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Review Article

Considering White Gold, Cotton, for its Fiber, Seed Oil, Traditional and Modern Health Benefits

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ABSTRACT
Cotton (*Gossypium* L.) has been a fundamental natural resource since the origin of various civilizations and still remains as one of the most major plant species for humans. Cotton has a diversity of applications, principally medicinal and many other usages such as pigments, derivatives for cattle feed, different uses of the oil extracts and etc. Cottonseed oil has a ration of 2:1 of polyynsaturated to saturated fatty acids and generally consists of 65-70% unsaturated fatty acids including 18-24% monounsaturated (oleic) and 42-52% polyunsaturated (linoleic), and 26-35% saturated (palmitic and stearic). The most important health benefits of cotton is treat respiratory diseases, treat skin problems, treat wounds, beneficial for breastfeeding mothers, a good cure for rat bite, an appropriate cure for scorpion bite, for joint and eye pains, for swollen legs, for removing bacteria in teeth, and alternative medicine for various diseases such as cancer, HIV and etc. Cotton seed oil mostly extracted from *Gossypium hirsutum* and *Gossypium herbaceum*, that are also grown for cotton fiber and animal feed. Gossypol is one of the most effective ingredients, both in traditional pharmaceutical practices and alternative modern medicinal preparations. It is a toxic polyphenolic bisesquiterpene which may have antifertility and antiviral properties. The obtained findings suggest potential of cotton as a natural resource in pharmaceutical industries.

Keywords: Cotton, Fiber, Oil, Health benefits, Traditional Chinese Medicine, Traditional Iranian medicine, Gossypol

INTRODUCTION

Cotton is a member of the Malvaceae family of plants so is related to the common mallow, marsh mallows, hollyhocks, hibiscus, okra, musk mallow, Indian or country cotton tree, the dinner plate tree and the fruit, durian, among others. It is a key crop in the world (Yu et al., 2012), and cotton fiber is also a source of natural textile, and cottonseed is a source of oil for human consumption, cotton meal and minerals for livestock feed (Yu et al., 2012; He et al., 2013). To ensure sustainability of cotton production, there should be crop improvement programs by diversifying the genetic base of cotton varieties to handle any biotic and abiotic stresses and a future change in climate. Current management practices of cotton include frequent tillage, which limit a complete adoption of conservation agriculture systems and overhead systems of irrigation. The use of cover crops and narrow row spacing may minimize tillage with the additional benefits of reduced weed pressure, improved soil health and a reduction in soil compaction and degradation. Modeling studies could help to forecast and minimize different production constraints; however, modeling approaches should bring holistic picture considering different aspects of crop production rather than isolated scenarios. Since 1960, world production of cotton fiber has doubled from 10.2 to 20.3 million tons, representing a moderate average annual growth of 1.7%. Although, there are numerous cotton producing countries, global production is largely dominated by China (28%), followed by the USA (17%), and India (12%). Cotton is primarily grown in dry tropical and subtropical climates at temperatures between 11ºC and 25ºC. The worldwide annual production is 60.9×10^6 tons.

Cotton occurrence, cultivation in the world, China and Iran

In the 5th century BC the father of history, the Greek historian Herodotus wrote this about cotton plants describing them: trees that bore wool, surpassing in beauty and in quality that of sheep's wool; and the Indians wear clothing from these trees (Wendel et al., 2010). It is the most widely used natural fiber and the sixth largest source of vegetable oil (FAO, 2012). It is ranked seventh in the world cultivated area and genetically modified cotton is the third most planted biotech crop worldwide (James, 2012). Cotton also is the only crop that did not acquire its value by being a staple food (Wendel et al., 2010). *Gossypium arboreum* is only known in cultivation and its origin is uncertain. It may have developed from *Gossypium herbaceum* L., though molecular comparisons support the hypothesis that *Gossypium arboreum* and *Gossypium herbaceum* diverged from a common ancestor. *Gossypium arboreum* has been cultivated in Asia for many centuries. It is still found there, but has mostly been replaced by *Gossypium hirsutum* L. From Asia *Gossypium arboreum* was brought to Sudan, and from there it spread to West Africa. Nowadays it is cultivated mainly in the drier parts of India and Pakistan, and sometimes in tropical Africa, where it has occasionally naturalized (Fryxell, 1979). In tropical Africa it is

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common in yards and abandoned dwelling sites (Seagull and Giavalis, 2004; Stetina et al., 2014; Bellaloui et al., 2015). Cotton is one of the world's leading agricultural crops, is plentiful and economically produced, making cotton products relatively inexpensive (Wilkin and Arpat, 2005; Stetina et al., 2014). Cotton originated in the African and Asian continents, and has been used for textile making for thousand years. Fragments of cloth from the Indus Valley Civilization in Pakistan show that the people living there aroung 3500 BC knew how to weave cotton into cloth. The first written mention of cotton was the Rig Veda written around 1500 BC (Khadi et al., 2010). The most important chemical constituents of cotton are alkaloids, phenolic compounds, terpenoids, tannins, sapnins flavonoids, cardiac glycosides and protein (Buser, 2001; Hedge et al., 2004; Knox et al., 2006; Ezuruike and Prieto, 2014). Both China and India are two of the world's largest producers and consumers of food and other agricultural products. Distribution of common secondary metabolites in cotton plant is shown in Figure 1. Chemical structures of some flavonoids in cotton is presented in Figure 2. Chemical structures of some phenolic acids present in cotton is shown in Figure 3. Chemical structures of some phenolic acid analogs present in cotton is shown in Figure 4.

Cultivation in China

Cotton is the leading cash crop in China (Koondhar, 2018). The cotton sown area accounts for about 30 percentage of the total sown area of all various cash crops. It is the main material used in the textile industry in China. More than 95 percentage of textile materials were cotton during the 1950s; and it still occupies 80 percent at present. There are some problems concerning rational location of cotton production in China. In order to solve the problems existing in civil cotton and supply, in view of strategy, a number of cotton production bases must be selected and built step by step in a planned way. The location of cotton production should be adjusted progressively in accordance with existing problems. The existing cotton production regions should be consolidated and improved. The cotton production region of the middle and lower reaches of the Huanghe river should be renewed quickly to make it become the largest stable and high-yield cotton production region. In the regions with suitable natural conditions and large water and soil potential, new cotton production regions should be developed in a planned way. In the regions where natural conditions are unsuitable or the competition between grain and cotton is sharp, cotton maybe replaced by grain and other crops. In the self-supporting regions one should raise the yield per unit areas, not exparde the fields (Zhu, 1991).

Cultivation in India

Cotton supports the livelihood of 95 million people in India. It is the only country in the world wherein all the four cultivated species are grown (*Gossypium arboretum*, *Gossypium herbaceum*, *Gossypium hirsutum*, and *Gossypium barbadense*). Historically, the Asiatic cotton (*G. arboretum* and *G. herbaceum*) cultivars were grown in India. Development of the high yielding upland cotton varieties (*G. hirsutum*) and the hybrids, led to the replacement of the traditional Asiatic cotton cultivars that were considered as low yielding and of poor quality. The Bt transgenic cotton hybrids were introduced in 2002 and now occupy 97% of the cotton acreage. Cotton cultivation in India extends from 10 oN to 30 oN ranging from an arid to sub-humid environments. Bulk of the cotton area (>65%) is rainfed. Erratic monsoon apart from poor soil fertility (low in organic carbon, nitrogen, phosphorus, and micronutrients such as zinc) are major abiotic constraints (Blaise and Kranthi, 2019). The problems facing the textile industry in India in terms of quality and productivity are discussed. The industry is facing problems such as shortfall in and uncertainty about cotton production, low cotton yields per hectare, quality of cotton, and cultivation of large number of Bt cotton including varieties. The use of poor quality inputs like seeds and pesticides results in low productivity of cotton. Cotton cultivation area zoning is essential based on soil profile. Cotton being a long duration crop is difficult to fit in a monsoon dependent irrigated Indian farming system, where the type of crop is decided by the amount of water in the dam.

Cultivation in Turkey

Basal et al. (2019) stated that cotton (*Gossypium herbaceum* L.) was first introduced to Anatolia from Indian subcontinent during the first century bce. Since then, cotton farming has been taking place in Anatolia. However, in the real sense, the cotton breeding studies started after establishment of Republic of Turkey. Cotton breeding studies in turkey started with introduction. Recently, there is a use of molecular methods together with classical breeding methods to develop cotton varieties. The common objectives in Turkey are to improve the yield and fiber quality, gain early maturity, and resistance to insect pests. The other objectives are to develop drought, salt and heat stress tolerance in cotton. Expanding the genetic diversity and genetic base of cotton is of immense importance for the continuity of the increase in cotton fiber yield in Turkey in the future. Cotton production in Turkey increased from 55000 MT in 1925-1930 to 854000 MT in 2011-2015, and cotton yield increased from 396 to 1796 kg/ha. In addition to improved agronomical applications, the improvement of new cotton varieties has been playing a crucial role for high yield. Modern tools and equipments are used in cotton cultivation from sowing to harvest. High input cost, contaminations, small land holding, lack of infrastructure for storage after ginning, unpredictable climate conditions, and poor irrigation management are the major challenges in cotton production. On the other hand, the Southeastern Anatolia Project, offers a great opportunity to increase cotton production. After the project has been completed in 2023, cotton production area in the region can reach one million ha. Increasing cotton demand of the textile industry is the driving force for increase in the cotton production. Cotton production is insufficient to meet consumption; therefore, Turkey imports an average of 900000-950000 tonnes of cotton each year. As the textile sector continues to be one of the indispensable sectors for the Turkish economy, cotton will continue to be an important product (Copur et al., 2016).

Cultivation in Pakistan

Cotton is the most important cash crop also in Pakistan. It is called, white gold in the farming community of the country due to its ability to generate revenue for the farmers. Cotton has a pivotal role in the economy of Pakistan as it is the main source of foreign exchange earnings, which directly contribute towards the gross domestic product (GDP) of the country. Seed cotton yield has been significant enhanced in the recent times due to the development and introduction of new germplasm and Bt cotton cultivars in the country. Furthermore, cotton breeding techniques and improved production methods have brought about betterment in the overall scenario of cotton. However, besides the historical rise in its production, the yield of cotton is reading a plateau due to several reasons. There are several factors affecting the cotton productivity in Pakistan. Due to insect susceptible nature of cotton, insect pests are the main suppressors of cotton productivity in all over the world, which are mainly managed by the use of insecticides. In addition to insect pests, unavailability of good quality seed, cotton diseases like cotton leaf curl disease (CLCuD), drought and heat stresses, laborious picking and un-predicting cotton pricing and shifting of cropping patterns in the cotton zone are the major constraints (Ali et al., 2019).

Cultivation in Australia

Australia is known worldwide for producing cotton of the finest quality. Cotton production has an important position in the economy of Australia, earning foreign exchange of two billion dollars annually. Australian cotton production is highly mechanized and its production systems are quite specialized with emphasis on more crops per drop. But, several factors are making Australian cotton production challengeable, such as climate change, water scarcity, emergence of new insects, diseases and weeds, waterlogged soils and rising production cost. Australian cotton growers, as well as, cotton scientists put sincere efforts to cope up with these important issues. New agronomic tools, for example, the skip-row technique for water saving in the dry land area, timely planting, and use of glyphosate-tolerant and Helicoverpa-resistant cultivars also were adopted to increase the yield potential. Synergy among weather forecasting, fertilizer, water and pest management mode is being considered for high efficiency of cotton production systems (Kaur et al., 2019).

Cultivation in African countries

Africa contributes about 8% of the global cotton production. In African continent, there are total six cotton basins among which West African basin is the most important. Sub-Saharan Africa has a climate favorable for pest growth and these results in severe attack of pests on cotton and subsequent yield losses. In West Africa, approximately 25-35% of cotton yield is lost because of pests. In addition to pest damage, many other challenges are faced by the farmers like low seed germination, insufficient seed storage facilities, low soil fertility, low literacy and lack of trainings. Cotton production in Africa could be increased by increasing the seed availability, support to agricultural research, and a capacity-building strategy, so that the farmers could get maximum profits from cotton (Amanet et al., 2019).

Cultivation in Iran

China, India, Pakistan, United States, Uzbekistan, and Brazil are main cotton producer countries, and Iran with annual production of nearly 253604 tons was the nineteenth country in the world cotton production. Total cotton harvested area in 2009 for Iran was almost 105370 ha with average yield of 2.4 tons per hectare, and the highest production belonged to Khorasan-Razavi and Khorasan-Jonobi province with production of 100503 and 33907 tons, respectively; Alborz province cotton production is 8052 with average yield of 4.9 ton per hectare (Pishgar-Komleh et al., 2012). The shares of energy inputs for cotton production is shown in Figure 5. China is one of the largest cotton producing country in the world, and among 31 provinces in mainland China, 24 provinces produce cotton and about 300 million people are involved in cotton production. Cotton is one of the most important cash crops in China and cotton is a pillar agricultural commodity in many regions and benefits a large rural population

(UNEP, 2002). Xinjiang leads in agricultural outputs in China, especially cotton production (Scull, 2008). Appiah et al. (2014) have suggested new policies maybe introducing incentives for farmers to use natural resources in a more sustainable way to maintain a sustainable agricultural production, especially cotton production in Xinjiang and an integrated framework of policies for production, natural resources and environment is required. China cotton production by producing region from 1980-2014 is presented in Figure 6. China's cotton policies are shown in Figure 7.

Cultivation and sustainability

Mollaee et al. (2019) revealed that cotton (*Gossypium hirsutum* L.) is currently grown in 100 countries and fulfills one-third of the global demand for natural fiber. Irrespective of production regions, cotton production across the world is constrained by the high incidence of pests and diseases, weed pressure and evolution of herbicide resistance in weeds, salinity and soil degradation, and climate aberrations such as drought, floods, and heat waves. Crop production potentials and constraints can vary with countries. Introduction of genetically modified (GM) cotton and its adoption by major producing countries have changed the global trends in cotton production. Although adoption of GM cotton has ensured a reduction in the usage of insecticides and improved in broad-spectrum weed control due to the flexibility in herbicide-based weed management, sustainability of GM cotton could be challenged by the evolution of resistance in insects and weed biotypes. Enhanced adoption of commercially available GM cotton may narrow down the existing genetic diversity of cotton varieties. To ensure sustainability, there should be crop improvement programs by diversifying the genetic base of cotton varieties to handle any biotic and abiotic stresses and a future change in climate. Current management practices of cotton include frequent tillage, which limit a complete adoption of conservation agriculture systems and overhead systems of irrigation. The use of cover crops and narrow row spacing may minimize tillage with the additional benefits of reduced weed pressure, improved soil health and a reduction in soil compaction and degradation. Modeling studies could help to forecast and minimize different production constraints; however, modeling approaches should bring a holistic picture considering different aspects of crop production rather than isolated scenarios. More avenues also exist for the efficient utilization of by-products. In a nutshell, science and technology should work hand in hand to minimize the uncertainties and explore more avenues for a profitable, environment-friendly and sustainable cotton production system. Radhakrishnan (2017) found that sustainability is an objective that refers to the environment and economic and social issues of any culture. Cotton farming systems are diverse and the issues associated with cotton cultivation vary owing to environmental, agro-ecological, climatic, socioeconomic and political situations. The role of biotechnology in cotton farming is important in producing durable hybrids and reducing the amount of insecticides and fertilizers. Global standards have been instituted to cultivate organic crops and voluntary sustainability initiatives assess many sustainability issues in cotton production. The cotton industry reaches out to all involved, from small poverty-stricken farmers to chic fashion stores in different parts of the globe. There is a call for a mass-market transformation in which sustainable cotton is the norm and for a change in global perspectives and the emergence of sustainable strategies to improve the livelihood of 250 million families involved in producing this valuable crop. Cotton production contributes considerably to Uzbekistan's export earnings. The various reforms implemented to increase the operational autonomy of agricultural producers considered the stability of cotton production, yet often at the expense of farm incomes. Options for improving the farm incomes can be achieved through modifications of the cotton policy settings. Such options are analyzed by replacing the present area-based yield prescriptions by tradable cotton targets between cotton-growing farms. The net benefits would increase due to the difference in land fertility and location to irrigation canal between contracted farms. However, the sustainability of such policy modifications would depend on strong mechanisms for price negotiation and conflict resolution (Shavkat and Djanibekov, 2015). China has also been giving consideration to how it can sustain it supply of cotton given current demands on the use of its agricultural land, particularly to grow food. Once strategy has been to increasingly locate its cotton production in its northwest, especially in Xinjiang (Zhao and Tisdell, 2009). If the Chinese economy continues to grow and develop at a fast pace, this is likely to result in significant structural change in Chinese agriculture as rural-to-urban migration continues. In turn, this may result in changes that favor merging of farms and greater mechanization in agriculture, that is a trend towards more industrial-type specialized farms. The long term implications of such changes for China's cotton industry are unclear but they may result in a decline in cotton production in all regions of China, except in its northwest. Interestingly, the supply of cotton from China has continued increasing despite the economic and environmental difficulties which its cotton-growers face. The depth and nature of these difficulties vary between the major cotton-producing regions of China. Another point is water is in short supply in the Yellow River Region and almost all the available water resources have been utilized in Northwest regions of China. Besides, will less agricultural labour available in China, there are likely to be economic pressures to increasingly mechanize and adopt more capitalintensive techniques for agricultural production, raise the size of farms and import agricultural produce rather than rely as heavily as in the past on domestic production. These complex economic changes may make it very difficult for China to sustain the level of its cotton production in the long term. Cotton production in the northern part of Ghana has contributed so much to the economic development of the inhabitants and the textile industry as a whole. It has been a source of livelihood for many if not all. Over the years, issues concerning cotton have been of great concern and sensitive to the government and people of the north. This paper therefore, seeks to explore the history behind cotton cultivation in northern Ghana, mode of marketing, the challenges confronting the sector and the prospects it holds for the Ghanaian textile industry. Information relevant to this study was gathered through interview, using descriptive case study research design approach to assess the phenomena of then and now of cotton production in Ghana. The study has shown that the cotton sector when well organized will provide income for folks in northern Ghana and invariably provide raw materials for the Ghanaian textile industry. It identifies the major setbacks militating against cotton cultivation in Ghana and recommendations for the way forward. The bottlenecks identified include poor farmer organization, lack of farm inputs, research into improved seeds and new technology in the cultivation of cotton (Asinyo et al., 2019). Ethiopia is one of the African countries that produce and export cotton. It has a long tradition of cotton cultivation with an estimated area of 2.6 million hectares suitable for this product. Of these 65% is found in 38 high potential cotton producing areas and the remaining 0.9 million ha or 35% is in 75 medium potential districts. Of the total land under cotton cultivation, 33% is cultivated by small holders, 45% by private farms and 22% are state owned farms. But, Ethiopia shares only 5% of total cotton produced in Africa. This is because it recently cultivates only 3% of the total suitable land for cotton production. Ethiopia produces an average of 33,842.11 metric tonnes in the year 2000-2018. The production trend shows some declining stage since 2012. Natural and technological constraints were existed for cotton production in this country. The country also participates on the export market and earned an average of $14,336,667 especially in the last decade. Currently the country exports with an average price of $1.45. Cotton market has also some constraints like price disincentives and lack of market information. Despite its inefficiency the cotton sector still has its own vital economic role on textile industry and employment creation. It employs about 52,754 smallholder farmers. Therefore, it is recommended that the government, the producers and other relevant stakeholders should work in collaboration to solve the constraints (Zeleke et al., 2019). Bt cotton was among the first transgenic crops to be used in commercial agriculture. A gene from the soil bacterium *Bacillus thuringiensis* (Bt) has been transferred to the cotton genome. This gene codes for production of a protein that is toxic to the cotton bollworms, severe insect pests in most cotton-growing regions of the world. In the United States and China, Bt cotton was commercialized in the mid-1990s, and today, the technology covers around 30-40% of the cotton area in both countries. Recent studies demonstrate that US and Chinese Bt adopters realize significant pesticide and cost savings. In 1996, Mexico and the United States became the first two countries to plant Bt cotton commercially. (Bt) cotton reduces use of insecticides, cuts farmers' production costs, and increases yields. Global adoption of Bt cotton has risen dramatically from 800,000 hectares in its year of introduction in 1996 to 5.7 million hectares (alone and stacked with herbicide- tolerant cotton) in 2003. Significant economic and production advantages have resulted from growing Bt cotton globally. Bt cotton can substantially reduce the number of pesticide sprayings, which reduces worker and environmental exposure to chemical insecticides and reduces energy use. The quality of life for farmers and their families can be improved by the increased income and time savings offered by Bt cotton. These economic, environmental, and social benefits are being realized by large and smallholder farmers alike in eight countries around the world. Bt cotton was planted on over 15 million hectares in 11 countries in 2009 and has contributed to a reduction of over 140 million kilograms of insecticide active ingredient between 1996 and 2008. It is estimated that between 1996 and 2005 the deployment of Bt cotton has reduced the volume of insecticide active ingredient used for pest control in cotton by 94.5 million kilograms and increased farm income through reduced costs and improved yields by US$7.5 billion. The efficacy of Bt maize and cotton against major pest species has been associated with an estimated 136.6 million kg global reduction in insecticide active ingredient used between 1996 and 2006 (29.9% reduction). Benefits vary by country and region and are heavily weighted towards cotton production, which has historically been one of the largest users of insecticides in the world. Many cotton production strategies (from the pest control point of view) have been applied in cotton production world – wide, these strategies are :- 1- Insecticides treatment Strategy (ITS) ; 2- Integrated pest management (IPM) strategy (IPMS); 3-Pheromone technology strategy (PTS) ; 4-Sterile insect release (SIR) strategy (SIRS); 5- Biological control Strategy (BCS); 6- Bt-transgenic strategy (Bt.S) and Organic strategy (OS) . This review focuses on the Bt cotton world use, benefits and production (Albeltagy, 2014). The main cotton producing countries China and India gave commercial approval for Bt cotton in 1997 and 2002, respectively. Today Bt varieties have reached over 50% of the total cotton area in China. The Bt technology is a mean to control lepidopteran cotton pests, hence offering the possibility to reduce the application of chemical pesticides and lowering production costs. Previous studies, which assess the Bt technology, claim a sharp reduction in pesticide use accompanied by significant human health and environmental benefits. In these studies, the conclusions on benefits were derived from a comparison between Bt and non-Bt varieties rather than from an analysis of the pest control effects of Bt crops. Furthermore, costs of possible long-term ecological effects of Bt crops were not included and, none of the studies has taken into account the uncertainty that underlies the main parameters. Thus, there is a danger that if results from case studies are generalized, wrong conclusions are drawn about prospects, opportunities and constraints of Bt crops on a global scale. The approach presented here complements previous studies by using a stochastic partial budgeting model that captures the key pest control properties of Bt cotton taking into account uncertainty (Pemsl et al., 2003).

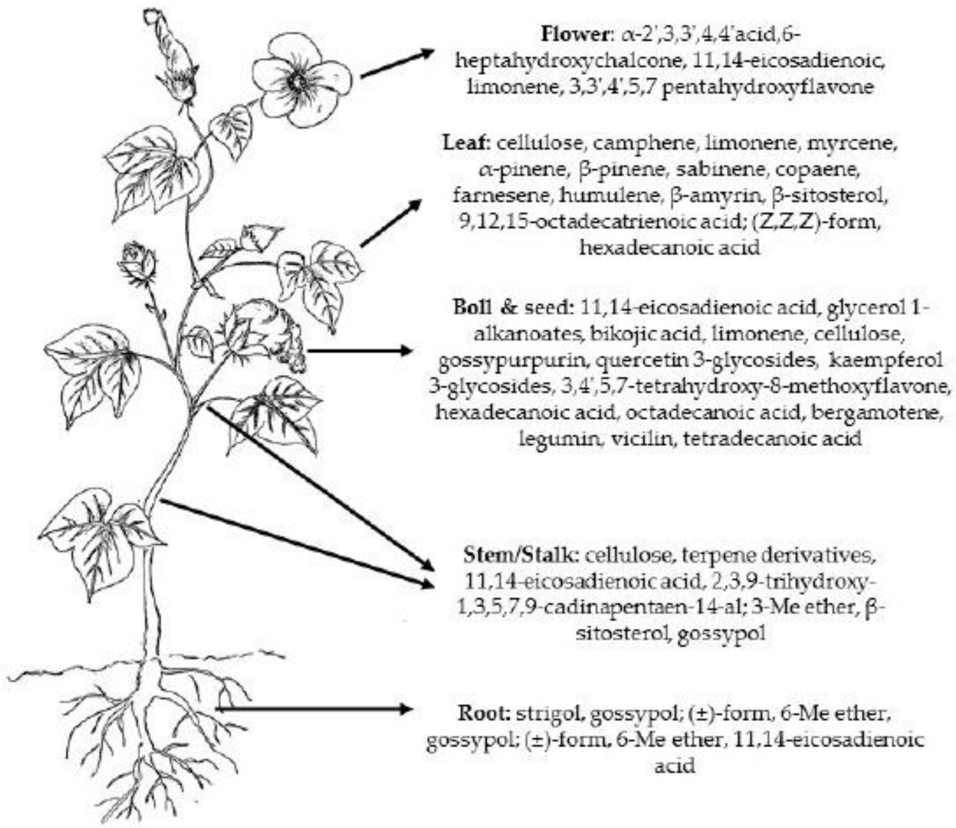
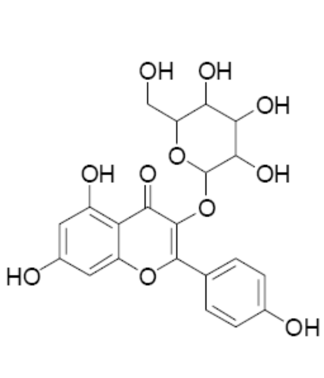
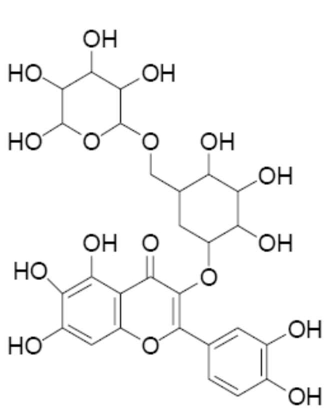


Figure 1. Distribution of common secondary metabolites in cotton plant (Egbuta et al., 2017).



kaempferol 3-glycosides; monoglycosides, 3-*O*-D-glucopyranoside



quercetin 3-glycosides; disaccharides, 3-*O*-[beta-D-galactopyranosyl-(1-6)-beta-D-glucopyranoside]

Figure 2. Chemical structures of some flavonoids in cotton (Egbuta et al., 2017).

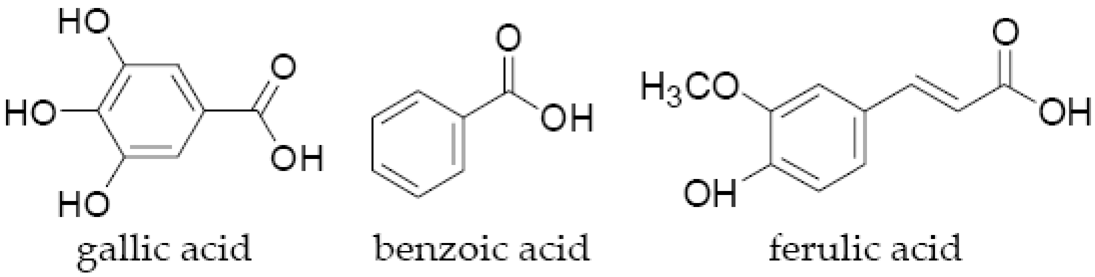


Figure 3. Chemical structures of some phenolic acids present in cotton (Egbuta et al., 2017).

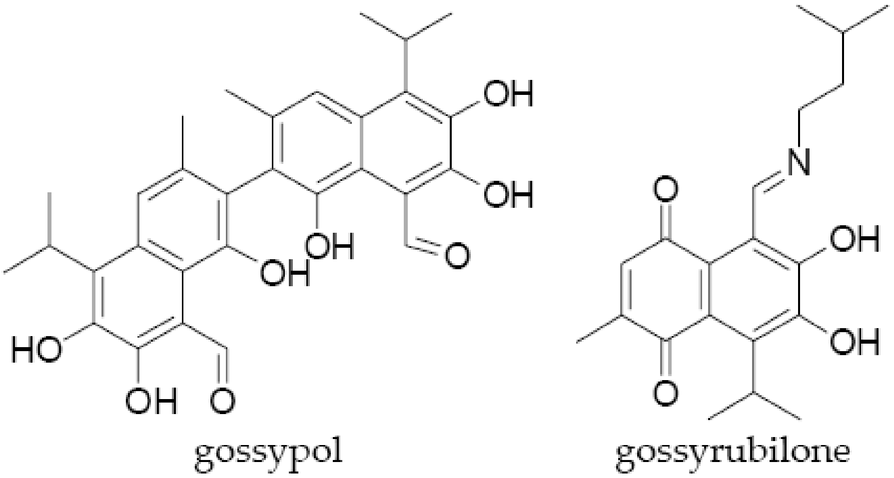


Figure 4. Chemical structures of some phenolic acid analogs present in cotton (Egbuta et al., 2017).

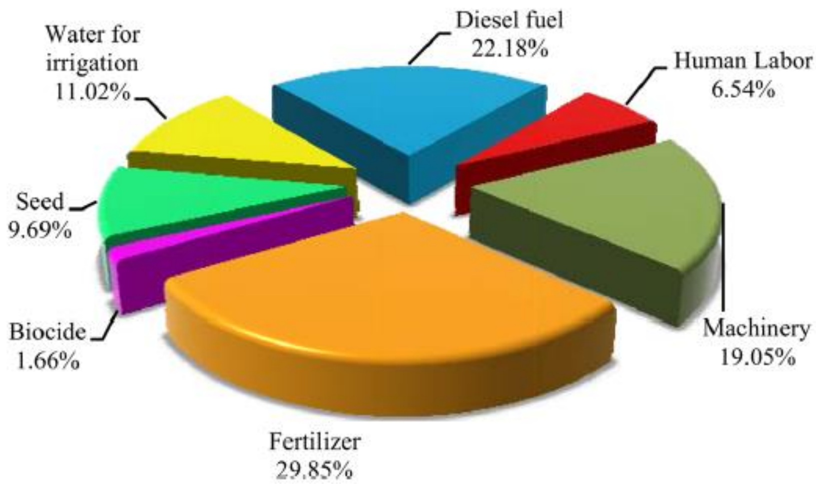


Figure 5. The shares of energy inputs for cotton production (Pishgar-Komleh et al., 2012).

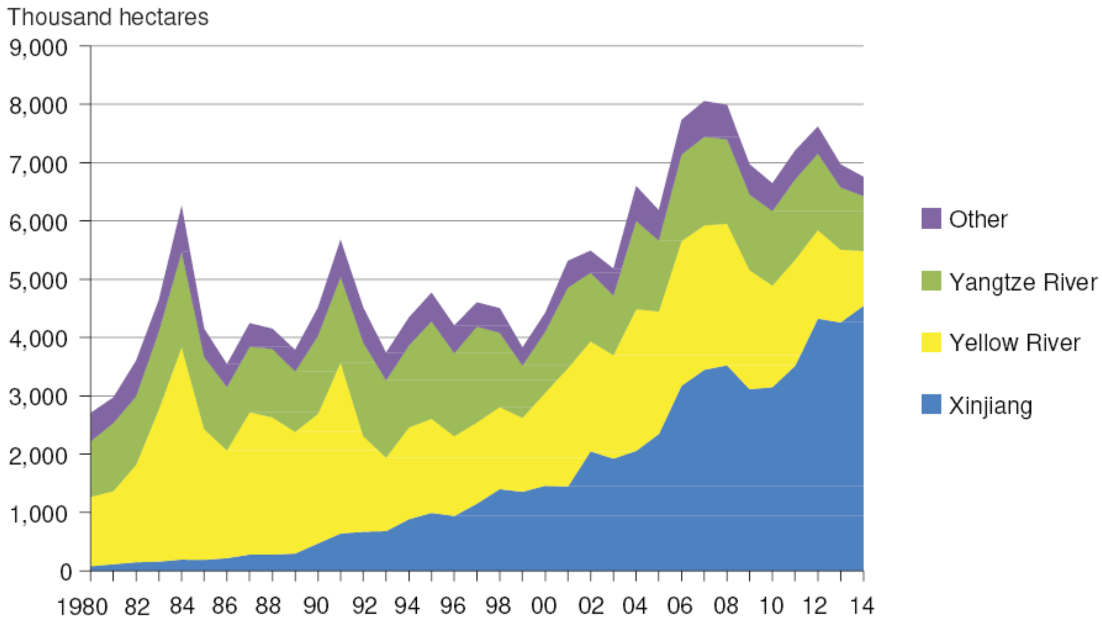


Figure 6. China cotton production by producing region from 1980-2014.

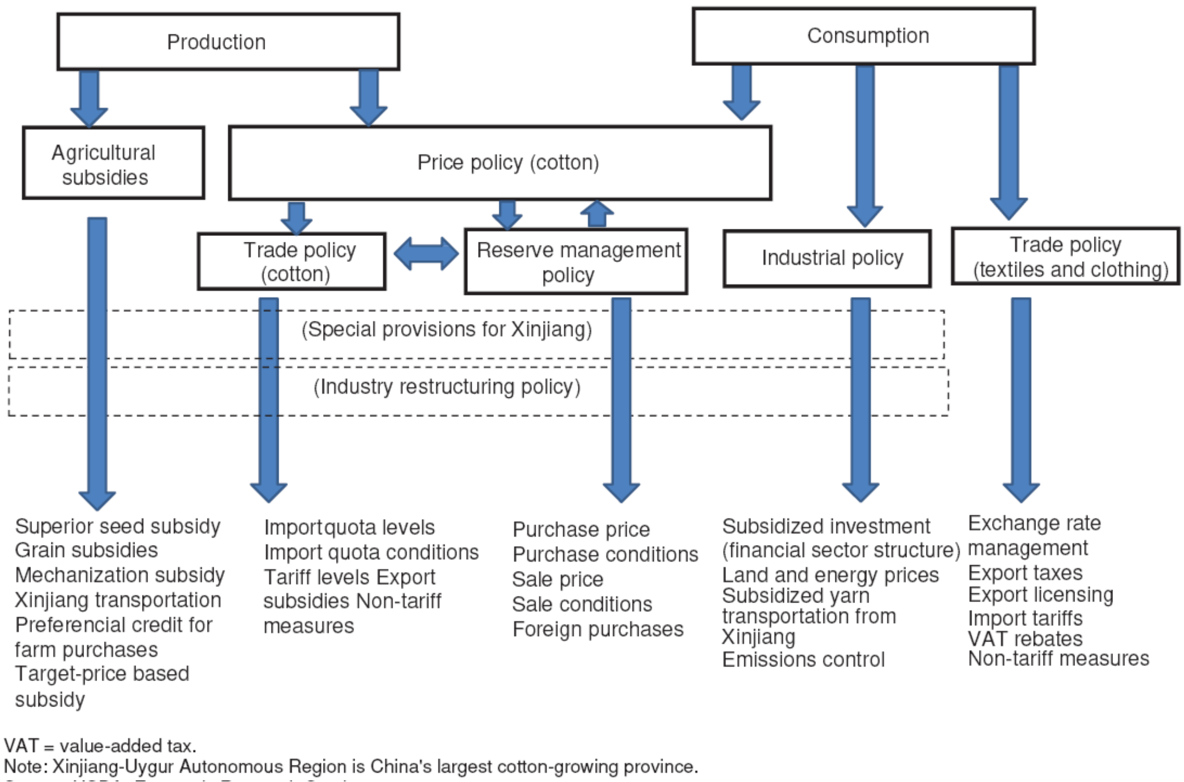


Figure 7. China's cotton policies.

Cottonseed oil

Cottonseed contains hull and kernel. The hull produces fiber and linters, and the kernel contain oil, protein, carbohydrate and other constituents such as vitamins, minerals, lecithin, sterols and etc. Cotton seed oil is extracted from cotton seed kernel and also termed as heart oil is among the most unsaturated edible oils. It does not need to be as fully hydrogenated for many a cooking purposes as is required in case of some of the more polyunsaturated oils. Cottonseed oil has a ration of 2: 1 of polyunsaturated to saturated fatty acids and generally consists of 65-70% unsaturated fatty acids including 18-24% monounsaturated (oleic), and 42-52% polyunsaturated (linoleci) and 26-35% saturated (plamitic and stearic). Cottonseed oil is described by scientists as being naturally hydrogenated because of the levels of oleic, palmitic, and stearic acids in its. Typical fatty acid composition in different forms of cottonseed oil is shown in Table 1. Tocopherol content in various edible oils is shown in Table 2. Analytical values on different parameters for various cottonseed oil is presented in Table 3. Mean gossypol content and the range of gossypol in different gossypium species is presented in Table 4. The range of fatty acid content of four cotton species is shown in Table 5. The main biotechnological goals for oil quality improvements are increasing oil content and quality, making cottonseed oil healthier, and gossypol free cotton. Inside the cotton seed is shown in Figure 7.

Table 1. Typical fatty acid composition in different forms of cottonseed oil.

Fatty acid	Cottonseed cooking oil	*Partially hydrogenated
Myristic (14:0)	0.8	0.9
Palmitic (16:0)	24.4	22.5
Palmitoleic (16:1)	0.4	0
Stearic (18:0)	2.2	5.5
Oleic (18:1)	17.2	50.0
**Linoleic (18:2)	55.0	20.3
**Linolenic (18:3)		
Summary		
% Saturates	27	29
% Monounsaturates	18	50
% Polyunsaturates	55	21

*Partially hydrogenated cottonseed oil (Iodine value, approximately 80).
**Essential Fatty Acids; Linolenic is an Omega-3 Fatty Acid.

Table 2. Tocopherol content in various edible oils.

Oil Crop	Total (mg/100 g)	Contents (mg/100 g)			a-Tocopherol equivalent
		a	b	g	
Canola	66	19	43	4	23
Corn	104	26	75	3	33
Cottonseed	65	35	30	-	38
Olive	13	12	1	-	12
Palm	26	6	11	9	8
Peanut	13	9	4	1	9
Rapeseed	67	22	19	26	24
Soybean	104	10	70	24	17
Sunflower	65	62	3	-	62

Table 3. Analytical values on different parameters for various cottonseed oil.

	Cottonseed Cooking Oil (RBD)*	Hydrogenated Cottonseed Shortening
Lovibond colour (Red Max.)	2.0–6.0	2.0-2.5
Free fatty acid (as Oleic % Max.)	0.05	0.05
Peroxide value (meq/kg. Max)	1.0	0.5
Iodine value	103-116	50-70
AOM stability (hrs.)	15	100-200+
Cloud point (ºF)	30-38	-
Melting point (ºF)	50-60	100-118
Pour point (ºF)	-	102-140
Smoke point (ºF)	430	-
Cold test (hrs.)	-	-
Flavour	Bland	Bland
Density (lb/gal @ 108ºC)	-	7.46

*RBD- Refined, Bleached & Deodorized; CSO Bulletin, 2000 Digital Edition Published on ww.cottonseed.com

Table 4. Mean gossypol content and the range of gossypol in different gossypium species (% free gossypol).

Species	Seed	Kernel
G. arboretum	0.69 (0.30-1.25)	1.31 (0.65-2.38)
G. herbaceum	0.77 (0.43-1.09)	1.44 (0.82-1.96)
G. hirsutum	0.77 (0.42-1.25)	1.39 (0.73-2.35)
G. barbadense	1.11 (0.73-1.49)	1.78 (.122-2.35)

Table 5. The range of fatty acid content of four cotton species.

Name of the species	Extent of variability			
	Palmitic acid (%)	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)
G. arboretum	23.1-25.9	2.3-3.4	20.8-26.3	41.1-50.6
G. herbaceum	20.5-23.4	3.2-4.4	17.5-20.8	51.3-55.1
G. hirsutum	23.1-28.0	2.4-3.4	14.7-20.9	47.6-55.4
G. barbadense	24.4-25.5	2.6-3.0	18.7-19.7	50.0-51.7
G. arboretum	8.90-21.2	1.1-2.9	16.5-30.7	30.0-59.3
G. hirsutum	8.83-24.4	1.2-4.5	10.3-30.2	20.6-58.0

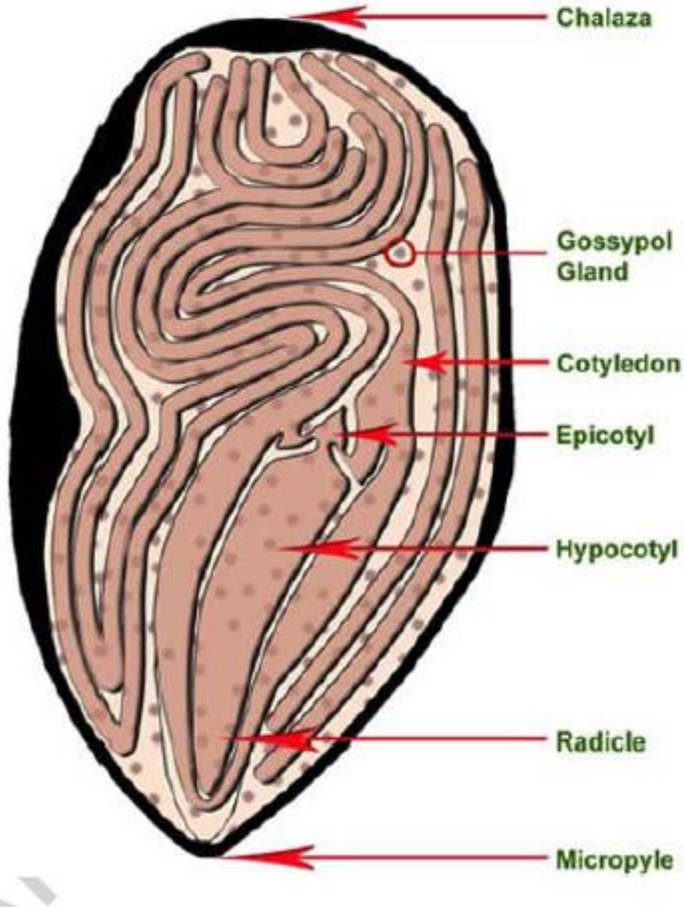


Figure 7. Inside the cotton seed (Ritchie et al., 2007).

Cotton in Traditional Iranian, Chinese and Asian Medicines and Modern Science

Herbal medicine has long been recognized as one of the oldest forms of remedies used by human beings (Soleymani and Shahrajabian, 2018; Sun et al., 2019a,b; Shahrajabian et al., 2020a,b), and many people in different parts of the world, especially developing countries still rely on traditional healing practices and medicinal plants for their daily health care needs (Ogbaji et al., 2018; Shahrajabian et al., 2019a,b; Sun et al., 2020a,b). In China, Chinese have long known the abortive properties of the plant and its effects on men sperm;

however, it was later noted that families who cooked with cottonseed oil had fewer children. Modern medical science has found that parts of the cotton plant may have potential use in the treatment of HIV and cancer. It has been found in one study to have the ability to inhibit cancerous growths in head and neck cancers. Since 1989, potential treatments were tested in vitro to control the human immunodeficiency virus (HIV) to reduce their enzymatic activities (Polska et al., 1989), with (-) gossypol (An et al., 2012). It can be used ingested as well as vaginal gels for HIV control, in addition to their effect to stop the mobility of sperms that serves as birth control and even to prevent other sexual transmitted diseases such as herpes (Ratsula et al., 1983). Plants synthesise hundreds of chemical compounds for different functions (Shahrajabian et al., 2019c,d). Chewing the root bark of the cotton plant is supposed to stimulate the sex organs and it has a reputation for being an aphrodisiac. In Ayuvedic medicine and other traditional medicine systems in the Indian subcontinent plants and their parts are used to improve blood circulation, for ear problems, colds, diarrhea and gout as well as a whole host of other ailments. The seeds and leaves are used in South East Asia and the subcontinent to treat a variety of health problems, and are used both internally and externally for skin problems and injuries. Powdered cotton seeds mixed with milk are given to those whit headaches, and an infusion of the seeds and leaves which said to be useful for cases of dysentery. Cotton seeds or the expressed juice from the leaves are used to treat skin problems, while the leaves can be made into a poultice for sprains or painful areas of the limbs. The seeds are ground and made into a paste with water and ginger for burns, and an infusion, a mixture of the seeds and leaves and also mustard seeds is used for snake bites and scorpion stings. The fibers can be made into a wide variety of fabrics ranging from lightweight voiles and laces to heavy sailcloths and thick-piled velveteens, suitable for a great variety of wearing apparel, home furnishings, and industrial uses. Cotton fabrics can be extremely durable and resistant to abrasion, and cotton accepts many dyes, is usually washable, and can be ironed at relatively high temperatures. The most important chemical constituents of cotton are alkaloids, phenolic compounds, terpenoids, tannins, sapnins flavonoids, cardiac glycosides and protein. The pharmacological investigations revealed that they possessed anti-diabetic, hypolipidemic, antioxidant, anticancer, antidepressant, antiepileptic, memory enhancement, wound healing, nephroprotective, hepatoprotective, antimicrobial, anthelmintic, antiprotozoal, insecticidal, diuretic, gastric ulcer healing and wide range of effects on reproductive systems. Health benefits of cotton included mucus, tannins, flavonoids, essential oil and other substances is shown in Table 6. Traditional uses and benefits of cotton is presented in Table 7. Ayurvedic health benefits of tree cotton is presented in Table 8.

Table 6. Health benefits of cotton included mucus, tannins, flavonoids, essential oil and other substances.

1-	Treat respiratory diseases.
2-	Treat skin problems.
3-	Treat wounds or inflamed mucus membrane in the respiratory organs.
4-	Beneficial for breastfeeding mothers.
5-	Cure for rat bite.
6-	For scorpion bite.
7-	For joint pains.
8-	For swollen legs.
9-	For eye pains.
10-	For removing bacteria in teeth.
11-	For mumps.
12-	For curing puss in the ears.
13-	For blood and sticky motions.
14-	Alternative medicine for various diseases.

Table 7. Traditional uses and benefits of cotton.

1-	Juice of the root is used in the treatment of fevers.
2-	Root bark is used as an abortifacient.
3-	Root decoction is used to prevent abortion.
4-	Powdered root bark is used to treat Lymphatic swellings.
5-	Fresh leaves of tree cotton are used to treat Ulcers.
6-	Macerated leaf is taken against vomiting.
7-	It is used for wound dressing and curbing infection.
8-	It is applied on forehead to relieve headache.
9-	It cures digestive disorders.
10-	It encourages proper Bile secretion in the liver.
11-	It helps in uterine contraction.
12-	It helps in breast enlargement.
13-	It supports healthy immune system.

14- Chewing the root bark of the cotton plant is thought to stimulate the sex organs and it has a reputation for being an aphrodisiac.
15- Seeds and leaves are used in South East Asia and the subcontinent to treat a variety of health problems, and are used both internally and externally for skin problems and injuries.
16- Powdered cotton seeds mixed with milk are given to those with headaches.
17- An infusion of the seeds and leaves is said to be useful for cases of dysentery.
18- Cotton seeds or the expressed juice from the leaves are used to treat skin problems.
19- Leaves can be made into a poultice for sprains or painful areas of the limbs.
20- Seeds are ground and made into a paste with water and ginger for burns.
21- An infusion, a mixture of the seeds and leaves and perhaps also mustard seeds is used for snake bites and scorpion stings.

Table 8. Ayurvedic health benefits of tree cotton.

Diarrhea
Maturant
Leucorrhoea
Ear Discharge
Galactagogue
Emacitation
Epilepsy
Menstrual pain
Curing hysteria and fear
Burn skin mark removal and healing

Gossypol, a poly-phenolic with potential contraceptive effects and trans-caryophyllene, a terpenoid having anti-inflammatory and cytotoxic properties, are examples of compounds present in cotton with potential beneficial impact on humans and animals (Fernandes et al., 2007; Han et al., 2007; Amiel et al., 2012). Egbuta et al. (2017) noted that three major classes of compounds and some primary metabolites have been previously identified in the plant, and among these compounds, most terpenoids and their derivatives (51), fatty acids (4), and phenolics (6), were found in the leaves, bolls, stalks, and stems. They have concluded that biological activities such as anti-microbial and anti-inflammatory activities, are associated with some of these phytochemicals, for example, β-bisabolol, a sesquiterpenoid enriched in the flowers of cotton plants, may have anti-inflammatory product application. Considering the abundance of biologically active compounds in the cotton plant, there is scope to develop a novel process within the current cotton fiber production system to separate these valuable phytochemicals, developing them into potentially high-value products. Biological activities of different compounds present in cotton is presented in Table 9.

Table 9. Biological activities of different compounds present in cotton (Egbuta et al., 2017).

Compounds	Biological activity
Terpenes	
Camphene	Aromatic properties, antioxidants effects
Limonene	Flavouring properties, gastro-protective effects, anti-cancer and anti-inflammatory activity
Myrcene	Analgesic effects, anti-microbial activity, anti-inflammatory activity, anti-catabolic activity
α and β-pinene	Gastro-protective effects, anti-microbial and anti-inflammatory effects
Sabinene	Anti-microbial activity, anti-oxidant activity
α-thujene	Pungent activity
Caryophyllene	Anti-inflammatory effects, anti-microbial activity, regulation of cellular lipid metabolism, flavouring properties
Farnesene	Anti-oxidant effects
Humulene	Anti-inflammatory properties, aromatic properties and cytotoxic activity
Bisabolol	Aromatic properties, anti-inflammatory effects, anti-carcinogenic activity, anti-microbial and anti-oxidative properties
Caryophyllene oxide	Cytotoxic activity, phytogrowth inhibition, analgesic and anti-inflammatory activity
3,10-dihydroxy-1,3,5,7-cadinatetraen-9-one	Phytoalexin, antifungal agent
β-sitosterol	Antimicrobial activity, anti-hypercholesteraemic and anti-inflammatory activity

Strigol	Germination stimulant
2,3,9-trihydroxy-1,3,5,7,9-cadinapentaen-14-al;3-Me ether	Phytoalexin
2,8,9-trihydroxy-1,3,5,7,9-cadinapentaen-14-al;8-deoxy	Antifungal activity
Phenols	
Chlorogenic acid	Anti-oxidant and anti-mutagenic activity
Gallic acid	Antioxidant activity, cytotoxic activity
4-hydroxybenzoic acid	Anti-microbial activity, used a preservative, oestrogenic activity, anti-inflammatory and anti-oxidant activity
Gossypol;(+)-from	Contraceptive and hypokalemic activity
3,3′,4′,5,7-pentahydroxyflavan; (2S,3R)-form	Cytotoxic and phytotoxic activity
3,3′,4′,5,7-pentahydroxyflavone;3′-*O*-β-D-glucopyranoside	Enzyme inhibitor, cytotoxic, anti-oxidant activity
Scopoletin	Anti-spasmodic and anti-inflammatory activity
Fatty acids	
11,14-eicosadienoic acid	Hormonal activity
Hexadecanoic acid	Anti-microbial and anti-inflammatory activity
Octadecanoic acid	Pharmaceutical excipient, surfactant and softening activity
9-octadecenoic acid; (Z)-form	Insecticidal, anti-bacterial and fungicidal activity
Tetradecanoic acid	Defoaming agent, flavor adjuvant used in food processing
Carbohydrates	
Cellulose	Capsule and tablet diluents
Proteins	
3-phosphoglycerate phosphatase	Enzyme activity
Vicilin	Anti-hypertensive activity

CONCLUSIONS

Cotton is one of the most important commercial crops and it is famous as white gold. Cotton production presents recent developments achieved by major cotton producing regions around the world, including China, India, the USA, Pakistan, Iran, Turkey, South American, Central Asia, Australia and Europe. The leaves are edible, seeds ground into a flour and added to bakery products; an oil obtained from the seed is used in salads, canned goods and manufactured into margarine. The root is abortifacient, emetic, and emmenagogue. An infusion of the root bark is used to treat difficult or irregular menstruation. The pulverized roots are used to procure an abortion. The stem bark is used in a preparation to strengthen the womb. The leaves are antipruritic, diuretic, and hypotensive. Leaves of the red variety of cotton are used for treating high blood pressure; abdominal cramps and pain; menstrual problems; painful ovaries; and difficult expulsion of afterbirth. The flower buds are used as an auricular analgesic. The seeds are crushed, and the juice given to babies as a treatment for thrush. The pressed cotton cake contains gossypol, which is used clinically as a male contraceptive. Gossyple is a toxic polyphenolic bisesquiterpene which may have antifertility and antiviral properties. Cotton seed oil mostly extracted from *Gossypium hirsutum* and *Gossypium herbaceum*, that are also grown for cotton fiber and animal feed. It is extracted from cottonseed kernel which are by-products of cotton fiber production. Cottonseed oil is among the most unsaturated oils, others being safflower, corn, soybean, rapeseed and sunflower seed oils. Cottonseed oil has a ration of 2:1 of polyynsaturated to saturated fatty acids and generally consists of 65-70% unsaturated fatty acids including 18-24% monounsaturated (oleic) and 42-52% polyunsaturated (linoleic), and 26-35% saturated (palmitic and stearic). The saturated fatty acids content makes it a relatively stable vegetable oil without partial hydrogenation, so it is called as naturally hydrogenated oil. Cottonseed oil is described by scientists as being naturally hydrogenated because of the levels of oleic, palmitic, and stearic acids in it. The major cottonseed oil˙s major benefits includes, its high level of antioxidants; tocopherols that contribute to its long life on the shelf. Cottonseed oil is cholesterol free, as it extracted from plants which make it a great choice to reduce cholesterol level. Cotton seed oil has high concentration of vitamin E, and its oil is more efficient for heart-healthy vitamin E than other vegetables oils, and as it is rich source of vitamin which is like antioxidant, it is important in fighting free radicals and essential for good health like skin health, anti-aging, hair quality, and numerous illnesses including cancers. It is obvious that the variety of traditional and modern medicinal uses of cotton is because of its active compounds that have been mentioned in different researches. With more control of the toxic effects of gossypol, applications on human health issues will increase.

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