

## Revealing Cotton Plants' Phytochemical Marvels: Beyond Fiber and Nutrition to Therapeutic Potential

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Cotton plants (*Gossypium* spp.) are not only a source of fibers but also harbor a rich reservoir of phytochemicals with various biological functions and practical applications. Understanding the distribution of these compounds within the cotton plant sheds light on the chemical composition of cotton waste generated during harvesting and ginning processes. Within these cotton processing by-products, such as burrs, leaves, crushed seeds, stalk, roots, and flowers, lie potentially valuable chemical compounds that find utility in industries like food manufacturing, perfumery, and pharmaceuticals.

One notable compound found abundantly in cotton is gossypol, known for its contraceptive properties. While concentrated in the seeds, gossypol also occurs in the roots and possibly other parts of the plant, showcasing the plant's comprehensive utilization potential. Additionally, phenolic compounds and terpenes present in various parts of the cotton plant, including the leaves, seeds, flowers, stalks, and roots, possess antimicrobial, antiviral, insecticidal, antioxidant, anti-inflammatory and cytotoxic properties. These properties open avenues for exploitation in agriculture and pest management, offering natural alternatives to synthetic chemicals.

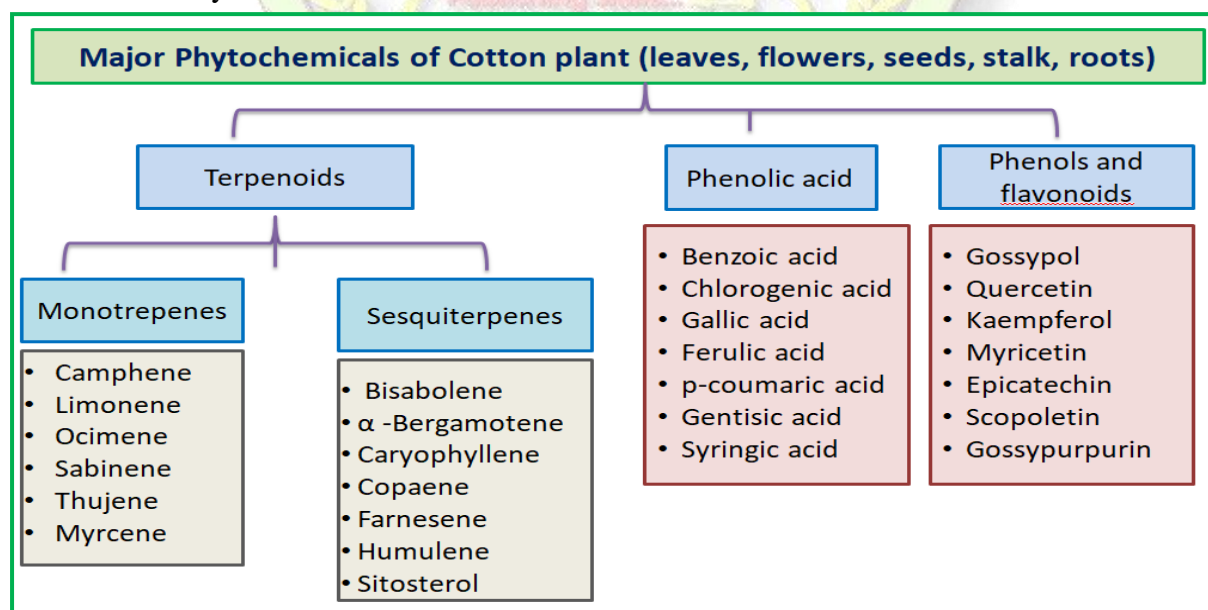


Figure 1. Major phytochemicals present in Cotton plant

The bioactive properties of phytochemicals derived from cotton vary depending on the species. For instance, flower extracts from *Gossypium herbaceum* display notable antioxidant activity in a study and demonstrated potential in inhibiting acetylcholinesterase (AChE), an enzyme involved in the breakdown of acetylcholine in the brain. Inhibiting AChE can help regulate neurotransmitter levels, which is beneficial for individuals suffering from Alzheimer's disease, as it may aid in preventing or alleviating cognitive decline associated with the condition. Leaf extracts from *Gossypium arboreum* have been found to protect fibroblast cells against oxidative damage, which is crucial for maintaining cellular health and resilience. Additionally, the aqueous and acetone extracts of *G. arboreum* leaves, rich in tannins and steroids, exhibit inhibitory activity against  $\alpha$ -amylase and  $\alpha$ -glucosidase enzymes. These enzymes are involved in carbohydrate digestion and their inhibition can help regulate blood sugar levels, making these extracts potentially beneficial for individuals with diabetes. The bioactive compounds, found in various parts of the cotton plant, have caught the attention of researchers and industries for their therapeutic potential and ecological benefits. By tapping into these diverse compounds, we can explore innovative applications in sectors ranging from agriculture to healthcare, harnessing the natural richness of the cotton plant for sustainable and beneficial purposes. Major phytochemicals of cotton plant are described below.

### **Polyphenols and Flavonoids**

Cotton plants are rich in polyphenols and flavonoids, compounds renowned for their potent antioxidant capabilities. These substances play a pivotal role in combating oxidative stress, a key factor implicated in the development of various chronic diseases. Apart from their antioxidant activity, polyphenols and flavonoids also possess anti-inflammatory properties, rendering them valuable in developing therapeutic agents for inflammatory conditions.

Among the polyphenols and flavonoids found in cotton plants, quercetin and kaempferol stand out for their antioxidant and anti-inflammatory attributes, particularly in leaves and seeds. Myricetin, another compound present in cotton leaves and seeds, contributes to antioxidant defenses and shields against oxidative harm. Epicatechin, sourced from cottonseeds and leaves, exerts antioxidant effects and safeguards heart health. Additionally, catechins, distributed throughout different parts of the cotton plant, contribute significantly to its protective mechanisms. Rutin, present in cotton leaves and seeds, showcases a dual role with antioxidant and anti-inflammatory activities. The diverse array of polyphenols and flavonoids in cotton plants not only underscores their natural defense mechanisms but also hints at their potential in mitigating oxidative stress-related health challenges and inflammation-driven disorders.

### **Terpenoids: Nature's Pharmacological Gems**

Terpenoids, another class of phytochemicals found in cotton plants, offer a wide spectrum of pharmacological activities. From antimicrobial and antiviral properties to anti-diabetic and neuroprotective effects, terpenoids showcase a remarkable range of therapeutic potential. Their versatility makes them attractive targets for drug discovery and development. The major terpenes found in cotton encompass a diverse range of compounds known for their aromatic and therapeutic properties. Limonene, for instance, contributes to a citrusy scent and has potential antioxidant and anticancer effects. Humulene, with its earthy and woody aroma, is being studied for its anti-inflammatory and pain-relieving properties. Camphene, known for its cooling and camphor-like scent, may have antimicrobial and antioxidant benefits. Myrcene, which imparts a fruity and herbal aroma, is investigated for its potential sedative and analgesic effects. Pinene, found in pine trees as well, has a pine-like scent and is associated with anti-inflammatory and bronchodilator properties. Thujene, another compound, has a spicy and herbal aroma and possess antifungal and antibacterial properties.

Caryophyllene exhibits anti-inflammatory and analgesic effects. Caryophyllene oxide, a derivative of caryophyllene, also has anti-inflammatory and antioxidant properties.  $\beta$ -sitosterol, a phytosterol, is associated with cholesterol-lowering effects and may have anti-inflammatory properties. Sabinene, with its spicy and citrusy scent, is being researched for potential antimicrobial and antioxidant benefits.

### **Gossypol: Compound with diverse activities**

At the heart of cotton's phytochemical profile lies gossypol, a polyphenolic compound with multifaceted properties. Originally recognized for its defense mechanism against pests, gossypol initially gained attention in scientific circles as a problematic anti-nutritional element found in cottonseeds, causing adverse effects on both livestock and human well-being. This negative reputation eclipsed the potential benefits of gossypol, concealing its positive attributes. In recent years, researchers have increasingly unveiled the latent therapeutic potential concealed within gossypol. Its distinct molecular structure and biological actions have kindled interest in its potential uses across various health-related fields. Initially utilized as a male contraceptive, gossypol has undergone extensive scrutiny, revealing a diverse range of nutritional and medicinal attributes, including antiviral, antioxidant, antiparasitic, and antibacterial properties. Particularly noteworthy are recent endeavors focused on investigating its potential as an anticancer agent against multiple cancer types, such as breast, colon, pancreatic, and prostate cancers, spurring a multitude of research initiatives. Studies have revealed its anticancer properties, including its ability to inhibit tumor growth and induce apoptosis in cancer cells. This dual action on cancer cells makes gossypol a promising candidate for novel cancer therapies.  $\alpha$ -Bisabolol, a frequently occurring compound found in cotton also exhibits the capacity to trigger apoptosis in malignant carcinoma cell lines while leaving healthy cells unaffected.

### **Harnessing Phytochemicals for Agriculture and pharmaceutical applications**

Beyond their therapeutic value, cotton phytochemicals offer sustainable solutions in agriculture. Compounds with insecticidal, herbicidal, or fungicidal properties derived from plants like cotton can offer environmentally friendly alternatives to synthetic chemicals, reducing ecological impact and promoting sustainable farming practices. In the pharmaceutical industry, phytochemicals are increasingly recognized for their therapeutic potential. Compounds from like gossypol in cotton have shown promising results in cancer research, while others exhibit antimicrobial, antioxidant, anti-inflammatory, or immunomodulatory properties. These bioactive compounds can serve as lead compounds for drug development, offering natural alternatives with potentially fewer side effects than synthetic drugs.

### **Future Directions**

The exploration of cotton phytochemicals opens doors to innovative applications across diverse sectors. Future research endeavors focus on optimizing extraction methods to harness phytochemicals efficiently, exploring their potential in drug development, nutraceuticals, and functional foods, and ensuring sustainable practices that benefit both human health and the environment.

In conclusion, cotton plants emerge not only as textile staples but also as reservoirs of phytochemical marvels with vast therapeutic potential. Unlocking the secrets of these bioactive compounds not only paves the way for novel therapies but also fosters sustainable agriculture and ecological stewardship, showcasing the multifaceted contributions of cotton to human well-being and environmental harmony.

**References**

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