{Staphylococcus aureus}, whereas methanol/ultrasonic flour extract stopped the development of all pathogenic microorganisms studied. All doum flour extracts, except the methanol/ultrasonic flour extract, showed no anti-bacterial action against \textit{Escherichia coli} colonies. The anti-bacterial properties of plant extracts against both gram-negative and gram-positive bacteria may indicate the existence of broad-spectrum antibiotic molecules or simply metabolic poisons.\textsuperscript{[44]} Doum flour had antibacterial and anti-hypertensive characteristics that were linked to the presence of flavonoids. Polyphenol cytotoxicity against bacteria might be due to inhibition of proteolytic enzymes (peptidases) and other associations that deactivate bacterial adhesins, cellular membrane transferrin, and nonspecific interactions with polysaccharides.\textsuperscript{[45]} Moreover, methanolic extracts of \textit{H. thebaica} had greater anti-fungal and anti-yeast activity compared to aqueous extracts. Previous research has shown that a solvent extract of \textit{H. tobbaco} is effective against a broad diversity of fungal species, including \textit{Candida albicans}, \textit{Microsporum gypseum}, \textit{Trichophyton rubrum}, \textit{Fusarium solani}, \textit{Mucor sp.}, and \textit{Aspergillus Niger}. Antimicrobial action may include complex processes such as the blocking of the cell wall and cell membrane manufacturing, DNA, protein formation, and nucleic-acid metabolism.\textsuperscript{[46]}

\textbf{Fertility activity}

One of the most important societal issues confronting modern countries is infertility. In general, approximately 50\% of all problems relating to infertility are accompanied by male partner-related issues Kenkel et al.\textsuperscript{[47]} Various medicines for infertility have been discovered up to now and are
delivering consistent outcomes. However, there is no effective treatment for people who have non-obstructive azoospermia, which is characterized by a lack of spermatids in the testes. Although data shows that many individuals experiencing infertility have an agetic susceptibility to the disorder, the reason behind the vast majority of instances has not been discovered. It is possible to infer that adding doum to Hy-Plus rabbit diets improves bucks’ fertilizing potential and does’ fertility attributes significantly. It is advised that rabbits be fed 500 g of doum per ton of feed, which is equivalent to the high dosage reported by Ghazal.[48] Many disorders, including cardiovascular disease, diabetes-mellitus, and liver disease, as well as inadequate vitamin consumption, have a detrimental influence on spermatogenesis and the manufacturing of normal sperm Hashemi et al.[49] Natural antioxidants like vitamin C and E, on either side, preserved sperm DNA from reactive oxygen species in rat testes studied by Jedlińska et al.[50]

Pharmacological properties

_H. thebaica_ (L) flour extracts are often used to treat high blood pressure, bilharzias, and as well as a hematinic agent. The aqueous extract of doum flour can control lipemia in renal disease, which lowers the risk of interstitial fibrosis and atherosclerotic. As a result, the innate, safe, and nontoxic _H. thebaica_ flour may have tremendous potential for usage as a hypolipidemic medication. It is also useful as a hypocholesterolemic ingredient, a hypolipidemic ingredient, and a hematinic solution.[15] Chromatography on a thin layer identified that doum flour contains considerable concentrations of polyphenols, hydroxyl-cinnamates, essential oils, coumarins, as well as flavonoids. It was shown that administering flavonoid extract to diabetic mice substantially enhanced adiponectin concentrations, which activate the hypoglycemic effect of insulin without affecting insulin amount in plasma, and reduced the mass and granuloma volume materials in the state of inflammation Abdou et al.[51] As a result, it is the most possible mechanism of anti-inflammatory activity. Moreover, the hypoglycemic action of these plants may be responsible for the increase in blood insulin concentration produced by enhanced pancreatic production of insulin from the islet of Langerhans or its secretion of bounded insulin, as well as an improvement in peripheral glycolysis.[52] The brew of doum flour is well permitted, with no death or illness until a dose of five grams/kilogram body weight is attained. The normal fertility characteristics were unaffected by the continuous oral ingestion of doum flour at 0.5 gram/kilogram body weight or 2 gram/kilogram body weight. While packed-cell-volume, hemoglobin content red blood cells (RBCs) corpuscles, and phagocytic action were all improved substantially Abdel-Rahim et al.[53] After 1 and 2 months of treatment with the brew of doum flour, considerable reductions in blood sugar, saturated fat, triglyceride, and total fat concentrations were noted. The results show the effectiveness of doum flour as hematinic and hypolipidemic, enhancing hepatorenal processes and having no negative impact on the sexual characteristics studied.

Rheological properties of doum fruit flour

A DFF was studied, utilizing a farinograph to evaluate the rheological properties of dough at 3 distinct stages. As the DFF concentration increased, so did liquid absorption. This rise is owing to DFF’s high fiber content. According to Hussein et al.[54] fiber is distinguished by its significant water retention capacity. The arrival rate and dough production time followed the same pattern. The recent research of Hussain et al.[55] reported that dietary fiber enriched flour showed higher water holding capacity. The general introduction of high-fiber elements into dough affected dough development, and when DFF concentration increased, dough production time increased. Similar results were observed by Borchani et al.[56] Sudha et al.[57] also noted that when the amount of dried apple pomace in the dough was raised, so did moisture absorption as well as arrival rate. Dough stability was reduced from 4.0 to 2.5 minutes as doum fruit flour concentration was enhanced, whereas mitigation improved from 80–140 BU and the
index of mixing tolerance was raised from 30–100 BU, owing to diluting the gluten-protein made from wheat with increasing DFF fiber content. This might be related to the interactions of fibrous components and gluten, which change dough mixing capabilities, as reported by Shouk and Ramadan.[58]

**Conclusion and future perspective**

The antimicrobial ability of *Hyphaene thebaica*, a renowned species because of its antioxidant, antitumor, and anti-inflammatory ability due to its polyphenolic content was investigated against different gram-negative and gram-positive bacteria as well as pathogenic fungi. This article demonstrates that doum flour extracts are potent antibacterial and pharmacological ingredients. DFF might be advantageous in the creation of functional foods with potential applications for hyperlipidemic patients. The investigation’s findings show the positive influence of doum fruit flour on human health as well as the rheological properties of doum flour in baking. Further research on the action and safety aspects of such extracts might lead to their being viable candidates for preserving food, functional foods, pharmaceuticals, and natural plant-based products.

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**References**

[1] Siddeeq, A.; Salih, Z. A.; Al-Farga, A.; Ata-Elnadeel, E. M. A.; Ali, A. O. Physiochemical, Nutritional and Functional Properties of Doum (Hyphaene Thebaica) Powder and Its Application in Some Processed Food Products. *J. Nutri. Food Sci. Forecast*. 2019, 2(1), 1009.

[2] Seleem, H. A. Effect of Blending Doum (Hyphaene Thebaica) Powder with Wheat Flour on the Nutritional Value and Quality of Cake. *Food Nutr. Sci.* 2015, 6(7), 622–632. DOI: 10.4236/fns.2015.67066.

[3] Brownlee, I. A. The Physiological Roles of Dietary Fibre. *Food Hydrocolloids*. 2011, 25(2), 238–250. DOI: 10.1016/j.foodhyd.2009.11.013.

[4] Glew, R. H.; Kramer, J. K.; Hernandez, M.; Pastuszyn, A.; Ernst, J.; Djomdi, N. N.; Jagt, D. J. V. The Amino Acid, Mineral and Fatty Acid Content of Three Species of Human Plant Foods in Cameroun. *Food*. 2010, 4(1), 1–6.

[5] Mo, L.; Liaw, L.; Evan, A. P.; Sommer, A. J.; Lieske, J. C.; Wu, X. R. Renal Calcinosi and Stone Formation in Mice Lacking Osteopontin, Tamm-Horsfall Protein, or Both. *Am. J. Physiol. Renal Physiol.* 2007, 293(6), F1935–F1943. DOI: 10.1152/ajprenal.00383.2007.

[6] Aboshora, W.; Yu, J.; Omar, K. A.; Li, Y.; Hassanin, H. A.; Navicha, W. B.; Zhang, L. Preparation of Doum Fruit (Hyphaene Thebaica) Dietary Fiber Supplemented Biscuits: Influence on Dough Characteristics, Biscuits Quality, Nutritional Profile and Antioxidant Properties. *J. Food Sci. Technol.* 2019, 56(3), 1328–1336. DOI: 10.1007/s13197-019-03605-z.

[7] Auwal, M.; Sanda, K.; Mairiga, I.; Lawan, F.; Mutah, A.; Tijjani, A.; Thaluvwa, A.; Ibrahim, A.; Njobdi, A. B.; Thaluvwa, A. B. The Phytochemical, Elemental and Hematologic Evaluation of Crude Mesocarp Extract of Hyphaene Thebaica (Doumpalm) in Wistar Albino Rats. *Asian J. Biochem*. 2013, 8(1), 14–23. DOI: 10.3923/ajb.2013.14.23.

[8] Aamer, R. Physicochemical Properties of Doum (Hyphaene Thebaica) Fruits and Utilization of Its Flour in Formulating Some Functional Foods. *Alexand.J. Food Sci. Technol.* 2015, 12(2), 29–40. DOI: 10.12816/0025396.
[32] Abas, F.; Lajis, N. H.; Israf, D. A.; Khozirah, S.; Kalsom, Y. U. Antioxidant and Nitric Oxide Inhibition Activities of Selected Malay Traditional Vegetables. Food Chem. 2006, 95(4), 566–573. DOI: 10.1016/j.foodchem.2005.01.034.

[33] Lih-Brody, L.; Powell, S. R.; Collier, K. P.; Reddy, G. M.; Cerchia, R.; Kahn, E.; Mullin, G. E.; Katz, S.; Floyd, R. A.; McKinley, M. J. Increased Oxidative Stress and Decreased Antioxidant Defenses in Mucosa of Inflammatory Bowel Disease. Digestive Diseases Sci. 1996, 41(10), 2078–2086. DOI: 10.1007/BF02093613.

[34] Cross, R. K.; Lapshin, O.; Finkelstein, J. Patient Subjective Assessment of Drug Side Effects in Inflammatory Bowel Disease. J. Clin. Gastroenterol. 2008, 42(3), 244–251. DOI: 10.1097/MCG.0b013e31802f19af.

[35] Ko, J. K. S.; Lam, F. Y. L.; Cheung, A. P. L. Amelioration of Experimental Colitis by Astragalus Membranaceus through anti-oxidation and Inhibition of Adhesion Molecule Synthesis. World J. Gastroenterol. WJG. 2005, 11 (37), 5787. DOI: 10.3748/wjg.v11.i37.5787.

[36] Shalaby, A.; Shatta, A. Potential Antioxidant and anti-inflammatory Effects of Hyphaena Thebaica in Experimentally Induced Inflammatory Bowel Disease. Int. J. Pharm. Res. 2013, 9, 51–60. DOI: 10.5897/AJPP2013.3451.

[37] Koganov, M. M.; Dueva, O. V.; Tsorin, B. L. Activities of plant-derived Phenols in a Fibroblast Cell Culture Model. J. Nat. Prod. 1999, 62(3), 481–483. DOI: 10.1021/np9801559.

[38] Witaicenis, A.; Seito, L. N.; Di Stasi, L. C. Intestinal anti-inflammatory Activity of Esculetin and 4-methylesculetin in the Trinitrobenezesulphonic Acid Model of Rat Colitis. Chem.-Biol. Interact. 2010, 186 (2), 211–218. DOI: 10.1016/j.cbi.2010.03.045.

[39] Shalby, A. B.; Hamza, A. H.; Ahmed, H. H. New Insight on the anti-inflammatory Effect of Some Egyptian Plants against Renal Dysfunction Induced by Cyclosporine. Eur. Rev. Med. Pharmacol. Sci. 2012, 16(4), 455–461.

[40] Xie, X. S.; Liu, H. C.; Yang, M.; Zuo, C.; Deng, Y.; Fan, J. M. Ginsenoside Rb1, a Panoxadiol Saponin against Oxidative Damage and Renal Interstitial Fibrosis in Rats with Unilateral Ureteral Obstruction. Chin. J. Integr. Med. 2009, 15(2), 133–140. DOI: 10.1007/S2095-4964(15)01671-6.

[41] Mohajeri, D.; Mousavi, G.; Mesgari, M.; Doustar, Y.; Nouri, M. K. Subacute Toxicity of Crocus Sativus L. (Saffron) Stigma Ethanol Extract in Rats. Am. J. Pharmacol. Toxicol. 2007, 2(4), 189–193. DOI: 10.3844/ajptsp.2007.189.193.

[42] Ugochukwu, N. H.; Babady, N. E.; Coburne, M.; Gassett, S. R. The Effect of Gongronema Latifolium Extracts on Serum Lipid Profile and Oxidative Stress in Hepatocytes of Diabetic Rats. J. Biosci. 2003, 28(1), 1–5. DOI: 10.1007/BF02970124.

[43] Esmaeili, M. A.; Somboli, A. Antioxidant, Free Radical Scavenging Activities of Salvia Brachyantha and Its Protective Effect against Oxidative Cardiac Cell Injury. Food Chem. Toxicol. 2010, 48(3), 846–853. DOI: 10.1016/j.fct.2010.02.035.

[44] El-egami, A. A.; Almagboul, A. Z.; Omar, M. E. A.; El-Tohami, M. S. Sudanese Plants Used in Folkloric Medicine: Screening for Antibac- Terial Activity. Fitoterapia Part X”. 2001, 72(7), 810–817. DOI: 10.1016/S0367-326X(01)00310-0.

[45] Cowan, M. M. Plant Products as Antimicrobial Agents. Clin Microbiol Rev. 1999, 12(4), 564–582. DOI: 10.1128/CMR.12.4.564.

[46] Oyaizu, M.; Fujimoto, Y.; Ogihara, H.; Sekimoto, K.; Naruse, A.; Naruse, U. Antioxidative and Antimicrobial Activities of Extracts from Several Utility Plants. Food Preservat. Sci. 2003, 29(1), 33–36. DOI: 10.5891/jafps.29.33.

[47] Kenkel, S.; Rolf, C.; Nieschlag, E. Occupational Risks for Male Fertility: An Analysis of Patients Attending a Tertiary Referral Centre. Int. J. Androl. 2001, 24(6), 318–326. DOI: 10.1046/j.1365-2605.2001.00304.x.

[48] Ghazal, M. N. Effect Of Supplementing Doum (Hyphaena Thebaica) To Diets On Reproductive And Productive Traits In Rabbis. Egypt. Poultry Sci. J. 2016, 36(3), 711–723. DOI: 10.21608/epsj.2016.168802.

[49] Hashemi, J. M. Pumpkin Seed Oil and Vitamin E Improve Reproductive Function of Male Rats Inflicted by Testicular Injury. World Appl. Sci. J. 2013, 23(10), 1351–1359.

[50] Jedlinska, M.; Bomba, G.; Jakubowski, K.; Rotkiewicz, T.; Jana, B.; Penkowski, A. Impact of Oxidative Stress and Supplementation with Vitamins E and C on Tests Morphology in rats. Res. Reprod. 2006, 52, 203–209. dspace.tbzmed.ac.ir:8080/xmlui/handle/123456789/53949.

[51] Abdou, H. S.; Salah, S. H.; El Raouf, A. A.; Abdel-Rahim, E. A. Chromosomal Aberrations and Nucleic Acids Systems Affected by Some Egyptian Medicinal Plants Used in Treating Female Pregnant Diabetic Rats. American Journal of Molecular Biology. 2011, 01(1), 26–32. DOI: 10.4236/ajmb.2011.11004.

[52] Al-Khalafah, H.; Khalil, A. A.; Amer, S. A.; Shalaby, S. I.; Badr, H. A.; Farag, M. F.; Abdel Rahman, A. N.; Abdel Rahman, A. N. Effects of Dietary Doum Palm Fruit Powder on Growth, Antioxidant Capacity, Immune Response, and Disease Resistance of African Catfish, Clarias Gariepinus (B.). Animals. 2020, 10(8), 1407. DOI: 10.3390/antibiotics10050567.

[53] Abdel-Rahim, E. A.; El-Beltagi, H. S.; Fayed, S. A. Comparative Studies on the Influences of Juniperus Phoenicea and Hyphaena Thebaica as Hypoglycemic Factors in Diabetic Rats. Adv. Food Sci. 2011, 33(3), 128–132. DOI: 10.5772/intechopen.74772.
[54] Hussein, A. M.; Salah, Z. A.; Hegazy, N. A. Physicochemical, Sensory and Functional Properties of wheat-doum Fruit Flour Composite Cakes. *Pol. J. Food Nutr. Sci.* 2010, 60(3). DOI: 10.1111/j.1365-2605.2001.00304.x.

[55] Hussain, M.; Ullah Khan, A.; Saeed, F.; Afzal, M.; Mushtaq, Z.; Niaz, B.; Hussain, S.; Mohamed, A. A.; Alamri, M. S.; Anjum, F. M. Physicochemical Characterization of Cereal Bran Cell Wall with Special Reference to Its Rheological and Functional Properties. *Int. J. Food Prop.* 2022, 25(1), 305–314. DOI: 10.1080/10942912.2022.2032138.

[56] Borchani, C.; Masmoudi, M.; Besbes, S.; Attia, H.; Deroanne, C.; Blecker, C. Effect of Date Flesh Fiber Concentrate Addition on Dough Performance and Bread Quality. *J. Texture Stud.* 2011, 42(4), 300–308. DOI: 10.1111/j.1745-4603.2010.00278.x.

[57] Sudha, M. L.; Baskaran, V.; Leelavathi, K. Apple Pomace as a Source of Dietary Fiber and Polyphenols and Its Effect on the Rheological Characteristics and Cake Making. *Food Chem.* 2007, 104(2), 686–692. DOI: 10.1016/j.foodchem.2006.12.016.

[58] Shouk, A. A.; Ramadan, M. T. Effect of Defatted Rice Bran Addition on the Quality of Pan Bread and Biscuit. *Minufiya J. Agric. Res.* 2007, 32, 1019–1036. DOI: 10.4236/fns.2015.67066.