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Pharmacological Benefits of Porang (*Amorphophallus muelleri* Blume): A Review

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Abstract

Porang (*Amorphophallus muelleri* Blume) is a tuber plant from the Araceae family that grows wild in Indonesian forests. Porang tubers have a high content of the active compound glucomannan, a low-calorie hydrocolloid dietary fiber with various health benefits. However, its potential in the pharmaceutical field has not been fully explored scientifically, so this scientific review aims to explore the potential of glucomannan and other bioactive compounds in porang in the pharmaceutical field based on literature studies, as well as the challenges of developing it as a leading commodity in Indonesia. In addition to glucomannan, porang also contains secondary metabolites such as alkaloid, flavonoids, saponins, tannins, and steroids. Research studies show that porang can be used in the treatment of various diseases, such as diabetes (especially type-2 diabetes mellitus), obesity, hypertension, and has the potential as anti-cholesterol, anti-tumor, anti-inflammatory, prebiotic agent, anti-bacterial, and wound healing. The majority of applications that are still in preclinical in vivo trials on experimental animals and the presence of calcium oxalate as an irritant compound are the challenges of developing Porang as herbal medicine. Therefore, the use of porang as herbal medicine still requires further research regarding safe processing and clinically appropriate dosage.

Keywords: ***Amorphophallus muelleri Blume, Glucomannan, Benefits, Health***

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Introduction

Porang (*Amorphophallus muelleri* Blume) is a type of tuber from the Araceae family, porang tubers are still closely related to suweg, walur, and iles-iles plants (Siswanto & Karamina, 2016; Rahayuningsih, 2020). Porang is usually found growing wild in Indonesian forest areas that have high water and humus content such as on the edges of thickets, hillsides, and along rivers (Naufali & Destiana, 2023; Ekowati *et al.*, 2015). Porang is a type of forest plant that has a high level of productivity with a profit value of IDR 42.18 million per hectare so that it has the potential to be developed in Indonesia (Mutmaidah & Rozi 2015). Indonesian people majority use porang as a medicine or food ingredient (Annisah & Muhtadi, 2021).

The part of the porang plant that is widely used by the community is the tuber. Porang tubers have a high glucomannan compound content compared to other types of plant tubers, ranging from 5-60% and in general other tubers in Indonesia have 14-35% glucomannan (Koswara, 2013). Glucomannan is a dietary fiber that is soluble in water (Saleh *et al.*, 2015). The high glucomannan content causes porang to be widely used in the health sector as an excipient for pharmaceutical preparations and an alternative diet for people with obesity and type 2 diabetes mellitus (Sutriningsih & Ariani, 2017). In addition, glucomannan in porang can also lower blood cholesterol levels, overcome high blood sugar,

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control body weight, and can act as a prebiotic (Nugrahaeni *et al*., 2014; Febrianti *et al*., 2023). Porang has been widely known and utilized by the Indonesian people since the Japanese occupation (Masniawati *et al*., 2023). The prospects for the porang commodity can be said to be very potential because it has high economic value in the industrial and health sectors as a priority (Utami, 2021). The increase in porang exports in Indonesia in 2023 based on data from the Central Statistics Agency in 2024 was recorded at 511.97 tons (Mutmaidah & Rozi 2015), but the potential of porang in the health sector has not been fully explored scientifically. Therefore, a more comprehensive scientific review is needed to further explore the potential benefits of glucomannan and other bioactive compounds contained in porang, as well as their use in the pharmaceutical sector.

Porang (*Amorphophallus muelleri* Blume) Characteristics

Porang plants were first discovered in the Andaman Islands of India. The distribution of porang plants took place eastward through Myanmar into Thailand and Indonesia (Naufali & Destiana, 2023). In Indonesia's tropical woods, this plant frequently grows wild. At elevations between 100 and 700 meters above sea level, porang plants can typically thrive in secondary forests, teak woods, forest edges, and shrubs (Yuzammi *et al*., 2014; Endang *et al*., 2022). Porang plants usually grow wild under tree stands, bushes, and among bamboo plants because porang is a group of plants that are tolerant of shade with a sunlight intensity of 40% (Udarno, 2020).

Porang is a tuber plant native to Indonesia from the Araceae family with vegetative propagation through stem tubers, leaf tubers (bulbils), and generatively using seeds (Sumarwoto, 2005; Afifi *et al*., 2019). The fibrous root system is white for the process of absorbing nutrients and water needed during growth and development (Saleh *et al*., 2015). Porang stems are whitish green, light green, and yellowish green with white striped patterns. The smooth, wavy leaf surface with red, pink, and white leaf edges (Illahi *et al*., 2022). Bulbils grow in the leaf axils, namely at each meeting of the stem and leaf base (Hidayat, 2020). Bulbils (khatak) are a characteristic of the porang plant and are not found in other iles plants (Apu *et al*., 2022). The stem tubers are round or oval with a rough surface covered in roots, the inside of the tuber is yellow (Ashan *et al*., 2023). Porang stem tubers experience a dormancy period of 4-5 months (Afifah *et al*., 2014).

Porang plants in taxonomic systematics are classified as follows (Indonesia Porang Research and Development Center, 2019) :

Kingdom : Plantae
Division : Magnoliophyta
Class : Liliopsida
Order : Arales
Family : Araceae
Genus : Amorphophallus
Species :*Amorphophallus muelleri* Blume

Porang tubers can grow well at air temperatures of around 25ºC - 35ºC, rainfall between 300-400 mm per month and altitudes of up to 1000 meters above sea level (masl). Good drainage and high nutrient content in the soil are needed for this species of plant (Wardani & Handrianto, 2019). Porang has a unique life cycle, the tubers begin to germinate when it starts to rain then grow well in the rainy season and throw off the air before the dry season arrives. The tubers are the part of the porang body that is still alive in the dry season (Santosa *et al*., 2016). Once they are two years old, porang tubers can be harvested for the first time with weigth more than 1 kg/tuber (Isnaini *et al*., 2023).

Figure 1. Porang plant (Isnaini *et al*., 2023).

The porang plant flower is a compound flower with a cob shape (spadix) measuring 10-20 cm, some flowers appear at the beginning of the rainy season and some at the end of the dry season, are unisexual (Sumarwoto, 2005; Gusmalawati *et al*., 2023). Staminate consists of 3-5 androus and is pale yellow with a prismatic or rectangular cross-section with sticky dimorphic pollen that is dark brown and transparent, while pistillate has a pistil with a cylindrical or slightly fusiform stigma, a short ovary, with the lower half and upper half reddish pink, 2-3 locules with one basal ovule per locule (Gusmalawati *et al*., 2013). Porang fruit is a berry with an oval or rounded shape when young, has a green color and turns bright red when ripe (Afifah *et al*., 2014). Porang fruit has 1- 3 seeds with a size ranging from 0.4-0.7 cm (Afifah, *et al*., 2014). The ripe seeds are produced in about one year with variations in gray or dark green color with a shape depending on the number of seeds in the fruit (Santosa *et al*., 2016).

Amorphophallus muelleri B. Active Compounds

Bioactive compounds contained in porang tubers include 80.16% carbohydrates, 54.23% starch, 4.96% fiber, 5.77% protein, 4.96% fat, and 45% glucomannan (Wulan *et al*., 2021; Sahputra, 2023). The main carbohydrate component in porang tubers is glucomannan. Analysis through Liquid Chromatography Mass Spectrophotometry (LCMS) reveals that the concentration of glucomannan in porang tubers is approximately 99,436.85 µg/g (Gusmalawati *et al*., 2019). Through the β-1,4-pyranoside bond, glucomannan polysaccharide consists of 33% D-glucose and 67% D-mannose (Figure 2), with a molar ratio of 1:1.6 to 1:1.4 (Behera & Ray, 2016; Luo *et al*., 2022).

Glucomannan is a hemicellulose type polysaccharide compound that is water-soluble, low calories, gluten-free, and hydrocolloid (Ibrahim, 2019). Glucomannan has several great characteristics, including a high capacity to store water and the ability to expand with water to 80–100 times its original dry weight with a viscosity of up to 35,000 cps (Luo *et al*., 2022; Sahputra, 2023). This solubility is attributed to the presence of 5% to 10% acetyl substituent residues at mannose on the main chain of glucomannan (Zhou *et al*., 2018). One molecule of glucomannan weight between 200,000 - 2,000,000 daltons (Luo *et al*., 2022).

Glucomannan content varies depending on the tuber part and the growth period of the plant, the type of plant, the age of the plant, the length of time after harvest, and the length of storage time (Gusmalawati *et al*., 2021). In addition to glucomannan, other carbohydrate compounds such as mannan, trehalose, mannose, galactose, glucose, rhamnose, arabinose, and xylose were also detected in post-harvest porang tubers (Gusmalawati *et al*., 2024). Porang tubers also contain several secondary metabolites including flavonoids, alkaloids, saponins, coumarins, tannins, steroids, and quinones (Suryani *et al*., 2023). Flavonoids, tannins, saponins, and steroids were also found in the porang leaves. Research by Erikania & Rosalina (2023) showed that porang leaves macerated using 96% ethanol solvent for 3 days had positive secondary metabolite content in the form of tannins, alkaloids, flavonoids, and saponins. Hanifah *et al.* (2024) also proved porang leaves extracted with ethyl acetate contain the highest levels of secondary compounds, namely flavonoids, tannins, saponins, and steroids with moderate antioxidant activity, namely an average IC_{50} value of 131.54 ppm.

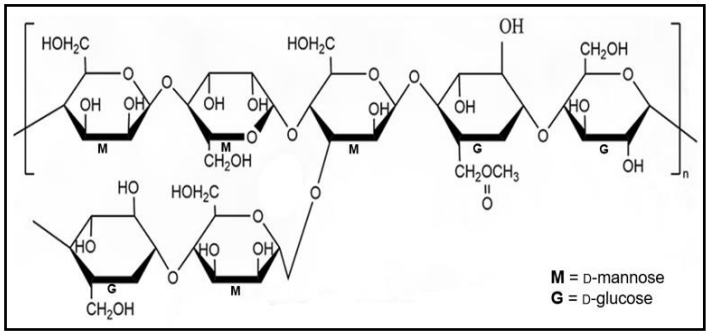

Figure 2. The polymer structure of glucomannan

Pharmacological Utilization of *Amorphophallus muelleri* B.

Porang (*Amorphophallus muelleri* B.), a native Indonesian plant has been known to have several benefits, especially in the health sector. One of the reasons porang is widely used in the health field is the glucomannan content in porang. Glucomannan is a high-molecular-weight polysaccharide that was originally extracted from the porang corms (underground storage organs). Glucomannan is known to have several benefits, including as an anti-diabetic, anti-obesity, anti-cholesterol, anti-hypertension, anti-tumor, anti-inflammatory, prebiotic agent, and other benefits.

1. Anti-diabetic

Diabetes causes impaired glucose metabolism, including decreased ability to process and store glucose, as well as increased glucose production by the liver. Porang (*Amorphophallus muelleri*) tubers have high glucomannan content as a water-soluble fiber known to have an effect on glucose homeostasis (Susanti, 2014). Diabetes is a chronic metabolic disorder characterized by the body's inability to effectively regulated blood glucose levels, either because of excessive insulin secretion by the pancreas or due to impaired insulin function (Ojo *et al.,* 2023). Insulin is a peptide-based hormone synthesized and secreted primarily by pancreatic β-cells residing in the islets of Langerhans, playing a central role in glucose homeostasis (Rahman *et al.,* 2021). Glucomannan therapy was thought to improve insulin sensitivity and upregulated more glucose uptake for energy production by increasing the activity of enzymes involved in glucose metabolism because the intensity of gluconeogenic enzymes was dramatically lowered. Konjac glucomannan (KGM) has a significant impact on the enzymatic activity of gluconeogenic and glycolytic enzymes in glucose metabolism (Fang *et al*., 2023).

Glucomannan boosts insulin sensitivity. One of the functions of insulin is inhibit gluconeogenesis which is closely related to diabetes (Luo *et al*., 2022). Research indicates that in people with type-2 diabetes (T2DM), glucomannan from porang can take the role of rice as a dietary fiber that can decrease hunger and promote fullness (Zhao *et al*., 2010). Long-term health benefits, including reduced blood lipid content, decreased post-meal blood glucose, and elevated insulin levels, may result from a porang-based type-2 diabetes diet. Glucomannan alleviated the symptoms of hyperglycemia by balancing the renal system, serum components, and metabolic abnormalities (Chen *et al*., 2019).

Porang glucomannan extract's hypoglycemic action on a high-fat diet and streptozotocin-induced glucose in rats with type-2 diabetes (T2DM) showed that the extract might enhance blood glucose regulation, glucose tolerance, and protect the pancreas from oxidative stress compared to the control group and dimethyl biguanide (DMBG) (Fang *et al*., 2023). The study's findings demonstrated that while hexokinase, glucose-6-phosphate dehydrogenase, and glycogen levels were increased in diabetic rats administered 80 mg/kg of KGM, but levels of gluconeogenesis enzymes decreased. That showed that administration of KGM to diabetic rats improved the disorder by increasing the activity of enzymes that support glucose utilization, increasing glucose storage as glycogen, and suppressing glucose production by the liver to reduce gluconeogenesis. This suggests that glucomannan can act as a natural anti-diabetic agent that support improved the glucose metabolism pathway specifically for T2DM patients.

2. Anti-obesity

Obesity is defined as having a body mass index (BMI) ≥ 25 kg/m^2 based on the Asia-Pacific criteria. Central obesity, based on the same standart is identified by a waist circumference >90 cm in men and >80 cm in women (Harbuwono *et al.,* 2018). Glucomannan can reduce the risk of obesity by lowering blood pressure, triglycerides, glucose, and cholesterol (Hosiana *et al*., 2023). Glucomannan can also lower blood glucose levels by preventing excess glucose absorption. This is proven by several studies conducted on experimental animals that show a decrease in blood glucose through increased expression of the insulin mRNA gene (Fatchiyah *et al*., 2019).

Glucomannan improve obesity through several mechanisms. Glucomannan reduces calorie intake because glucomannan is difficult to break down by human enzymes (especially

endo-1,4-beta-mannanase). Glucomannan is also a soluble fiber that forms a thick gel-like mass when hydrated in the stomach, thereby reducing the rate of gastric emptying in order to reduce meal frequency and calorie intake. Glucomannan can increase intestinal peristalsis, thereby improving digestion. Glucomannan metabolizes energy by excreting feces, thus helping to reduce body weight without disrupting normal metabolism (Fang *et al*., 2023).

Studies on porang flour effect on mice's body weight, fat mass, and fat cells demonstrate glucomannan's potential as an anti-obesity. According to these findings, porang flour can lower blood fat levels by increasing the expression of genes involved in energy and fat metabolism in the liver and adipose tissue (Kang *et al*., 2018). Additionally, high-fat diet mice that are resistant to obesity can have more normal flora in their intestines when porang flour is added. Similar studies have also shown that processed porang polysaccharide flour shows a gastric emptying effect which results in a decrease in total cholesterol and triglyceride levels. This is due to porang's fiber content which promote the production of glucagon-like peptide (GLP) because it's easily fermented by gastrointestinal flora (Fatchiyah *et al.*, 2019).

3. Anti-cholesterol

Cholesterol is a steroid biomolecule in animal cells essential for hormone synthesis, membrane structure, vitamin D production, and the formation of bile salts and bile acids (Idoko *et al.,* 2021). Despite the important role that cholesterol plays, having too much of it in the body can be a risk factor for cardiovascular disease (Rahman *et al.,* 2024). The glucomannan content in porang has also been shown to have anti-cholesterol and anti-obesity properties. According to a few studies, porang's glucomannan may boost lipid metabolism and inhibit the synthesis of cholesterol. After being turned into flour, porang tubers contain glucomannan, which can ferment in the large intestine. This fermentation activity produces propionic acid, which can lower the liver's synthesis of cholesterol. As a result, total blood cholesterol levels are decreasing (Chen *et al*., 2019).

Long-term low-dose KGM consumption can increase LDL-C and cholesterol, and reduce blood lipid levels (Hayeeawaema *et al*., 2020). According to clinical studies, diabetic patients with high cholesterol levels can lower their cholesterol levels by adding 0.7g of KGM per 100 calories to their diet (Patel, 2008). The hypolipidemic effect is thought to be achieved through increased excretion of sterols or bile acids, and this assumption has been confirmed by experimental studies in animals. Serum of konjac glucomannan (SKGM) treatment was more efficient in lipid regulation with improved the hyperglicemia and hyperlipidemia symptoms in type 2 diabetic rats (Chen *et al*., 2019). KGM can significantly increase hormones related to food intake including adenosine monophosphate-activated kinase (AMPK) levels. AMPK activation by KGM can help improve energy metabolism, manage glucose, and lipid homeostasis (Gao *et al*. 2024). That showed glucomannan regulates metabolic parameters of lipid, glucose, and cholesterol levels.

4. Anti-hypertension

Hypertension or high blood pressure is defined by systolic pressure ≥140 mmHg and diastolic pressure ≥90 mmHg. Although often asymptomatic, untreated hypertension is considered highly serious due to it's strong association with increased risks of stroke, heart attack, heart failure, and kidney failure (Putra *et al.,* 2024). The use of porang in the pharmacology field related to the glucomannan effect on lowering blood pressure has been carried out in vivo on rats suffering from hypertension. Treatment of 50mg glucomannan supplement from Konjac on male Wistar rat can lowering blood pressure significantly after 6 hours (Putra *et al*., 2024). Glucomannan can decrease blood pressure by inhibiting the Angiotensin Converting Enzyme (ACE) through the mechanism of the ACE inhibitor (ACE-i). Fountain *et al*., (2023) revealed the renin-angiotensin system, which includes renin, angiotensinogen, and angiotensin converting enzyme (ACE) regulates blood pressure. Renin is an enzyme made by the kidneys that combines with angiotensinogen to form angiotensin I, whereas angiotensin is a precursor protein that is produced, secreted, and released into the blood vessels by the liver. In order to trigger physiological processes, ACE converts the biologically inert angiotensin I into active angiotensin II (Chua *et al*., 2010).

5. Anti-tumor

Tumor is a type of cell that grows at an irregular rate and has no useful function for the human body (Alrizzaqi *et al.,* 2018). Other studies have also proven that glucomannan of porang has antitumor activity. Porang tuber extract, extracted with organic solutions (ethanol and betadine) as a medicine for gastric cancer can inhibiting the growth of cancer cells by promoting cell cycle arrest and increasing apoptosis (Chen *et al*., 2017). Porang tuber extract has the potential to be used as traditional chemotherapy to treat gastric cancer because it triggers the mechanism of cancer cell death through autophagy. Glucomannan inhibits the proliferation of tumor cells by the blocking G0/G1 to G2/M phase transition, decreasing proliferative cell nuclear antigen (PCNA) expression, upregulating pro-apoptotic proteins like Caspase-9 and BAX (Bcl-2 Associated X Protein), and downregulating anti-apoptotic genes like *Survivin* and *BCL2* (B-cell lymphoma-2) (Li *et al*., 2019). Furthermore, glucomannan prevents the spread of malignant cells by raising E-cadherin levels and the expression of CCR7 (C-C Chemokine Receptor type 7) and CXCR4 (C-X-C Chemokine Receptor type 4) (Li *et al*., 2019). Glucomannan causes tumor cell to decrease reactive oxygen species (ROS) secretion and increase autophagy, which can minimize DNA damage and the ensuing mutation events likelihood.

Glucomannan works against cancer via a dual inhibition mechanism. Glucomannan directly inhibit the phosphatidylinositol-3-Kinase to Protein Kinase B (PI3K/AKT) as the tumor-promoting signaling to reducing tumor cell viability and spread. Glucomannan administration indirectly modulate of the gut environment to reducing inflammation and carcinogen load, promoting probiotic growth, and short chain fatty acids (SCFAs) production, which protect against inflammation-associated carcinogenesis, especially in the gastrointestinal tract (Li *et al*., 2019).

Porang glucomannan extracted by ethanol and ligarine significantly inhibited the growth of cultured human gastric cancer cell lines SGC-7901 and AGS, with IC50 of 35-45 µg/ml (Chen *et al*., 2017). Glucomannan displays a protective effect by promoting the expression of genes associated with ROS scavenging and autophagy induction. The microtetrazolium (MTT) assay with involving nude mice was used to examine the reversal effect of KGM on 5-FU in multidrug-resistant (MDR) cancer cells, which include 5-fluorouracil (5-FU) resistance. To investigate the effects of 5-FU and KGM on the expression of genes associated with MDR, polymerase chain reaction (PCR), and western blotting were also employed. This in vivo studies was shown that KGM was suggestion to suppress significantly the growth of HepG2/5-FU cells (a hepatocellular carcinoma cell line resistant to 5-FU) (Chen *et al*., 2020).

6. Anti-inflammatory

Inflammation represents the immune system's protective response to harmful stimuli including pathogens, cellular damage, toxic agent, or radiation by eliminating the source of injury and triggering tissue repair. As such, it serves as a crucial defense mechanism essential for maintaining health (Chen *et al.,* 2017). Glucomannan modulates the immune system through interleukin (IL-6 and IL-10). Glucomanan can increase the body's anti-inflammatory response by reducing IL-6 levels and increasing IL-10 levels. The pro-inflammatory cytokine IL-6 is linked to increased levels the anti-inflammatory cytokine of chronic inflammatory disorders, while IL-10 helps maintain the balance of the immune response. Free radicals are helpful in preserving cell health and lowering the risk of chronic inflammation, while antioxidants help fight them off.

Tumor necrosis factor α (TNF-α) and interleukin-1 Beta (IL-1β) production levels were significantly reduced in LPS-stimulated RAW264.7 cells by ultrasound-degraded oxidized konjac glucomannan (U-OKGM) (Zheng *et al.,* 2019). Inflammatory cytokines, including TNF-α and IL-1β, are known as pro-inflammatory factors. The mice that were given konjac oligosaccharides (KOS) showed lower expression of pro-inflammatory factors (TNF-α and IL-1β) in mice suffering from colitis induced by sodium phosphate sulfate (TNBS) (Liu *et al*., 2016). This suggests that KOS treatment efficiently reduce the overexpression of pro-inflammatory cytokine and enzymes, which play a key role in the anti-inflammatory properties. Zhao *et al*. (2020) reported KGM at moderate dosages (80 mg/kg bw) can inhibit

oxidative stress by controlling the nuclear factor erythroid 2-related factor 2 (Nrf2) pathway as a major transcription factor that regulates antioxidant gene expression. It can also reduce inflammation by controlling the nuclear factor-kappa B (NF-kB) pathway as a key regulator in inflammatory responses.

7. Prebiotic Agent

Prebiotics are carbohydrates and fibers that cannot be digested and fermented that can increase the number of probiotic in the intestinal tract through anti-inflammatory functions (Kang *et al*., 2018). Glucomannan has been reported to have significant effects on gut microbiota. The gut microbiota is responsible for immune function, nutrition, and metabolism, and therefore has a major influence on a person's health and disease (Bozomitu *et al*., 2022). Glucomannan hydrolysate acts as a prebiotic to stimulate the growth of lactic acid bacteria. A good balance of gut microbiota contributes to weight control, glucose metabolism, and body fat reduction (Fang *et al*., 2023). Changes in the relative abundance of gut bacteria such as *Clostridium*, *Candidatus saccharimonas*, and other members of the *Firmicutes* and *Christensenellaceae* phylum suggest that KGM can alter the composition of gut microbiota (Gao *et al.*, 2024). They play important roles in gut health, digestion, and metabolism. Glucomannan supports increased production of short chain fat acids (SCFAs) such acetate, valerate, and isobutyrate by gut bacteria. Glucomanan also helps maintain the stability of intestinal wall permeability, which can prevent inflammation and support digestive system health by reducing zonulin levels *(Gao et al*., 2024). The synbiotic made up of *Lactobacillus acidophilus, Bifidobacterium infantis* and konjac glucomannan oligosaccharides (KGM-O) not only improved intestinal barrier protection, but also directly improved gut microbiota dysbiosis by increasing probiotic and decreasing potentially pathogen bacteria (Kang *et al*., 2023). This showed the glucomannan play a prebiotic role to maintaining gut health, improving nutrient absorption, and reducing inflammation on gut.

8. Other Benefits

Product konjac flour (PKF)-derived gel have many utilized by Chinese people to treat many hematogical and skin conditions (Chua *et al*., 2010). Porang contains antibacterial and wound-healing properties, according to some previous research. (Kaczmarek-Szczepańska *et al*., 2024) revealed that tannic acid and D-glucono-1,5-lactone were used to bioactivate konjac glucomannan films, which had strong antibacterial qualities. These outstanding results are encouraging because they were able to considerably lower the growth rates of *Escherichia coli* and *Staphylococcus aureus* in bacterial broth and produce inhibition zones against *S. aureus* in agar plates (Kaczmarek-Szczepańska *et al*., 2024). Alkaloids, flavonoids, and saponins are among the substances found in porang tuber ethanol extract that have antibacterial properties. The concentration of porang tuber extract facial soap gel at 7% is most effective in inhibiting *Propionibacterium acne* bacteria with average inhibition zone of 16mm (Tahar *et al*., 2023). The combination of KGM with natural proteins such as silk offers a smart breakthrough as a wound dressing material that supports natural healing without the need for additional external growth factors (Feng *et al*., 2019). Acetylated KGM has the potential to be used as a biomaterial for active bandages, not only as a wound protector, but also as an active wound healing agent through stimulation of cell regeneration and vascularization (Wang *et al*., 2020).

The Challenges of Developing Porang as Herbal Medicine

Porang tubers contain several irritants including inorganic salts such as calcium oxalate (Chairiyah *et al*., 2013). Oxalate crystals that can be found in porang plants (*Amorphophallus muelleri* B.) have four types of shapes, namely druse, raphide, prism, and styloid crystals (Lawrie *et al*., 2023). Oxalate crystals, particularly the raphide type (needle-shaped crystals), serve as dual-function defense structures. Active defenses are referring to damage caused by herbivores due to mechanical penetration of crystals into tissue. Passive defenses exposed in the form of the plant's ability to minimize the effects of stress due to physical and chemical factors from the environment (Ardhian & Indriyani 2013).

Excessive consumption of oxalate crystal might cause renal crystallization and decrease the body's bioavailability of calcium (Franceschi & Nakata 2005). If calcium oxalate

is ingested without prior processed, it also results in mouth and throat irritation and inflammation (Hosiana *et al*., 2023). This is one of the limitations of the use of porang as a food ingredient. However, soaking in salt or acid is the right initial treatment to remove most of the calcium oxalate before processing porang tubers (Saleh *et al*., 2015).

The results of the study on porang glucomannan as herbal medicine should not be directly disseminated to the public without permission because it contains calcium oxalate substance that can cause intestinal and oral irritation if not properly processed (Putra *et al*., 2024). In addition, further study is needed regarding the dosage of glucomannan supplements in humans because the majority studies was conducted on Wistar rats as experimental animal, so that porang glucomannan can be used as one of the potential herbal medicines in the future.

Conclusion

Glucomannan is the main bioactive compound in porang tubers (*Amorphophallus muelleri* B.). Glucomannan is a dietary fiber that is soluble in water and low in calories, thus contributing many pharmacological benefits. Research studies show that porang can be used in the treatment of various diseases, such as diabetes (especially type-2 diabetes mellitus), obesity, hypertension, and has the potential as anti-cholesterol, anti-tumor, anti-inflammatory, prebiotic agent, anti-bacterial, and wound healing.

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