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Complete Chloroplast Genome, Distribution, and Pharmacological Activities *Pogostemon*: A Mini Review

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Abstract: *Pogostemon* Desf. is the largest genus in the Pogostemoneae (Lamiaceae). The plastid genomes of *Pogostemon* species ranged from 151,824 to 152,707 bp in length and comprise 114 genes including 80 protein coding genes, 30 tRNA genes, and four rRNA genes. *Pogostemon* is found mostly in tropical and subtropical areas of Asia. *P. cablin* as one of the commercial species of the genus *Pogostemon* has various abundant pharmacological activities, such as anti-hypertension, anti-diabetic, anti-cancer, anti-inflammatory, anti-aging, etc. This review studied the complete chloroplast genome of *Pogostemon*, distribution of *Pogostemon*, and pharmacological activity of *P. cablin*. Online literature searches were carried out to compile the article. The following search terms were used to find online publications: *Pogostemon*, distribution of *Pogostemon*, complete chloroplast genome of *Pogostemon*, and pharmacological activity of *P. cablin* plants in PubMed (Medline) and Web of Science. Additionally, several assessments of prior and present data from the *Pogostemon* and *P. cablin* research publication were included into one review.

Keywords: Complete chloroplast genome; Pharmacological activities; *Pogostemon*

Introduction

Pogostemon Desf. is the largest genus in the Pogostemoneae (Lamiaceae) tribe with over 80 species. This genus has been divided into three subgenera, which are subg. *Pogostemon*, subg. *Allopogostemon* Bhatti & Ingr., and subg. *Dysophyllus* Bhatti & Ingr., based on the most recent infrageneric classifications (Yao et al., 2015). The latter is composed of aquatic and marshland plants, while the former two (*Pogostemon* sensu stricto) are composed of terrestrial herbs and subshrubs (Zhang et al., 2020a). The genus is easily identified from other Lamiaceae genera by the presence of moniliform hairs in the midst of the staminal filaments. *Pogostemon* is found mostly in tropical and subtropical areas of Asia, although there are also several species in tropical Africa, Northern Australia, Japan, and the Korea Peninsula (Yao et al., 2016; Hu et al., 2021).

The chloroplast (cp) genomes have been called the ultra-barcode for phylogenomic studies (Bock et al., 2014; Gitzendanner et al., 2018; Zhang et al., 2017a) and species/cultivar identification (Zhang et al., 2019). The past ten years have seen remarkable advancements in high-throughput sequencing (HTS) technology, making it routine to get hundreds to thousands of organelle loci (Zimmer & Wen, 2015; McKain et al., 2018). Complete cp genome counts have skyrocketed in the last several years. For the genus *Pogostemon*, cp genome data are currently lacking. There are now just 24 publically published cp genome sequences from five *Pogostemon* species, with the most well researched being the genome of *P. cablin*.

In this article we will also discuss the potential pharmacological activity of one of the commercial species of the *Pogostemon* genus, *Pogostemon cablin*. In China, India, Indonesia, Malaysia, the Philippines, and Singapore, the species has been widely farmed (Zhang

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et al., 2019). Due to its fixative ability, which extends the longevity of other smells, patchouli oil is a crucial component in the perfume and cosmetics industries. *P. cablin* is one among the top 20 plants that produce essential oils, and it is thought to have enormous economic potential (Swamy & Sinniah, 2016). The multicomponent structure of patchouli has been demonstrated to promote a number of pharmacological effects, and it has been demonstrated to be anti-inflammatory (Jeong et al., 2013b), anti-microbial (Hussain et al., 2011b), anti-tumor (Jeong et al., 2013a), anti-aging (Feng et al., 2014), and anti-oxidant (Hussain et al., 2011a). Additionally, patchouli and its extracts have amazing beneficial effects that support the proper operation of tissues and organs. These findings include the prevention of atherosclerosis (Wang et al., 2016a), the suppression of adipogenesis and fat accumulation in adipocytes (Wu et al., 2019), the alleviation of ischemia/reperfusion-induced brain injury (Wei et al., 2018), and the protection against ulcers and *Helicobacter pylori* infection of the digestive tract (Yu et al., 2015; Zheng et al., 2014).

Method

The articles are sourced from Google Scholar, PubMed (Medline) and Web of Science, and other sources inside the Scopus database. The articles that were taken were published between 2013 and 2023, or the previous ten years. The terms distribution of *Pogostemon*, chloroplast genome of *Pogostemon*, pharmacological activity, and *Pogostemon cablin* are used in the article search. There were 68 related articles were found. Figure 1 depicts the flow that was employed during the implementation phase.

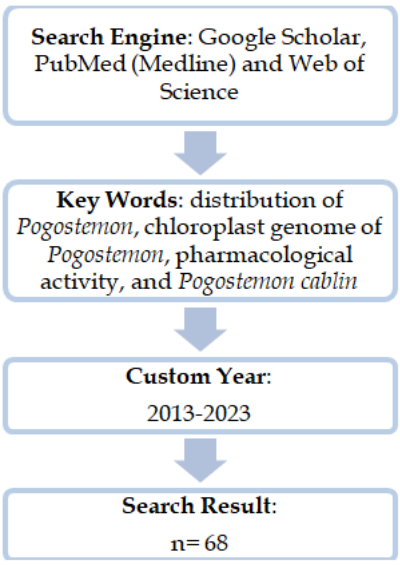

Figure 1. Systematic literature review conducting stage flow

As for the aim of this journal, first, we also describe the size of the chloroplast genome and the sequencing methods used in the *Pogostemon* species. Secondly, we want to describe the distribution of *Pogostemon* species which is expected to be useful as a reference. Third, we explain the pharmacological activity of one of the highly potential Pogostemon species, *Pogostemon cablin*.

Result and Discussion

Complete Chloroplast Genome of Pogostemon

Chloroplasts are metabolically active organelles that support life on Earth by using photosynthesis and the release of oxygen to convert solar energy into carbohydrates (Daniell et al., 2016b). In addition to absorption of nitrogen and sulfur, chloroplast also synthesize amino acids, nucleotides, fatty acids, produce phytohormones, certain vitamins, production of defense compounds, alternative splicing of the transcripts, a variety of secondary metabolites, that are essential for optimal plant development and physiology (Petrillo et al., 2014; Bobik & Burch-Smith, 2015; Toufexi et al., 2013).

Most important proteins that regulate photosynthesis and other metabolic processes are encoded by the chloroplast genome (Daniell et al., 2016b). Moreover, in terms of species identification, phylogenetic implications, and population genetic analysis, chloroplast genomes are particularly useful (Yang et al., 2013). It is always preferable to use the chloroplast genome analysis because it is haploid, inherited from the mother, and contains highly conserved genes in order to comprehend the evolution and phylogenetic link between various progeny (Khan et al., 2018). In addition, due to its singleparent (maternal) inheritance and recombination-free nature, chloroplast genomics has recently been discovered to be very promising and has been employed for phylogenetic investigations on a large scale (Liu et al., 2018). According to Zhang et al. (2017b), the study of plant chloroplast genetics has been extremely beneficial in understanding gene flow, cytoplasmic diversity, and population differentiation.

The plastid genome encodes ~80–100 proteins, all rRNAs, and ~30 of 64 tRNAs (Daniell et al., 2016b). It is separated into four main regions: two copies of an inverted repeat (IR), a small single-copy (SSC) area, and a large single-copy (LSC) region (Daniell et al., 2016a; Wambugu et al., 2015). The DNA sequences between IR areas in the same chloroplast genome are identical, with not a single nucleotide differing, among the 800 known chloroplast genomes (Daniell et al., 2016b). This is because the copy correction method makes sure that modifications made to one copy of the IR are replicated

in the other, however, little has been learned about this mechanism (Daniell et al., 2016a). Although the plastid genome is typically assumed to be circular, there is also evidence of linear plastid genomes. The proportion of circular vs linear genomes remains contentious (Oldenburg & Bendich, 2015), and further research is required to settle this issue.

Table 1. Complete Chloroplast Genome of *Pogostemon* Data Derived from the NCBI Database

Definition	Accession	Size (bp)	Sequencing Technology	Reference
Pogostemon septentrionalis chloroplast, complete genome	NC_065984.1	152,514	Illumina	Zhang et al., 2020a
Pogostemon plectranthoides chloroplast, complete genome	NC_065983.1	152,430	Illumina	Zhang et al., 2020a
Pogostemon septentrionalis chloroplast, complete genome	MK770349.1	152,514	Illumina	Zhang et al., 2020a
Pogostemon plectranthoides chloroplast, complete genome	MK770348.1	152,430	Illumina	Zhang et al., 2020a
Pogostemon cablin isolate Shipai chloroplast, complete genome	NC_042796.1	152,461	Illumina	Zhang et al., 2019
Pogostemon cablin isolate Shipai chloroplast, complete genome	MF287372.1	152,461	Illumina	Zhang et al., 2019
Pogostemon cablin isolate GY chloroplast, complete genome	MF445415.1	152,461	Illumina	Zhang et al., 2019
*Pogostemon cablin*isolate Hainan chloroplast, complete genome	MF287373.1	152,462	Illumina	Zhang et al., 2019
Pogostemon cablin isolate G8 chloroplast, complete genome	OP856515.1	152,464	Illumina	NA
Pogostemon cablin isolate G7 chloroplast, complete genome	OP856514.1	152,462	Illumina	NA
Pogostemon cablin isolate G6 chloroplast, complete genome	OP856513.1	152,464	Illumina	NA
Pogostemon cablin isolate G5 chloroplast, complete genome	OP856512.1	152,462	Illumina	NA
Pogostemon cablin isolate G4 chloroplast, complete genome	OP856511.1	152,461	Illumina	NA
Pogostemon cablin isolate G3 chloroplast, complete genome	OP856510.1	152,461	Illumina	NA
Pogostemon cablin isolate G2 chloroplast, complete genome	OP856509.1	152,464	Illumina	NA
Pogostemon cablin isolate G1 chloroplast, complete genome	OP856508.1	152,463	Illumina	NA
Pogostemon cablin isolate YN chloroplast, complete genome	MF445417.1	152,461	Illumina	NA
Pogostemon cablin isolate VT chloroplast, complete genome	MF445416.1	152,461	Illumina	NA
Pogostemon cablin isolate S1-5 ecotype shipai chloroplast, complete sequence, whole genome shotgun sequence	CM043014.1	152,461	PacBio Sequel	NA
UNVERIFIED: *Pogostemon cablin* chloroplast, sequence	KX230834.1	152,460	Illumina	He et al., 2016
Pogostemon stellatus isolate PDBK2014-1557 chloroplast, complete genome	NC_031434.1	151,824	Illumina	Yi & Kim, 2016
Pogostemon yatabeanus isolate PDBK2014-1822 chloroplast, complete genome	NC_031433.1	152,707	Illumina	Yi & Kim, 2016
Pogostemon stellatus isolate PDBK2014-1557 chloroplast, complete genome	KP718620.1	151,824	Illumina	Yi & Kim, 2016
Pogostemon yatabeanus isolate PDBK2014-1822 chloroplast, complete genome	KP718618.1	152,707	Illumina	Yi & Kim, 2016

*NA: Not Available

Distribution of Pogostemon

Pogostemon Desf. is the largest genus in Pogostemoneae, Lamioideae, and Lamiaceae (Zhao et al., 2021). *Pogostemon* is found mostly in tropical and subtropical areas of Asia, although there are also several species in tropical Africa, Northern Australia, Japan, and the Korea Peninsula (Yao et al., 2016; Hu et al., 2021). Five of these species are unique to Africa and the indian subcontinent has the largest species diversity within the genus (Yuan et al., 2022). According to Yao et al. (2015), there are 27 species of *Pogostemon* which are also distributed in China.

Table 2. Distribution of *Pogostemon*

Species	Distribution
Mnesithea veldkampii	India
Pogostemon amaranthoides	Assam, China South-Central, East Himalaya, Myanmar, Nepal, West Himalaya
Pogostemon andersonii	East Himalaya, Myanmar
Pogostemon aquaticus	Malawi, Mozambique, Tanzania, Zambia
Pogostemon atropurpureus	India
Pogostemon auricularius	Andaman Is., Assam, Bangladesh, Borneo, Cambodia, China South-Central, China Southeast, East Himalaya, Hainan, India, Jawa, Laos, Malaya, Maluku, Myanmar, Nepal, New Guinea, Nicobar Is., Philippines, Sri Lanka, Sulawesi, Sumatera, Taiwan, Thailand, Vietnam
Pogostemon barbatus	Cambodia, China Southeast, Hainan, Laos, Vietnam
Pogostemon benghalensis	Andaman Is., Assam, Bangladesh, East Himalaya, India, Myanmar, Nepal, Pakistan, Thailand, Vietnam, West Himalaya
Pogostemon brachystachyus	Assam, China South-Central, East Himalaya, Myanmar
Pogostemon cablin	Jawa, Lesser Sunda Is., Malaya, New Guinea, Philippines, Sri Lanka, Sulawesi, Sumatera, China Southeast, Fiji, Hainan, Samoa, Taiwan, Thailand, Tonga, Trinidad-Tobago, Vietnam
Pogostemon chinensis	Assam, China South-Central, China Southeast, Myanmar
Pogostemon crassicaulis	Assam, Bangladesh, East Himalaya, India, Myanmar, Nepal, Thailand, Vietnam, West Himalaya
Pogostemon cristatus	Lesser Sunda Is
Pogostemon cruciatus	Assam, Bangladesh, Cambodia, China South-Central, East Himalaya, India, Laos, Myanmar, Nepal, Thailand, Vietnam, West Himalaya
Pogostemon dasianus	Assam
Pogostemon deccanensis	India
Pogostemon dielsianus	China South-Central
Pogostemon elsholtzioides	Assam, East Himalaya, Tibet
Pogostemon erectus	India
Pogostemon falcatus	China South-Central
Pogostemon fauriei	Korea, Manchuria
Pogostemon formosanus	Taiwan
Pogostemon gardneri	India
Pogostemon glaber	Assam, Bangladesh, Cambodia, China South-Central, China Southeast, East Himalaya, Hainan, Laos, Myanmar, Nepal, Thailand, Vietnam
Pogostemon glabratus	Thailand
Pogostemon globulosus	Thailand, Vietnam
Pogostemon griffithii	Myanmar, Bangladesh
Pogostemon guamensis	Marianas
Pogostemon hainanensis	Hainan
Pogostemon hedgei	India
Pogostemon helferi	East Himalaya, India, Myanmar, Thailand
Pogostemon henanensis	China Southeast
Pogostemon heyneanus	Bangladesh, Borneo, India, Jawa, Lesser Sunda Is., Malaya, Myanmar, Philippines, Sri Lanka, Sumatera
Pogostemon hirsutus	Sri Lanka
Pogostemon hispidocalyx	China South-Central
Pogostemon hispidus	Assam, Bangladesh, Myanmar, Thailand
Pogostemon jaitapurensis	India
Pogostemon kachinensis	Myanmar
Pogostemon koehneanus	Thailand
Pogostemon latifolius	China South-Central
Pogostemon linearis	Assam, China South-Central, East Himalaya, Myanmar, Thailand
Pogostemon litigiosus	Vietnam
Pogostemon manipurensis	Assam
Pogostemon menthoides	Assam, Borneo, China South-Central, East Himalaya, Jawa, Lesser Sunda Is., Myanmar, Philippines, Thailand, Vietnam
Pogostemon micangensis	Angola, Cameroon, Gabon
Pogostemon mollis	India
Pogostemon monticola	Taiwan
Pogostemon mutamba	Angola
Pogostemon myosuroides	India
Pogostemon nelsonii	Vietnam

Species	Distribution
Pogostemon nilagiricus	India
Pogostemon nudus	Thailand
Pogostemon paludosus	India
Pogostemon paniculatus	Bangladesh, India, Myanmar, Thailand
Pogostemon parviflorus	Bangladesh, Cambodia, China South-Central, China Southeast, India, Myanmar, Vietnam
Pogostemon peethapushpum	India
Pogostemon peguanus	Cambodia, Myanmar, Thailand, Vietnam
Pogostemon pentagonus	China South-Central, India, Laos, Thailand, Vietnam
Pogostemon petelotii	Vietnam
Pogostemon petiolaris	India
Pogostemon philippinensis	Philippines
Pogostemon plectranthoides	Bangladesh, India
Pogostemon pressii	India
Pogostemon pubescens	India, Thailand
Pogostemon pumilus	Assam, Bangladesh, East Himalaya, Nepal, West Himalaya
Pogostemon purpurascens	Assam, India, West Himalaya
Pogostemon quadrifolius	Assam, Bangladesh, China South-Central, India, Myanmar
Pogostemon raghavendranii	India
Pogostemon rajendranii	India
Pogostemon reflexus	Sri Lanka
Pogostemon reticulates	Philippines, Sulawesi
Pogostemon rogersii	Angola, Malawi, Zambia
Pogostemon rotundatus	India
Pogostemon rugosus	India
Pogostemon rupestris	Sri Lanka
Pogostemon salicifolius	India
Pogostemon sampsonii	China Southeast, Hainan
Pogostemon septentrionalis	China Southeast
Pogostemon speciosus	India
Pogostemon stellatus	Assam, Bangladesh, Borneo, Cambodia, China South-Central, China Southeast, East Himalaya, Hainan, India, Japan, Korea, Laos, Malaya, Maluku, Myanmar, Nansei-shoto, Nepal, New Guinea, Northern Territory, Philippines, Queensland, Sri Lanka, Sulawesi, Sumatera, Taiwan, Thailand, Vietnam, Western Australia
Pogostemon stocksii	India
Pogostemon strigosus	Assam, Bangladesh, Myanmar
Pogostemon szemaoensis	China South-Central
Pogostemon tisserantii	Cameroon, Central African Repu, Chad
Pogostemon travancoricus	India
Pogostemon trinervis	Thailand
Pogostemon tuberculosus	East Himalaya, Nepal
Pogostemon velatus	Philippines
Pogostemon vestitus	India
Pogostemon villosus	Assam, Bangladesh, India, Sumatera
Pogostemon wattii	Assam
Pogostemon wightii	India
Pogostemon xanthiifolius	China South-Central
Pogostemon yatabeanus	Amur, China South-Central, China Southeast, Japan, Khabarovsk, Korea, Primorye

Pharmacological Activities of Pogostemon cablin, One of the Multifunctional Species of the Genus Pogostemon

Anti-Hypertensive Effect

Chronic and important factors like hypertension might cause premature death and worsen disability (Azam & Azizan, 2018). Hypertension is a disorder that affects more than one billion people globally and is responsible for 9.4 million annual fatalities. Agents that can lower systemic blood pressure significantly lower the risk of major cardiovascular disease-related events, such as stroke and coronary heart disease (Ettehad et al., 2016). Therefore, it is crucial to keep your blood pressure within normal bounds. Due to its function as a Ca^{2+} antagonist in an endothelium-independent mechanism, PA significantly increases the vasorelaxant effect. The underlying mechanisms involve the release of intracellular Ca^{2+} through the vascular smooth muscle cells' membrane and the blocking of extracellular Ca^{2+} infusion (Hu et al., 2018).

Antidiabetic Effect

As a major risk factor for several metabolic illnesses, obesity is strongly associated with the occurrence of type 2 diabetes. This is one of the elements that contribute to the metabolic syndrome; an environment that is made worse by a diet high in fat, a sedentary lifestyle, and maybe aging (Kim et al., 2012). High-fat diet (HFD)-induced obese mice showed a net reduction in body weight after receiving PA; PA inhibited obesity and fat accumulation in adipocytes via upregulating beta-catenin expression and activation (Lee et al., 2020b). Numerous additional disorders, including as nonalcoholic fatty liver disease (NAFLD), have also been linked to prolonged HFD consumption. NAFLD is the most prevalent chronic liver illness in the world right now (Younossi et al., 2016) and a key cause of liver disease that affects 30% of the US population. In the diagnosis of NAFLD, hepatomegaly and central obesity are common physical examination results, but there are no typical findings (Rinella, 2015). A study by Wu et al. (2019) examined the protective effects of PA when used to treat rats with HFD-induced hepatic steatosis, and these investigations found that PA was effective in reducing hepatic steatosis brought on by an HFD. By reducing endoplasmic reticulum stress signals and controlling the absorption, assembly, and secretion of very low-density lipoproteins, PA controlled this effect. The administration of PA is linked to the control of the expression of microsomal triglyceridetransfer protein, apolipoprotein B100, and the very low-density lipoprotein receptor, among other underlying mechanisms.

A recent study by Lee et al. (2020b) examined the potential benefits of PA in obesity-induced diabetes using an animal model. Glucose tolerance tests demonstrated that oral PA dosages might dramatically lower blood glucose in a mouse model of HFD-induced obesity. In vitro experiments conducted on differentiated C2C12 myocytes additionally revealed that PA markedly boosted the absorption of glucose and elevated the 5′ phosphorylation of protein kinase B and adenosine monophosphate-activated protein kinase.

Anticancer Effect

After heart attacks, cancer is the second greatest cause of death worldwide (Nagai & Kim, 2017). Around the world, 90.5 million individuals received a cancer diagnosis in 2015. In 2019, there were 10 million deaths caused by cancer globally and 23.6 million new cases of the disease annually, up 26 and 21% over the previous ten years, respectively (Fendt et al., 2020). Among the least researched herbs, *Pogostemon cablin* has a variety of biological functions that enhance physiological balance, including its curative role in endometrial (Tsai et al., 2015), colorectal (Chien et al., 2020), blood (Chien et al., 2021), prostate (Cai et al., 2022), ovarian (Homayoun et al., 2022), liver (Rezazadeh et al., 2022), skin (Chang et al., 2023), lung (Liang et al., 2023), and nasopharing cancer (Syahraini et al., 2023).

A recent study by Syahraini et al. (2023) examined the possible bioactive chemicals in *P. cablin* that could serve as BCL-2 protein inhibitors that prevent apoptosis using in-silico analysis. This study showed that *P. cablin*, primarily through rhamnetin and apigenin, has remarkable potency as an alternative or supplementary therapy against radiation and chemotherapy resistance of NPC. In another recent study by Liang et al. (2023) examined the effect of PA on VCR and A549-resistant NSCLC A549/V16 cells by inducing DNA damage mediated by reactive oxygen species (ROS) was described. The CHK1 and CHK2 signaling pathways were activated in PA-treated cells due to an increase in intracellular ROS levels. Through its regulation of p53/p21 and CDK2/cyclin E1 expression, PA further reduced proliferation and colonyforming ability and produced cell cycle arrest at the G0/G1 phase. Furthermore, by initiating the Bax/caspase-9/caspase-3 intrinsic pathway, PA promoted apoptosis and raised the proportion of cells in the subG1 phase. Furthermore, following PA treatment, there was a downregulation of the markers for cancer stem cells (CD44 and CD133) and drug resistance (p-glycoprotein). Additionally, A549 and A549/V16 cells showed synergistic inhibitory effect when PA and cisplatin were combined.

Anti-Inflammatory Effect

The essential oil that *P. cablin* produces is regarded as the most significant bioactive material since it contains a variety of hydrocarbons and sesquiterpenes, including β-patchoulene (β-PAE), pogostone, and patchouli alcohol, to provide a variety of characteristics. One of patchouli oil's most notable biological qualities is its anti-inflammatory action (Zhang et al., 2016). Redness, swelling, heat, and discomfort at one or more infected areas are signs of infammation, which is a major defense mechanism against encroaching pathogens. Numerous studies have demonstrated the role of inflammation within the cause of numerous illnesses, including as aging, cancer, heart failure, and other serious and incapacitating conditions (Mansouri et al., 2015). Circulating pro-inflammatory mediators, such as IL-6, IL-1, TNF-, nitric oxide (NO), and PGE2, among others, mediate these reactions (Freire & Dyke, 2013). Agents that can control inflammation by producing and releasing pro-inflammatory mediators are therefore extremely important as a way to manage this reaction. Lipopolysaccharide (LPS), a crucial part of Gram-negative bacteria, mediates inflammation brought on by

reactions from macrophages (Kobayashi et al., 2016). By having the ability to keep the balance between the production of pro- and anti-inflammatory cytokines, β-PAE has a significant anti-inflammatory effect on LPS-stimulated RAW 264.7 macrophages (Yang et al., 2017).

A recent study by Wu et al. (2020) investigated PA's potential as a treatment for intestinal barrier damage and inflammation. First, TNBS-induced UC, or chemically induced colitis, demonstrated its curative effect on UC. Next, DSS-induced UC, or the acute attack stage of UC, which is where the clinical course of UC in humans typically occurs, was used to examine its efficacy against UC. TNF-α, IFN-γ, IL-1β, IL-6, and IL-17 are among the blood levels that P.A. lowers. It also lowers the mRNA expression of pro-inflammatory cytokines, such as iNOS, COX-2, TNF-α, IL-1β, and IL-6. In both animal models, PA concurrently increased the expression of mucin-1 and mucin-2 mRNA and tight junction proteins (such as ZO-1, ZO2, claudin-1, and occludin).

Furthermore, PA enhanced clinical parameters and histological damage. Accordingly, in both colitis models, PA may protect the integrity of the intestinal epithelial barrier, greatly lower the expression of pro-inflammatory cytokines, and improve the macroscopic colonic lesions. Another recent study found that in both in vitro and in vivo settings, PA functions as a pregnancy X receptor (PXR) agonist and reduces the inflammatory response by PXR-mediated inhibition of the NF-κB pathway (Zhang et al., 2020b). The liver and intestinal epithelium both have high expression levels of PXR, which controls the transcription of genes related to the xenobiotic transport and detoxification pathway. Pro-inflammatory cytokines are produced as a result of NF-kB activation, which PXR can block (Lee et al., 2020a).

Anti-Aging

The natural and unavoidable process of aging is defined by a steady decline in physiological processes, which makes a person more susceptible to long-term illnesses and eventually passes away. A variety of age-related illnesses, including cancer, heart disease, metabolic disorders, liver, renal, and neurological diseases, as well as inflammatory and autoimmune diseases, dysbiosis, frequently come with aging (Song & Zhang, 2023). Apart from the internal effects of aging, skin aging has also caused many problems for individuals. Research has shown a correlation between cellular stress response, energy metabolism, stem cell failure, and skin aging. Therefore, many people are dedicated to finding ways to slow down the aging process to improve skin aging (Wu & Pan, 2022). According to earlier research, phydroxyphenylethanol, flavonoids, and natural triterpenoids all reduce the effects of aging. Triterpenoids and phenylethanol have an anti-aging impact because of their actions on anti-aging proteins and a number of longevity genes (Cañuelo et al., 2016; Staats et al., 2019; Bahrami & Bakhtiari, 2016).

In recent years, *Pogostemon cablin* has been tested in several studies related to aging, such as skin aging (Lin et al., 2014; Wang et al., 2016b; Ande & Bakal, 2022; Wu & Pan, 2022), Alzheimer's disease (Banerjee & Satish, 2022), and cartilage aging (Chen et al., 2022). Wu et al. (2022) have conducted research based on network pharmacology and molecular docking. Following the screening, 112 intersection targets between *Pogostemon cablin* and active chemicals associated with skin aging were identified. According to the molecular docking results, TP53, JUN, HSP90AAL, AKT1, and MAPK1 were linked to quercetin, apigenin, irisnepalensis isoflavone, 3,23-dihydroxy12-oleorene-28-oleic acid, 5-hydroxy-7,4'- dimethoxyflavone, and other significant compounds via hydrogen bonds with a high binding energy. Wang et al. (2016b) reported that pogostone pretreatment evidently inhibited the abnormal expression of MMP-1 and MMP-3. MMP induction, particularly MMP-1 and MMP-3, is thought to be intimately linked to the premature aging of mice's skin caused by UV exposure. Apart from that, Lin et al. (2014) showed that PO helps to prevent photoaging and is able to preserve the integrity of the skin's structure after being exposed to UV radiation.

Banerjee et al. (2022) assessed the therapeutic potential of *Pogostemon cablin* essential oil against Alzheimer's disease in mice that was experimentally produced using Passive shock avoidance paradigm (PSAP) and Morris water maze (MWM). This was followed by an assessment of the enzyme's inhibitory qualities by measuring the amount of brain acetyl cholinesterase activity. The result was confirmed *Pogostemon cablin* essential oil has been shown to have a dose-dependent protective effect against Alzheimer's disease caused by scopolamine. Another study by Chen et al.(2022), In a model of aging mice induced by D-gal, PA therapy could reduce the degeneration of cartilage extracellular matrix (ECM). Additional examination using western blot and immunofluorescent labeling demonstrated that PA prevented D-gal-induced chondrocyte senescence via triggering the antioxidative system. The results showed that PA was a viable option for stopping the oxidative stress-mediated senescence in chondrocytes, which in turn prevents the quality loss of aged cartilage.

Conclusion

The chloroplast genome from *Pogostemon* ranged from 151,824 to 152,707 bp in length and comprise 114 genes including 80 protein coding genes, 30 tRNA genes, and four rRNA genes. *Pogostemon* is found mostly in tropical and subtropical areas of Asia. *P. cablin* as one of the commercial species of the genus *Pogostemon* has various abundant pharmacological activities, such as anti-hypertension, anti-diabetic, anti-cancer, anti-inflammatory, and anti-aging.

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Author Contributions
Cut Nathasya Fahira conceptualized the research idea, designed of methodology, management and coordination responsibility; Essy Harnelly analyzed data, conducted a research and investigation process; Zumaidar conducted literature review and provided critical feedback on the manuscript.

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Conflicts of Interest
The author declared no conflict of interest.

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