Review Paper:

**Beneficial Impacts and Phytocomponents of Cinnamomum in Indonesia: A Review**

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**Abstract**

Cinnamon, Lauraceae family, is believed to be the world's good spice. Cinnamon is widely developed in Indonesia and is utilized as a spice in the kitchen and as a medicine. In Indonesia itself, the mention of the cinnamon plant can be different in various regions. Cinnamon can produce bark, bark essential oil, cinnamon oleoresin, bark powder and leaf essential oil. Cinnamon can give food taste and aroma. Cinnamon is a great source of micronutrients and macronutrients.

Cinnamon can be an important source of energy, carbohydrates, vitamins and minerals. Cinnamon is a great spice for human health and nutrition, because cinnamon has various active phytochemical compounds that play an important role in pharmacological activity.

**Keywords:** Cinnamon, medicine, food security, phytochemistry, nutrients, pharmacology

**Introduction**

Indonesia is the largest archipelagic country with tropical landscapes. Parts of Indonesia consist of seasonal forests, tropical forests, mountainous vegetation, shrubs and coastal plants. Indonesia has been declared a country with the second-largest biodiversity in the world after Brazil. There are around 40,000 species of endemic plants in Indonesia of which 6,000 are medicinal plants55,77,78. With that, many Indonesians use medicinal plants to treat diseases51, one of which is cinnamon66.

Cinnamon is classified as the genus Cinnamomum and family Lauraceae, which was first classified in 176059. Cinnamomum is a popular genus among in the Lauraceae family, in addition to the genus Persea and Laurus89. Cinnamon is widely developed in Indonesia and is utilized as a spice in the kitchen. The mainly developed cinnamon plant in Indonesia is *C. burmannii* B. with production areas in West Sumatra and Jambi. The product is known as cassia-vera or Korinjii cassia51.

In addition, there is *C. zeylanicum* Nees, known as Ceylon cinnamon because it is mostly produced in Sri Lanka and its product is known as cinnamon64. This type of cinnamon is also found in Java. Apart from these two types, there is also another type of *C. cassia*, which is found in China6.

Cinnamon bark can be used directly in its original form or powder, essential oil and oleoresin. Cinnamon oil can be obtained from the branches, bark, twigs and leaves by distillation while the oleoresin can be obtained by extracting cinnamon bark with organic solvents90.

Meanwhile, *C. cassia* is mainly produced in Indonesia and has a stronger aroma and taste between the two varieties. This cheaper variety is what we usually buy in markets as a type of seasoning51. Cinnamon is useful for treating various digestive tract disorders such as dyspepsia, flatulence, diarrhea and as an appetite enhancer89. The content of biologically active compounds found in cinnamon includes tannins, flavonoids, saponins, eugenols and essential oils. These compounds are believed to have antimicrobial140, antidiabetic52, antiinflammatory15 and anticancer activities4.

**Taxonomy**

Kingdom: Plantae
Division: Magnoliophyta
Class: Magnoliopsida
Order: Laurales
Family: Lauraceae
Genus: Cinnamomum
Species: *C. Burmannii, C. Zeylanicum, C. cassia*

**Origin Names**

In Indonesia, the cinnamon plant is named differently in various regions. In Sumatra, the cinnamon plant is better known as *holim, holim manis, modang siak-siak* (Batak language). In Minangkabau, it is known as *madang kult manih*, in Javanesse it is known as *huru mentek*, while in Sundanese it is better known as *kiamis*, in Madura, it is called *kanyenggar*, in Bali it is *cingar*, in Sumba it is known as *kaninggu* and in Flores it is known as *paundinga*90.

**Plant Description**

The cinnamon is about 8 meters to 10 meters high. Cinnamon sticks have an upright and woody shape, branched, rather heavy, dense, have a fine structure and fiber. The part that is most often used and utilized is the inside of the cinnamon bark.
The branches and twigs of the cinnamon plant contain a lot of essential oil which can usually be used as an export commodity to other countries. The leaves are oval and also tapered slightly to the edge with about 3 to 5 leaf bones. The petiole is 0.5 - 1.5 cm long with 3 leaf bones that grow curved. The leaves are reddish when they are young and turned to dark green as they get older.

In old leaves, the bones will come out pale and the underside is white. It has small flowers that smell quite foul and the stalks on subsequent flowers are white. It has eggs-like fruit and large petals. The flowers are androgynous or perfect flowers with yellow color and are small in size. There are 6 flower petals in two arrangements. This flower is not a flower. Insects play a role in the persistence of flowers. The flower petals in two arrangements. This flower is not a flower. Insects play a role in the persistence of flowers. The fruit is one seed and is swollen and has an elongated round shape. The color of the fruit is purple and green with a diameter 0.36 - 0.77 cm and length 1.32 - 1.64 cm. The seed’s length is 0.85-1.31 cm with a diameter of 0.58-0.67 cm. The morphology of cinnamon can be seen in figure 1.

**Geographical Distribution**

In Indonesia, *C. burmannii* cinnamon is found in West Sumatra, North Sumatra, Jambi, Bengkulu, West Java, Tengah Java, East Java and Maluku. Meanwhile, *C. cassia* is found in Kebumen, Baturaden and Purwokerto areas. This type of cinnamon has also been extensively grown in China. *C. cullilawan* and *C. Zeylanicum* are found on Seram Island, Ambon and Papua. This type of cinnamon is found on Ceylon Island (Sri Lanka). To date, Sri Lanka has the largest cinnamon cultivation in the world followed by Seychelles and the Republic of Malagasy.

**Medicinal Use**

The first benefit of free cinnamon is its ability to ward off radicals. Cinnamon has strong antioxidants like polyphenols. Antioxidants act to defend against free radical damage. Because of its strong antioxidant content, cinnamon can also be utilized as a safe food preservative and help overcome infection. The next health benefit of cinnamon is to help the body fight infection and repair damaged tissue. A study showed that the antioxidant content in it has strong anti-inflammatory properties. Ultimately, this spice can help to reduce the severity of disease.

Cinnamon has been known to avoid the danger of heart disorders, one of the most frequent causes of fatality in the world. A patient had diabetes, after drinking half a teaspoon of cinnamon every day, it showed a good effect, which was reducing levels of low-density lipoprotein (LDL), while increasing high-density lipoprotein (HD). Cinnamon can increase insulin sensitivity.

Insulin is one of the main hormones that guides metabolism and energy. This hormone is important to transport sugar from the bloodstream to body cells. Some human are immune to the influences of insulin, a condition regarded as insulin reaction. This condition is commonly seen in someone with metabolic syndrome and diabetes. Cinnamon can weaken insulin resistance, thereby supports this hormone to do its activities. Increased insulin sensitivity would decrease the amount of blood sugar. Cinnamon has a strong antidiabetic effect that has a good effect on insulin reaction.

First, cinnamon is known to reduce the levels of glucose that goes down into the bloodstream when eating. It is made by disrupting the digestive system, thereby freeing the digestive system. Second, the compounds in cinnamon can act on cells with insulin, where it increases the consumption of glucose by cells. Nevertheless, it is not working faster than insulin. Cinnamon can reduce neurodegenerative diseases.
Neurodegenerative disorders are perverted by the progressive structure of the arrangement or duty of brain cells. Parkinson’s and Alzheimer’s are widely known diseases. The compounds isolated from cinnamon preclude protein construct in the brain, which is a characteristic of Alzheimer’s illness\textsuperscript{32}. Meanwhile, in a research conducted on rats with Parkinson’s, the benefits of cinnamon help protect neurons. These are the cells that are responsible to elicit sensory from the outside\textsuperscript{36}. Another benefit of cinnamon is to prevent cancer. Cancer is a dangerous illness which controls irresponsible cell development. A research on rats with intestine cancer proved that cinnamon is affecting the detoxification enzymes in the intestine. In addition, cinnamon also protects the body from further cancer growth\textsuperscript{42}.

These discoveries are supported by a test-tube test showing that cinnamon gives the barrier response in intestinal cells\textsuperscript{66}. Even so, the benefits of cinnamon in humans still require controlled studies. Lastly, it helps treat bacterial\textsuperscript{54} and fungal infections\textsuperscript{88}. Cinnamaldehyde is the main active compound of cinnamon, which can support eradication of some types of infections\textsuperscript{56}. Cinnamon oil is considered to be good in treating respiratory infections caused by fungi\textsuperscript{75}. In addition, cinnamon is also effective against specific bacteria such as Salmonella and Listeria\textsuperscript{68}. Nevertheless, the proof is still scanty and to date, there has been no evidence of infection elsewhere in the body.

**Phytochemistry**

Cinnamon, \textit{Lauraceae} family, is believed to be a great spices in the world. This plant comes from Indonesia, Australia, Saudi Arabia, Thailand, China and South America. This plant can grow up to 50 feet tall, has bright green leaves, rough surface and long. The flowers are white or yellow. This plant can produce bark, bark essential oil, leaf essential oil, bark powder and cinnamon oleoresin which can be employed as a kitchen spice\textsuperscript{54}. Cinnamon oleoresin is a brown powder that is made by extracting benzene (2.5-4.3%) and ethanol (10-12%)\textsuperscript{71}.

Cinnamon contains 59.55-80.59% carbohydrates, 53.1% dietary fiber, 9.5-10.5% moisture, 3.89-4.65% protein, 3.55% ash and vitamins\textsuperscript{20}. Cinnamon contains various phytochemicals such as cinnamaldehyde, monoterpenes, phellandrine, linalool, caryophyllene, cinnamaldehyde, hydrocarbon, pinene, benzaldehyde, benzyl benzoate, cinnamyl alcohol, eugenol acetate, cinnamyl acetate, eugenol and methyl eugenol\textsuperscript{28,31,87,91}. Some of the phytochemical structures in cinnamon can be seen in figure 2.

The essential oil is the main compound of cinnamon bark (2.8%), with the main component being cinnamaldehyde (60-90%). Marongiu et al\textsuperscript{17} found 19 active compounds from cinnamon by CO\textsubscript{2} extraction, reporting that the main compounds of cinnamon are eugenol (3.0%), \(\gamma\)-terpineol (4.4%), trans-\(\beta\)-caryophyllene (6.0%) and trans-cinnamaldehyde (77.1%). Cinnamon leaves contain eugenol which is the main compound of cinnamon leaf oil (65-97%) and essential oil (0.24-3.0%)\textsuperscript{71}. Besides that, in flower oil and cinnamon root bark, there are main components namely linalool, trans-cinnamyl acetate and camphor\textsuperscript{65}. The polyphenol content in cinnamon is quite high and the main phenolics are feryllic acid, vanillic acid and caffeic acid\textsuperscript{53}.

Abeysekera et al\textsuperscript{1} in a study proved that the cinnamon leaves and bark contain elevated flavonoids, besides the ethanol extract of cinnamon bark and leaves also contains high phenolics and in the ethanol extract of wood leaves sweetness was 44.57±0.5 mg GAE/g. In addition, in cinnamon extract, there are also phytochemical compounds such as alkaloids, terpenoids, steroids, anthraquinones, tannins, glycosides, coumarins and saponins\textsuperscript{23,72,73,81,82}.

Fig. 2: Some phytochemicals of cinnamon- A: Cinnamaldehyde, B: Eugenol, C: Cinnamyl acetate, D: \(\beta\)-Caryophyllene, E: Linalool and F: Cinnamyl alcohol\textsuperscript{71}.
Nutritive Value: Nutrition is an important part in regulating the systems and functions of the people’s bodies. Cinnamon is good spice utilized as a food ingredient. Cinnamon can give food taste and aroma. Cinnamon is a great source of micronutrients and macronutrients so that cinnamon can be a source of energy, carbohydrates, vitamins and minerals. Cinnamon contains macro nutrients which include carbohydrates (80.59 g), protein (3.99 g), energy (247 kcal/1035 kJ), fat (1.24 g) and ash (3.6 g). In addition, cinnamon contains mineral nutritional value which includes phosphorus (60 mg), zinc (1.83 mg), manganese (17.466 mg), iron (8.32 mg), potassium (431 mg), calcium (1002 mg), copper (0.339 mg) and magnesium (60 mg). The nutritional value of vitamins in cinnamon includes riboflavin (0.041 mg), vitamin C (3.8 mg), vitamin A (295 IU), pantothenic acid (0.558 mg), niacin (1.332 mg) and thiamine (0.002 mg).

Pharmacological Activity
Cinnamon is the great spice for health and nutrition because cinnamon has various active phytochemical compounds that play a role in pharmacological activity.

Antimicrobial and antifungal activity: Cinnamon has several antimicrobial and antifungal activities that have been proved in many studies. In one study it was reported that cinnamon oil is significant in inhibiting bacteria (Staphylococcus aureus and Pediococcus halophilus), fungi (Mucor plumbeus, Eurotium sp, Penicillium roqueforti and Aspergillus flavus) and yeast (Pichansia membranaefaciens, Candida lipolytica, Debaryomyces). The results of these studies prove that cinnamon can be utilized as an antifungal and antimicrobial agent.

In another research a mixture of cinnamon and clove oil was used to evaluate its antimicrobial activity against gram-positive and gram-negative bacteria. Another study revealed that cinnamon oil has antimicrobial and antifungal activity against the development of bacteria (Escherichia coli, Staphylococcus aureus and Pseudomonas aeruginosa) and yeast (Saccharomyces cerevisiae, Candida albicans and Schizosaccharomyces pombe). A recent research revealed the potential of cinnamon extract in inhibiting the growth of normal microflora. On the whole essential oil from cinnamon has strong antimicrobial and antifungal activity compared to other plant extracts like Syzygium aromaticum and Azadirachta indica.

Anti-diabetic and anti-obesity activity: It was shown that the abdominal fat weight and final body weight in the mice after giving Cinnamomum camphora seed kernel oil reduced. In addition, amounts of low density lipoprotein cholesterol and blood triglycerides significantly increased rapidly.

Pharmacological studies explain that Cinnamomum zeylanicum extract can improve insulin hypoglycemic properties, so that C. zeylanicum extract can be an oral diabetes drug in diabetes patients. A report shows that the water extract of C. zeylanicum bark has a role in reducing amounts of blood glucose in rats injected with alloxan.

Another study evaluated Cinnamomum cassia extract in inhibiting the weight gain of fat rats induced by a high-fat diet (HFD) through increased energy output and suppression of lipid accumulation, thus increasing mitochondrial activity in muscle cells in order to avoid the accumulation of lipids in the liver and reduce blood lipids. The polyphenol compounds from C. cassia can significantly inhibit the activity of SREBP-1, along with target genes (SCD1 and FAS) and increase lipid metabolism in HepG2 cells, the outcomes of this study prove that polyphenols from C. cassia protect the liver by how to inhibit de novo lipid synthesis through the SIRT1-AMPK-ACC pathway.

The essential oil and linalool compounds from Cinnamomum osmophloeum play an active role in hypolipidemic activity and weight control. Linalool and essential oil compounds from C. osmophloeum can inhibit the accumulation and production of lipids without showing side effects, mice that have been given essential oils and linalool compounds from C. osmophloeum experienced a change in body weight by 2.5%, which is smaller than the control group which was 3.9%. In addition, alanine aminotransferase, total cholesterol, aspartate aminotransferase, triglycerides and blood glucose remained normal in mice that had been given essential oil and linalool compounds from C. osmophloeum stack up with the control group. Thereunto, the linalool compounds from C. osmophloeum also play a role in controlling intracellular lipids in 3T3-L1 adipocytes.

Anti-inflammatory activity: cinnamon has anti-inflammatory activity proved in several researches. cinnamon has several flavonoid compounds such as hesperidin, hypolaetin, quercetin, reserpin, gossypin, oroxindin, all of which have anti-inflammatory activity. One study revealed that 2'-hydroxycinnamaldehyde dissociated from Cinnamomum cassia bark significantly inhibited nitric oxide production by precluding the activation of the nuclear factor kappa-light-chain-enhancer of activated B cells (NF-κB), this suggests that C. cassia has potential as an anti-inflammatory drug.

Ethanol extract of C. cassia has anti-inflammatory activity in degrading spleen-tyrosinekinase/Src-(Syk/Src-) activation mediated by NF-κB. Several compounds isolated from Cinnamomum ramulus have anti-inflammatory activity by holding down the activity of cyclooxygenase-2 synthesis, induced nitric oxide and production of nitric oxide in the central nervous system.

Therefore, C. ramulus can be a potential drug for treating neurodegenerative diseases that are mediated by inflammation. In addition, the water extract of cinnamon
can reduce the risk of tumor necrosis induced by lipopolysaccharides in serum.

**Anticancer activity:** Proyanadin fraction and cinnamon water extract through HPLC can preclude the activity of vascular endothelial growth factor subtype 2 kinase, so that it can inhibit angiogenesis which is involved in cancer. Cinnamaldehydes from cinnamon have been checked and synthesized as an inhibitor against angiogenesis. CB403, which is a chemical synthesized from 2'-hydroxycinnamaldehyde acquired from the compound cinnamaldehyde, plays a role in inhibiting tumor growth. Based on these results, it can prove that cinnamon can be an anticancer drug.

In another study, it was revealed that cinnamon aldehyde compounds from cinnamon can inhibit the production of tumor necrosis factor alpha induced by interleukin-8 on A375 cells and can inhibit NF-kB activity. Another study also declared that the trans-cinnamaldehyde compound from *C. osmophloeum* can inhibit tumor cell development and increase tumor cell apoptosis.

Oral administration of cardamom and cinnamon extracts to rats can increase the activity of glutathione-transferase (GST) antioxidants and detoxification enzymes, so that they can reduce lipid peroxidation in mice with colon cancer. The essential oil from *C. cassia* extract can suppress oxidative stress in murine B16 melanoma cells by inhibiting melanin production induced by the alpha melanocyte hormone.

**Immunomodulatory activity:** Liu et al. isolated several chemical compounds from the bark of *C. cassia* which has a role in immunomodulatory activity. The outcomes of this research showed that the effect of suppressing B cell proliferation and suppressing cinnacisides F was weaker than the positive control. Zhou et al. reported that cinnamomols A and B compounds dissociated from *C. cassia* leaves can increase the proliferation of ConA-induced murine T cells.

In another study, two alcohol extracts (MeOH and EtOH) from *Cinnamomum verum* were used to evaluate their immunomodulatory activity against rheumatoid arthritis (RA) and type-II collagen-induced arthritis (CIA). The outcomes of this study showed that the alcoholic extracts of EtOH and MeOH from *C. verum* showed good therapeutic effects in type-II collagen-induced arthritis rats (CIA). The extract can also inhibit all rheumatoid arthritis (RA) related proteins such as TNF-α, mCalpain, CAII and NFATC3.

**Cardioprotective:** *Cinnamomum cassia* has cardioprotective activity and is widely studied. Kwon et al. reported that *C. cassia* bark extract can withstand proliferating cell nucleus antigen (PCNA) expression, block the initial signal transduction stimulated by PDGF and regulate p21/p27 protein levels and suppress factor proliferation. growth of VSMC-induced platelet derivatives (PDGF)-bb via G0/G1 blockade. Several active compounds in cinnamon such as cinnamyl alcohol, eugenol and cinnamic acid, can act as cardioprotective agents. Aqueous extract of *C. cassia* can inhibit angiogenesis by suppressing proliferation induced by invasion factors migration, tube formation, vascular endothelial growth (VEGF) and intracellular signaling (activation of matrix metalloproteinases and phosphorylation of ERK, p38, VEGFR) in umbilical vein endothelial cell culture. humans (HUVeCs).

*C. cassia* extract has protective and preventive activities for diabetic cardiomyopathy by means of increasing the value of ADP, ATP and PCR in myocardial tissue, as well as fixing heart function and energy metabolism to slow heart damage.

**Neuroprotective activity:** In research conducted by Upadhyay et al. revealed that the water extract of *Cinnamomum tamala* leaves showed anti-stress, antidepressant and anxiolytic activity. The outcomes proved that the aqueous extract of *C. tamala* leaves produced anti-stress effects similar to those of *Withania somnifera*, induced antidepressant activity similar to imipramine and generated an anxiolytic effect comparable to that of lorazepam, so that the water extract of *C. tamala* leaves can treat mental illness.

**Cytoprotective activity:** Elkady and Ramadan showed that the water extract of *Cinnamomum cassia* had cytoprotective activity. The water extract of *C. cassia* can inhibit the *in vitro* cytotoxic impact of cis-diammine dichloroplatinum (CDDP), which is obtained by releasing mitochondrial cytochrome c, arranges the activity of cytoprotective genes (heme oxygenase (HO) -1), activates caspase-3, suppresses CDDP-induced increase in mitochondrial Bax protein expression, makes DNA fragmentation and produces ROS.

In another study, two new Nrf2 activators, 3,3',4,4'-tetrahydroxydiphenyl (THD, 266) and 3S-(+)-9-oxonorololid (NLD, 74) isolated from *Cinnamomum chartophyllum* were investigated for their cytoprotective activity in prevent oxidative processes in the epithelial cells of the lungs. In this study it was concluded that the Nrf2 and NADPH genes (γ-glutamylcysteine synthetase (γ-GCS) and quinone oxidoreductase 1 (NQO-1)) in lung epithelial cells were significantly activated and Nrf2 stabilization was enhanced by THD and NLD administration. In addition, THD and NLD can protect lung epithelial cells from sodium arsenite-induced cytotoxicity.

**Cholesterol and lipid lowering effects:** The application of cinnamon to mice had an effect on the lipid profile, in which the levels of triglycerides and high density lipoprotein (HDL) cholesterol decreased. In another research, a decrease was reported in triglycerides, total cholesterol and low-density lipoproteins in mice given *C. cassia* powder for 35 days. In addition, cinnamon oil can decrease cholesterol.
levels in broiler chickens\textsuperscript{10}. Khan et al\textsuperscript{15} revealed that cinnamon at doses of 1, 3 and 6 g per day can have an effect on the reduction in triglycerides, serum glucose levels, LDL cholesterol and total cholesterol in humans.

**Anti-HIV activity:** *C. cassia* bark is effective against HIV type 1 by inhibiting virus-induced cytopathogenicity in MT 4 cells\textsuperscript{62}. Cinnamon extract contains compounds that can block and bind HIV type 1 infection in target cells with an inhibitory concentration value of 50%. Certain flavonoid compounds from cinnamon can block HIV type 1 infection and infection in ghost cells\textsuperscript{13}.

**Conclusion**

Cinnamon is an economical spice and makes a great medicine. Cinnamon is widely utilized in Indonesia and is utilized as a spice in the kitchen. Cinnamon in the form of essential oil, phenolic compounds, flavonoids, bark and powdered bark plays a role in the pharmacological activity of cinnamon.

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