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Overview of Phytochemical Compounds and Pharmacological Activities of Ananas Comosus L. Merr

Hartati R, Suarantika F, Fidrianny I*

Department of Pharmaceutical Biology, School of Pharmacy, Bandung Institute of Technology, Bandung-40132, Indonesia, Fax: +62-222504852

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Abstract

Ananas comosus L. Merr, known as pineapple, belongs to the Bromeliaceae family. This plant has been used as traditional medicine and continues until now in conventional herbal medicine. The pineapple was distributed in some countries such as China, India, Indonesia, Malaysia, Thailand and originated from South America. This article delved the scientific work about Ananas comosus focussing their usage as traditional medicine, chemical compounds and biological activities. All of the pieces of information were obtained from the scientific literature such as Science Direct, Google Scholar, Scopus and PubMed. Based on the literature survey,different parts of pineapple (Ananas comosus) are used in traditional medicine, used asan anti-inflammatory agent,anti-oedema, digestive disorder, antimicrobial, vermicide, and purgative. Phytochemical compounds from A. comosus have been provided, including ascorbic acid, quercetin, flavones-3-ol, flavones, and ferulic acid. The crude extracts of A. comosus have many pharmacological activities such as antifungal, anti-inflammatory, antioxidant, antibacterial. This discovery becomes possible due to scientific isolation and in vivo or in vitro analysis of A.comosus.

*Corresponding Author

Name: Fidrianny I
Phone: +62-222504852
Email: irdafidrianny@gmail.com

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INTRODUCTION

Ananas comosus(pineapple) belongs to subfamily Bromeliodeae and family Bromeliaceae. Bromeliaceae contained around 2794 species and 56 genera. A. comosus has synonym name, Bromelia comosa, Bromelia ananas, Ananas sativus, Ananassa Sativa (Mondal *et al.*, 2011). This plant originated in Latin America, definitely from Amazon river at the north region, A. comosus is now grown widely, in tropical and subtropical regions, this plant became the third commercial tropical fruit in the world and fourth most cultivated fruit crop. According to many researchers, A. comosus was released to various regions of the world through historians and travellers, mainly the Portuguese and Spanish who disseminated information regarding A. comosus. Mutations in A. comosus such as size, seedless, enhancement sweetness, juiciness and the improved flavour was developed since their founding.This plant has been utilised as a traditional medicine in many countries, and native civilisation (Mondal *et al.*, 2011) and this medicinal of A. comosusare related to bromelain, it is a group proteolytic enzymes. It has been presented to have several biological activities such as antithrombotic, anti edematous, anti-inflammatory and fibrinolytic activities in vitro and in vivo.Even though being used as traditional medicine and there was important information about A. comosus but for research developments still required more information about

this plant. This review verified the use of A. comosusin traditional medicine, pharmacology activities and explored on phytochemical compounds.

MATERIALS AND METHODS

Data and information in this article were collected from scientific literature databases such as Science Direct, Google Scholar, Scopus and PubMed.

RESULTS AND DISCUSSION

Botanical Aspect

In the worldwide pineapple in tropical regions have around 30 cultivars of which are cultivated in distinct environmental areas.Based on leaves and fruit characterisation A. comosus cultivars are categorised into five classes, named as "Red Spanish", "Pernambuco" (Abacaxi), "Queen", "Smooth Cayenne", and "Perolera" or "Motilona". Adult plants of the cultivar "Queen" and "Smooth Cayenne" respectively are up to 1 m and 1.5 m high, and had 0.5 m, 1 m wide (Guang *et al.*, 2016) . Generally in appearance, A. comosus has a spiral morphology due to the arrangement of the leaves, waxy leaves, short and sturdy stem. When preparing its fruit, it usually produces up to 200 flowers, and after that individual fruits of the flowers join together to create a pineapple. When the first fruit is produced, suckers are formed in the leaves axils of the main stem. After a year of growth, the axis lengthens and thickens, and the stem grows into a spike-like inflorescence up to 15 cm long. Flower colours depending on variety, from lavender through light purple to red, formed on an inflorescence at the apex of the stem. A. comosus can grow around at a temperature of 18–32 °C, most productive under dry environments, as it can be planted in the soil that does not require a lot of water, it requires as much as 5 cm^3 water per month from irrigation or rain, during autumn and spring an average rainfall is of 115 cm^3. Most pineapples are cultivated on hillsides, and it thrives well when grown on a north-easterly aspect where they receive the maximum amount of sunlight and warmth. A. comosus require sandy soils with high organic matter and having a pH range from 4.5 to 6.5, with good water drainage makes soil perfect for A. comosus production, therefore provide good water drainage system. Around 18 to 24 months period is usually required from growing to harvest. A. comosus can be harvested throughout the year during flowering (Morton and Dowling, 2013)

Traditional Uses

Ananas comosus L. Merr. ItIs the most edible member of the family Bromeliaceae, this plant is used in folk remedies for a digestive disorder, and it's diuretic property also it has been reported to act as an abortifacient. However, no scientific evidence supported the efficacy of A. comosus in inducing abortion (Yabesh *et al.*, 2014). A. comosus is usually used as food and juice of ripe fruit assumed can be used as antiscorbuticand diaphoresis (Kalaiselvi *et al.*, 2012). The root and fruit either eaten or utilised topically were used as an anti-inflammatory and as a proteolytic agent. In the Philippine, this plant traditionally was utilised as antihelminthic, and a decoction of A. comosus root used to treat diarrhoea. The fruit had the potential in promoting digestion as well as treating throat problems and its activityto prevent heart disease. It was also used as a natural diuretic in bronchial tissues to clear mucus (Hossain and Rahman, 2011). In China, cortex of A. comosus potential as antidiarrheal agents, alexipharmic and antitussive; and leaves of A. comosus were usually applied as an antidyspepsia or antidiarrheal agent in Chinese Traditional Medicine.A. comosus is one of the tropical fruits in Indonesia and known as nanas among Indonesian, which used to treat cough, maintain blood pressure and boost immunity. Subang, Bogor, Riau, Palembang and Blitar, the primary producer in Indonesia, is supplying A. comosus. The usage of A. comosus as traditional medicine will be presented in Table 1.

Phytochemical Compounds

Phytochemicals are naturally occurring in plants part such as leaves, fruit, roots, bark, peel, flowers, a stem that have defence mechanism and protect from various diseases. Phytochemicals compounds are primary metabolites such as proteins and carbohydrateand secondary metabolites such as alkaloid, flavonoids, phenolic compound, saponin, steroid and terpenoid (Kalaiselvi *et al.*, 2012). A phytochemical constituent from a crude extract of leaves, stem and fruit of A. comosus showed the presence of such as terpenoids, flavonoids, amino acid, protein, cardiac glycosides, phytosterols, carbohydrate, alkaloids, and saponins. Fresh pineapple fruit contained many fibre, carbohydrate and some minerals especially calcium, potassium,phosphorus, iron and sodium, also included copper, its contribution in the absorption of iron, regulates blood pressure and heart rate. It also contained some vitamins including ascorbic acid, folic acid, pyridoxine, pantothenic acid, niacin, riboflavin, thiamine, and retinol.The antioxidant activities related to the plants genetic and environmental factors, and the nutritional level is affected by diverse factors such as maturity stage, climatic, handling, varieties, and soil. Previous studies also said that A. comosus had the potential to be

Table 1: Traditional uses of Ananas comosus L. Merr.

A. comosus Plant Part	Traditional Uses	References
Peel	Antirheumatic activity, antioxidative, antibacterial	(Putri *et al.*, 2018)
Fruit	Fermented fruit in therapeutic for cancer, fruit residue as nutraceutical against diabetes, reduce pain after surgery and sport injuries	(Riya *et al.*, 2014)
Leaves	Antidiabetic activity, leaves juice as purgative, emmenogogue, and vermifuge	(Kalpana *et al.*, 2014)

Table 2: Volatile components found in A. comosus

Volatile components	Odour description	References
Methyl-3-(methylthio) propanoate*	Pineapple-like	(Teai *et al.*, 2001)
Ethyl-2methylbutanoate*		(Teai *et al.*, 2001)
Ethyl acetate*		(Umano *et al.*, 1992)
Ethyl-3-(methylthio) propanoate	Fruity, pineapple-like	(Teai *et al.*, 2001)
2,5-dimethyl-4-hydroxy 3-(2H) furanone	Burnt pineapple	(Umano *et al.*, 1992)
Butane 2, 3 diol diacetate	Honey-like	(Umano *et al.*, 1992)

Table 3: Pharmacological activities of Ananas comosus L. Merr.

Sample of Ananas comosus	Pharmacological Activities	References
Methanolic fruit peel extract	Antirheumatoid, antioxidant and antibacterial activities	(Poadang *et al.*, 2017)
Fermented fruitextracts	Candidate in therapeutic approaches for cancer	(Rashad *et al.*, 2015)
Leaves extract	Antidiabetic activity using streptozotocin (STZ) induced diabetic rat method	(Kalpana *et al.*, 2014)
Fruit residue	Nutraceutical for diabetes and related problems	(Romelle *et al.*, 2016)
Ethyl acetate fraction fruit	Tocolytic activity on rat and human arteri	(Monji *et al.*, 2018)

a good source of antioxidant, because in this plant presence of flavonoids, ascorbic acid and phenolic compounds (Hossain and Rahman, 2011), flavones-3-ol,quercetin, flavones (Mhatre *et al.*, 2009), ferulic acid and p-coumaric acid. Both A. comosus rind and core presented β-carotene and L-ascorbic acid, but lutein and α-carotene were found only in A. comosus rind (Freitas *et al.*, 2015). In dry methanol peel extract of A. comosus had major polyphenolic compounds were catechin, epicatechin, gallic acid and ferulic acid. Based on previous research, individual phenolics in A. comosuswere myricetin,p-hydroxybenzoic acid, p-hydroxybenzoic aldehyde, syringic acid, tannic acid, sinapic acid, caffeic acid, salicylic acid and trans-cinnamic acid. Distinct and pleasant flavour make A. comosusas popular fruit because there are volatile components. More than 280 compounds have been found among the volatiles of A. comosus.

Volatile compounds in A. comosuswill be expressed in Table 2. The sugar in A. comosus such asglucose, sucrose, and fructose. The primary non-volatile organic acids at this plant were malic and citric.Stem and full-grown fruit contained proteolytic enzyme,

bromelain, which belongs to the group of endopeptidases, also in this plant there was melaton in as well. The amount of bromelain found in fruit A. comosus much less than in the stem, and the highest was seen at the top of the fruit but fruit bromelain had high proteolytic activity compared to stem bromelain. Bromelain activity showed higher during fruit development than the ripening stage parallel with the total protein content. The enzymatic action of these enzymes in the range of pH 5.5-8. Another enzyme was polyphenol oxidase (PPO), at harvest time, its activity was usually low, and the activity will be higher after inducing by chilling stress. PPO activity varied among distinct parts of the collected fruit. The skin and crown leaves gave higher levels thanthe pulp of the fruit. Bromelain was a mixture of diverse thiol endopeptidases, cellulases, glycoproteins, carbohydrates, phosphatases, glucosidase, peroxidases and few protease inhibitors (Difonzo *et al.*, 2019).

Pharmacological Activities

The previous studydemonstrated that A. comosus extracts contained phenolics and flavonoids compounds which can act as an antioxidant (Bamidele and Fasogbon, 2017), antibacterial (Dutta and Bhattacharyya, 2013), and anti-inflammatory. General pharmacological uses for A. comosus as can be seen inTable 3.

Antimicrobial and Nontoxic Activities

The water extract of the crown leaves of A. comosusex pressed nuclease, peroxidase along with considerable antibacterial, gelatinolytic, collagenase, nonspecific proteolytic, anti-fungal, acid and alkaline phosphatase, and fibrinolyticactivities. Leaves extract A. comosus actas antibacterial withminimum inhibitory concentration (MIC) varied from 1.65 to 4.95 mg/ml against Bacillus subtilis, Candida albicans, Escherichia coli and Staphylococcus aureus (Dutta and Bhattacharyya, 2013). Based on previous research, it was supposed that bromelain and saponin were important components against Gram-negative, meanwhile flavonoids and polyphenols potent to inhibit Gram-positive bacteria, which work in the peptidoglycan layer. Bromelain was predicted causing injury and cell death by inducing protein breakdown in the bacterial membrane, while saponin worked by increasing permeability of the membrane of a bacterial cell and quickly enter the cell, after that influence the cell metabolism and denatures proteins on the cell membrane. Therefore, lysis will occur in the cell membrane. Pineapple extract at a concentration of 0.2 g/mleliminated non-Multidrug Resistant Pseudomonas aeruginosa, exhibited antibacterial activity against Streptococcus pneumoniae and Staphylococcus aureus. The chloroform and acetone extract of A. comosusgaveantimicrobial activity against Candida albicans, candida tropicalis, Candida glabrata, Cryptococcus luteolus and candida rubrum.Acute toxicity testing indicated thatleaves extract upto 5000 mg/kg in rats by oral administration did not present death or toxicity. Thereforeit can be concluded that nontoxicextract (Ajibade *et al.*, 2015).

Antioxidant Activities

Previous researchesexpressed that antioxidant activity may be related to anthocyanins, catechins,isoflavones, flavones, and other phenolics compounds (Mhatre *et al.*, 2009). The antioxidant activity was produced by different mechanisms which were free radical scavenging, catalase activity increase, oxidative enzymes inhibition and metal chelation. Based on (Mhatre *et al.*, 2009), the methanol extracts of A. comosusex pressed the highest antioxidant activity in DPPH assay (1933.0 $\pm$ 9.1% equivalent of ascorbic acid). Previous research statedthat combination of bromelain and antibiotic therapy gave more effective in cutaneous Staphylococcus infection, pneumonia, bronchitis, thrombophlebitis, pyelonephritis, cellulitis in perirectal and rectal abscesses, urinary tract infections and sinusitis. Bromelain, trypsin, rutin and antibiotics in combination had been given as adjuvant therapy for children with sepsis. Also, combination bromelain, ox bile, and pancreatin were sufficient to reduce faeces fat excretion in a patient with pancreatic steatorrhea, improvement in pain, flatulence and faeces frequency (Pellicano *et al.*, 2009).

Anticancer Activities

The ethanolic peel extract of A. comosus (250 mg/kg body weight) for 30 days orally had activities to lower lipid peroxidation, and tumour weight in breast tissue expressed near to normal levels. Based on the experiments, it can be predicted that A comosus had anti-breast cancer potential. Bromelain can inhibit nuclear factor-KB (NF-KB) translocation via G2/M arrest to apoptosis in human epidermoid carcinoma and melanoma cells. Bromelain exposed to selectively induce apoptosis in tumour cells by upregulation of p53 expression and initiation of the mitochondrial apoptotic pathway by increasing Bax expression and cytochrome c release. Also, bromelain work significantly decreased the evolution of gastric carcinoma Kato-III cell lines Báez *et al.* (2007)

Anti-Inflammatory Activities

A. cosmoses extracted exhibited anti-inflammatory

activity in the gastrointestinal tract and had good influence to treat ulcerous colitis and Crohn's disease. The research revealed that pineapple peel extract had protective effects on brain tissue to prohibit an alcohol-induced change in phospholipids and lipid peroxidation (Erukainure *et al.*, 2011). Fruit of A. comosus had an impact on inhibition and augmentation of uterine contractility with an objective mechanism in a 5-HT pathway. Bromelain asanti-inflammatory activity works in a way downregulates COX-2 and PGE-2 expression levels in murine microglial cells and human monocytic leukaemia cell lines. In mouse macrophage and human peripheral blood mononuclear cells (PBMC), bromelainactivated the inflammatory mediators, including interleukin (IL), -1β, IL-6, interferon (INF)-γ and tumour necrosis factor (TNF)-α.

Furthermore, in patients with osteomyelo fibrosis and rheumatoid arthritis, bromelain modulated the expression of transforming growth factor (TGF)-β, which is a primary regulator of inflammation. When bromelain was given to the murine model of acute asthma, this enzyme worked to decrease airway reactivity and sensitivity to irritants, reduced markers of lung inflammation and moderated aspects of local airway immunity.In a rheumatoid arthritis rat model, a combination of bromelain and cyclosporine could reduce inflammation and arthritis (Secor *et al.*, 2008).

Cardioprotective Activities

The water-ethanolic extracts of various parts of A. comosus had cardio protective effects by reducing triglycerides, cholesterol, LDL, and VLDL levels, as well as as partate transaminase and alanine transaminase levels, also increasing in HDL levels. In vitro and in vivo experimentshowed that bromelain could minimise the severity of angina pectoris, transient ischemic attacks and prevented aggregation of human blood platelets and minimised the symptoms in hypertensive patients. Previous research stated that bromelain could decrease the damage of apoptosis and endothelial cell in hepatic ischemia. Bromelain had a potent fibrinolytic activity. It dissolved arteriosclerotic plaque in rabbit aortawith effect by breaking down cholesterol plaques.A. comosus had potent antioxidant and bromelain activity, and it could preserve cell membrane integrity and remedy cardiac systolic/diastolic dysfunction induced by isoproterenol in rats (Saxena and Panjwani, 2014).

Antimalaria Activities

It had been revealed that the unripe of Ananas comosus could be applied for malaria treatment in Okeigbo - Southwest Nigeria (Odugbemi *et al.*, 2008).

Hypolipidemic Activities

Ethanolic leaves extract of Ananas comosus had a hypolipidemic effect, that related to inhibiting HMG CoA reductase and from there selectively increased plasma lipoprotein lipase activity (Xie *et al.*, 2007).

Anthelminthic Activities

Leaves of A. comosus has been traditionally applied as oral anthelminthic medicine in North-East India. Anthelmintic activity of A. comosus leaves extract was investigated using adult Indian earthworms (Pheretima Posthuma) and exposed that there was dose-dependent increase with the time taken paralysis and time taken for death as parameters (Kataki, 2010). In vitro evidence showed that bromelain used as antihelmintic activities against the gastrointestinal nematodes, Trichuris muris and Heligmosomoides polygyrus.

CONCLUSIONS

This literature review aimed to report traditional uses, chemical compounds and pharmacological activities of the Ananas comosus L. Merr. This plant is a tropical fruit, that is consumed as fruit, food and traditional medicine. Based on research, there are such a lot of phytochemical compounds in Ananas comosus L. Merr, such as flavonoids, ascorbic acid and phenolic compounds.Most of the studies in pharmacological activities of A. comosus were limited to in vitro experiment.

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Conflict of Interest

Authors declare no conflict of interest.

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