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Pharmacognosy, Phytochemistry and Pharmacological Profile of Brassica Oleracea (Kale)

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ABSTRACT

Many plants used in day-to-day life have unexplored medical potential one of such plant is Kale. Kale's scientific name is Brassica oleracea (Family: Brassicaceae).This is popularly called as super food my many food fanatics presently, mainly due to its beneficial properties. In the present articles its uses, pharmacognosy, phytochemistry and pharmacology are described in detail with an emphasis on its commercial value.

KEY WORDS: *Brassica oleracea, Karle Kale, Glucosinolates; Phenolic compounds; Carotenoids.*

INTRODUCTION:

Kale is a leafy vegetable plant belonging to Brassicaceae family. Brassica vegetables can be cultivated in various environments and seasons, and are generally consumed in various parts of the world. Hence, they are both nutritionally and economically crucial vegetables.[1] It contains different types of antioxidants like phenolics, carotenoids, which protect the cellular systems from oxidative damage and decrease the risk of chronic diseases.[2] Kale is an important plant grown in tropical and subtropical regions of the world.[3] Kale exhibits the highest antioxidant activity compare to other several vegetables.[4] Kale considered as super food and it has Antioxidant, Anticancer, Cardiovascular and Gastrointestinal Activity.[5] Kale is one of the oldest plants of Brassica species originated from the eastern Mediterranean.[6]

It is widely used plant for Ayurveda Preparations and used as treatment either as alone or Combination with other plants.7 Kale varieties are typically identified by their leaf texture, shape and the presence of tiny flower buds, similar to those found in broccoli.[8]The nutrient rich vegetable kale can be either a biennial or a perennial plant. Kale Plants consists of three main parts: roots, stems and leaves, all of which have uses in both medicinal and nutraceutical fields. Brassica oleracea varacephala is a type of kale known for its attractive, curly, and smooth leaves. Its growing popularity worldwide is due to its rich nutritional profile. These visually appealing leaves are often consumed both raw and cooked, although they can be tough to chew.[9]

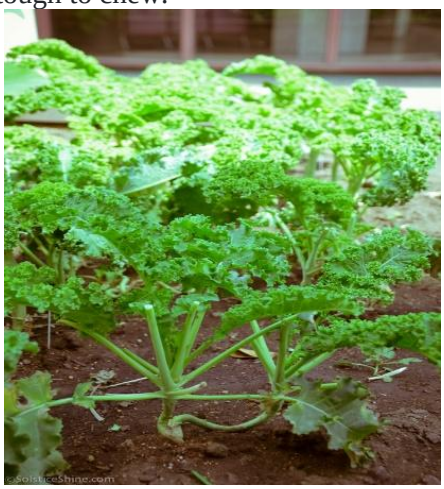

Figure 1: Image of Kale plant.

The Latin name for kale is Brassica oleracea, also called borecole, and it belongs to the cabbage family. In Nigeria, because of its wide-ranging health benefits, it is often referred to as the "hospital too far." Kale is cultivated annually,

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with a growing cycle of around two months, although the yield may vary based on growing conditions and plant variety.[10] It is rich in antioxidants like tocophenol, beta-carotene, and vitamin C, and contains high levels of macro- and micro-minerals, fiber, phytochemicals and both fat- and water-soluble vitamins and bioactive compounds. These beneficial components are retained through various processing techniques. Thanks to its dense nutritional and bioactive content, kale plays a significant role in combating chronic diseases. [11] The referenced study highlights how different processing methods help retain these nutrients and bioactive elements on an industrial scale. To address increasing concerns about product quality and production costs, the food industry is now adopting combined drying technologies. [12]

HISTORY:

Kale is a leafy green vegetable thar has been grown for thousands of years. It originally came from the eastern Mediterranean and Asia Minor, where people started growing it around 2000 years ago. The ancient Greeks and Romans used kale as food and even for medicine.

In the Middle Ages, kale becomes very popular in Europe because it could grow in cold weather and was full of nutrients. It later spread to other parts of the world, including North America, where it was brought by European settlers.

Today, kale is known as a “Superfood” because It’s very healthy and full of vitamins. People eat it in salads, smoothies, soups, and more.[13]

CLASSIFICATION:

Kale is a popular plant and its taxonomical classification is given in Table 1.[14]

Taxonomic Rank	Classification
Kingdom	Plantae
Phylum	Angiosperms
Class	Eudicots
Order	Brassicas
Family	Brassicaceae
Genus	Brassica
Species	Brassica oleracea
Variety	Sabellica

Table 1: Taxonomical classification of kale.

PHARMACOGNOSY:

Many popular plants like kale are well studied for their macroscopical and microscopical charecters.[15,16]
Macroscopical Characteristics

Parameter	Description
Color	Leaves are dark green to bluish-green or purple depending on the variety
odor	Mild, earthy, cabbage-like
Taste	Slightly bitter, more intense in mature leaves
Shape	Curled, frilled, or flat large leaves with a central rib
Size	Leaves 30-60cm long; whole plant up to 1.5m tall
Texture	Leathery, waxy surface

Table 2: Summary of Macroscopic characters

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Microscopical Characteristics

Tissue	Features
Epidermis	Covered with waxy cuticle, presence of both glandular and non-glandular trichomes
Stomata	An isocytic type stomata on both leaf surfaces
Mesophyll	Differentiated into palisade and spongy parenchyma
Vascular Bundles	Collateral and closed, embedded in mesophyll with bundle sheath.[17]

Table 3: Summary of Microscopic characters

PHYTOCHEMISTRY:

Kale, a nutrient dense member of the Brassicaceae family, has attracted considerable scientific interest due to its rich and diverse phytochemical composition. The primary classes of bioactive compounds in kale include glucosinolates, phenolic compounds, carotenoids, and flavonoids. These constituents contribute significantly to kale's antioxidant, anti-inflammatory, and chemopreventive properties. [18,19]

Glucosinolates:

Glucosinolates are sulfur containing secondary metabolites unique to Brasssica vegetables, kale contains a wide array of these compounds, including glucoraphanin, glucobrassicin, and sinigrin. Upon enzymatic hydrolysis by myrosinase, glucosinolates yield biologically active compounds such as isothiocyanates, nitriles, and indoles which have been linked to anti-cancer and detoxification effects.[18,19]

Phenolic compounds:

Phenolic compounds and flavonoids in kale contribute to its strong antioxidant activity. Major phenolic acids include caffeic acid, ferulic acid and sinapic acid, while key flavonoids include quercetin and kaempferol. These compounds play a role in reducing oxidative stress and managing chronic diseases such as cardiovascular disorders, diabetes, and neurodegenerative diseases. [18,19]

Carotenoids:

Kale is a potent source of carotenoids, especially beta –carotene, lutein, zeaxanthin and neoxanthin, which are crucial foe vision health and antioxidant defense. These lipid- soluble pigments also have protective effects against age-related macular degeneration and oxidative damage.[20]

Flavonoids:

Flavonoids such as kaempferol and quercetin are abundant in kale and contribute to its anti- inflammatory, anti-viral, and cardio-protective effects. These compounds modulate various cellular signaling pathways and help mitigate inflammation and carcinogenesis. [18,19]

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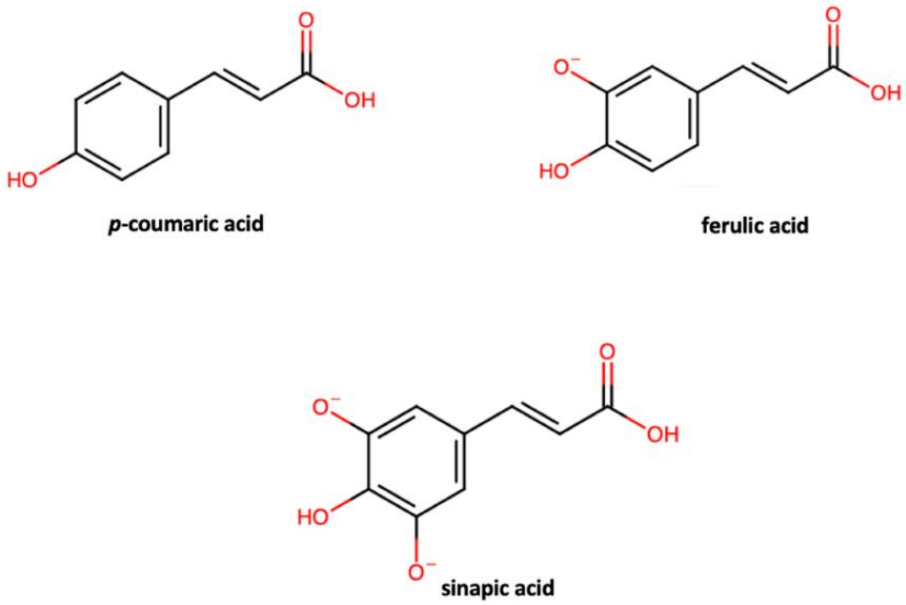

Figure 2: Phytochemical constituents of Kale.

MEDICINAL VALUE:

Effect on Gastrointestinal Tract:

Plants belonging to the acephala group exhibit antiulcer properties, making them effective in treating gastric and peptic ulcers.[21] Gastric ulcers are primarily caused by the bacterium Helicobacter pylori, which significantly increases the risk of gastric cancer.[22] Kale contains glucoraphanin, a precursor of sulforaphane. This connection suggests that kale's antiulcer effect may stem from sulforaphane's ability to combat H. pylori.

Effect on Cardiovascular System:

Polyphenols, glucosinolates, and vitamin C and E are known to support cardiovascular health. Cruciferous vegetables due to their bioactive compounds, can help lower LDL cholesterol, fight free radicals, and regulate GST activity.23 Among these, kale has shown the highest capacity for binding bile acids when compare to other vegetables. This ability is enhanced through steam cooking, indicating that kale can positively influence cardiovascular health and may reduce cancer risk when consumed cooked.[24]

PHARMACOLOGY:

Kale is a leafy green vegetable renowned for its medicinal properties. Its health benefits are attributed to a rich profile of bioactive compounds, including flavonoids, glucosinolates, carotenoids, and phenolic acids.

1. Antioxidant and Anti-inflammatory Properties:

Normally free radical formation is controlled naturally by various beneficial compounds known as antioxidants.[25]Oxidative stress plays a key role in the prognosis of the various diseases. An imbalance between the free radicals and antioxidant leads to oxidative stress.[26] Kale is abundant in antioxidants such as quercetin and kaempferol, which help neutralize free radicals and reduce oxidative stress. These compounds also exhibit anti-inflammatory effects, potentially lowering the risk of chronic diseases like cancer and cardiovascular disorders.[27]

2. Cardiovascular Health:

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The fiber and bile acid sequestrants in kale can help lower LDL Cholesterol levels. A Study involving individuals with metabolic Syndrome found that daily consumption of kale powder led to significant reductions in LDL cholesterol, blood pressure, and fasting blood sugar levels.[28]

3. Bone Health:

Osteoporosis is a skeletal disease characterized by the low bone mass and micro architectural deterioration with a resulting increase in bone fragility and hence susceptibility to fracture.[29] Osteoporosis has recently earned great emphasis in modern society and medicine as it is a "silent disease" it has no symptoms and its occurrence can only be known by an incidence of a fracture.[29] Rich in vitamin K, Kale plays a crucial role in bone metabolism and calcium absorption, potentially reducing the risk of osteoporosis and fractures.[30]

4. Eye Health:

Kale contains lutein and zeaxanthin, carotenoids that protect against age related macular degeneration and cataracts by filtering harmful high-energy light wavelengths.

5. Anticancer Properties:

Glucosinolates in kale are converted into biologically active compounds like sulforaphane which have been shown to inhibit the growth of cancer cells in laboratory studies.

6. Detoxification Support:

Toxic liver injury produced by drugs and chemicals may virtually mimic any form of naturally-occurring liver disease.[31]

The high fiber content in kale aids in digestive health and supports the body's natural detoxification processes by promoting regular bowel movements and the elimination of toxins.

7. Nutrient Density:

Kale is a nutrient-dense food, providing significant amounts of vitamins A, C and K, as well as minerals like calcium and iron, all while being low in calories.[32]

MISCELLANEOUS:

Toxicity:

Kale contains oxalic acid, which can bind calcium and magnesium, reducing their absorption and increasing the risk of kidney stones, particularly in susceptible individuals.[33]

Kale is rich in glucosinolates, which can impair thyroid function by inhibiting iodine uptake, especially in individuals with iodine deficiency or thyroid disorders.[34]

Allergies:

Allergic reactions to kale are rare but possible. Symptoms may include itching, swelling, hives and in severe cases anaphylaxis.35 Kale may trigger reactions in individuals with lipid transfer protein syndrome, a plant food allergy.[36]

Interactions:

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Kale is high in vitamin K, which can antagonize warfarin and other anticoagulants, reducing their effectiveness and requiring their effectiveness and requiring dosage adjustments.[37]

MARKET VALUE:

The global market value of kale has experienced significant growth in recent years, driven by increasing consumer awareness of its health benefits and versatility in food products.

Kale rise in popularity has impacted agricultural practices and market economics. The increased demand has led farmers to shift cultivation towards kale, influencing crop diversity and introducing challenges such as price fluctuations and supply chain vulnerabilities.

Kale's nutritional composition and its potential in developing value-added products. While not directly addressing market value, the study underscores kale's health benefits, suggesting opportunities for market expansion through products like kale-infused bread and beverages.38

Cultivated crops are expected not only to provide high nutritional value but also to maintain consistently high yields. According to Kmiecik et al. (2006), kale yields vary depending on several factors, including cultivar and harvest date: In 2005, yields ranged from 5.14 to 9.32 kg/m2, with an average of 8.60 kg/m2 for the cultivar Winterbor F1, 8.30 kg/m^2 for Redbor F1. The total kale yield in the following year was slightly lower compared to 2005.

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SUMMARY TABLE:

Summary table of kale plant as described below in Table 4.

S. No	Plant Part	Activity	Extract	Model	Standard Drug	Dose	Parameters	Mechanism	Stats P Value	Author Year
1.	Leaf	Antioxidant, Antimicrobial	Ethanol	*In vitro*	None	100mg/ml	Radicals Scavenging, bacterial inhibition	Glucosinolates, Phenolics	Not specified	Marjana Radunz et al. 2024[40]
2..	Leaves	Antioxidant, Antiproliferative	Polyphenolic extract	DPPH assay Hel a cell	N/A	Not specified	Radical scavenging activity; cell viability	Neutralization free radicals; Inhibition on of cancer cell proliferation	*In vitro*, N/A	Dario Lucic, 2023[41]
3.	Flower	Antioxidant	Aqueous, ethanol, petroleum and ether	*In vivo*	Metformin	100-400mg/kg	Blood glucose, insulin, lipid profile.	Glucosinolates, polyphenols	P less than 0.001	Sumeet Gupta et al. 2022[42]
4.	Leaf	Skin health and aging	Ethanol	clinical trial	Placebo	175mg BFKE twice daily	Skin elasticity, hydration, wrinkled depth	Flavonoid glycosylates	P less than0.05	Torsten Grothe, 2022[43]
5.	Leaf	Neuroprotective	Not specified	*In vitro*	NMDA	100 micro-M	Neurotoxicity inhibition	Quarcetin	Not specified	Daniel A Jacob, 2021[44]
6.	Leaf	Antioxidant, Antiproliferative	Polyphenolic extract	DPPH assay; HepG2 liver cancer cells	N/A	50-100 micro-M	Radical Scavenging activity; Cell viability, DNA damage	Inhibition of topoisomerase 2, induction of DNA damage; neutralization of free radicals	*In vitro* N/A	Dunja Samec et al. 2019[45]

Table 4. Summary Table of Kale plant.

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