CHAPTER 1.0

INTRODUCTION

1.1 GENERAL INTRODUCTION

The genus *Amorphophallus* spp. belongs to the Araceae family and consists of some 170 species distributed throughout the world (Hetterscheid & Ittenbach, 1996; Sedayu, et al. 2010). The species are perennial in nature and thrive well under the plant canopy in the tropics spreading from East-Africa to Polynesia including Malaysia.

Amorphophallus is considered a herb which usually produces one leaf from an underground tuber with spotted petiole (leaf stalk), grows upright and holds the leaf-blade (lamina) like an umbrella. This leaf is dissected into many smaller leaflets. When the tubers or corm mature, it will develop a "typical" aroid flower. Most are scented but some exude unpleasant smells which remind us of rotting meat or sewage. There are also species that do produce a pleasant carrot-like, anise, chocolate or even a fruity fragrance. There is high diversity in the genus in terms of size, leaf shape, scent, flowers, tubers and leaf stalks.

About more than five species of *Amorphophallus* has been used as food source and folk medicine. *Amorphophallus konjac*, for instance, has long been used in Asia as a food source and in traditional medicine (Chua et al. 2010). Flour extracted from the corm of this species is used to make noodles, tofu and snack. While the gel prepared from flour of the corm, has been used by the Chinese for detoxification, tumour-suppression, blood stasis alleviation and phlegm liquefaction.

In Japan, *A. konjac* is a household name among Japanese whereby it is being used in the preparation of konyakku.

Even in Malaysia, the use of the corms of several species of *Amorphophallus* can be traced back for more than 2000 years, whereby during food scarcity like the wet monsoon season, the corm of *A. paeoniifolius*, for instance, have been used as the best substitute for rice (Keleny, 1962). Early records indicated that *A. paeoniifolius* have been used in culinary recipe, religious ceremonies, and folk medicine.

In recent years, the potential benefits of purified powder produced from the corm of some species of *Amorphophallus,* for example *A. konjac,* have been scientifically and clinically studied and summarized by Chua et al. (2010). The purified powder form or better known as konjac glucomannan (GM) is the best known natural, edible, water soluble polysaccharide or fibre. The high water solubility combined with low energy value, low vitamin content and low nutritional value makes GM an ideal food supplement to regulate body functions resulting from poor diet.

Among its uses include overcoming obesity, control hyperglycemia and hypercholesterolemia activities, used in drug delivery, fat and gelatin replacer. The Food Chemical Codex lists the current uses of GM in the United States as a gelling agent, thickener, film former and emulsifier. The Food and Drug Administration (FDA) has classified konjac flour as "Generally Recognised As Safe"- "GRAS" material when used as an ingredient in formulated foods (CFR Title 21 § 170.30) and the European Country (EC) has also released it as a food additive under E425.

The major health problem among Malaysians is obesity and the major cause of death in Malaysia can be associated with cardiovascular diseases and diabetes.

Cardiovascular disease accounted for 25% of all deaths in Malaysia (Chin et al. 2008). Glucomannan can be a new source of food ingredient in our cuisine. By promoting and consuming this new food ingredient into our diet, the health quality among Malaysians can be enhanced.

Species of *Amorphophallus* identified with high glucomannan content can be domesticated and cultivated hence it can be considered a high value crop. For example, Konjac (*A. konjac* Koch) is considered a high value commercial crop in Japan and China. The price of Konjac glucomannan flour is up to more than USD 7,000 per ton in 2009 (Misra et al. 2010).

Gelatin, a very important food ingredient in ice cream, confectionary and capsules for medicine is mainly derived from pig which is considered non-halal to Muslim. Efforts in the Muslim World, in particular Malaysia to find a gelatin replacer from a plant source for glucomannan is in progress.

The problems of procuring halal and kosher gelatin in the world market could also be overcome provided a new replacement for gel from plant source, namely, glucomannan, can be secured from the plant studied. Gelatin from plant source is preferable over animal source because of source from the latter can be a carrier of pathogenic virus like the Boisson Spongial Encaphalitis (BSE) virus and it could be harmful to human when consumed.

Establishment of ecological data and parameters is important because in a way it could elucidate us the climatic and agronomic requirements of this underutilized plant, taking into consideration that some species of *Amorphophallus* have the potential of becoming a very important high value crop for Malaysia.

In line with the government's Economic Transformation Programme (ETP) proposed roadmap to set up new growth targets and projections to become a high-income nation, certain *Amorphophallus* species subject to the suitability and glucomannan content, could be introduced as a crop especially to the rural smallholders, under the existing perennial plantation and fruit crops. This plant is easy to grow and it thrives well under plant canopy; it may also be suitable to be cultivated under oil palm, rubber and fruit tree canopy and there may be no need to have new areas for planting.

1.2 OBJECTIVE

The rich biodiversity of Malaysian flora includes many species of *Amorphophallus* which have not been fully identified. So far no studies have been done on the ecology of *Amorphophallus* spp. in Peninsular Malaysia. Establishment of ecological baseline data is important for this underutilized but potential plant. Similarly, the glucomannan content of various species have not been studied at all.

It is against this backdrop that the objectives of my study are:

i) To establish some practical ecological data for selected species of indigenous and naturalized *Amorphophallus* spp. in Peninsular Malaysia.

ii) To study the spatial distribution of *Amorphophallus prainii* and *Amorphophallus paeoniifolius* and their preferred habitat.

iii) To determine the glucomannan content of selected *Amorphophallus* species during their growth phase.

CHAPTER 2.0

LITERATURE REVIEW

2.1 THE GENUS *Amorphophallus*

The name *Amorphophallus* comes from the Latin words of ‘amorpho’ means deformed and ‘phallus’ means a male anatomical member. According to The International Plant Names Index (IPNI), *Amorphophallus* is the genus in the kingdom Plantae, subkingdom Tracheobiota (Vascular plants), with superdivision under Spermatophyta (Seed plants), in the class of Liliopsida (Monocotyledons) under subclass Arecidae, in the order of Arales, and in the family of Araceae.

2.1.1 General Morphology of *Amorphophallus*

Plants of the genus *Amorphophallus* vary from small to massive terrestrial plants. They are herbaceous plants with subterraneous stem, tuberous, but rarely a chain of tubers or rhizomes. Tuber shapes are globose, subglobose, depressed-globose, saucer-shaped or vertically elongate and unbranched or branched. The tuber represents one module and being renewed each season. (Pitojo, 2007)

The leaf is usually solitary, rarely paired, emerging from the top of the tuber or rhizome, lasting one growing-season or rarely long-lasting. The petiole is terete, rarely angulate, smooth, shallowly grooved or partly rugulose, rarely entirely verrucate or hairy, unicolorous or variously blotched. Lamina is decompound and divided into three main branches. The main branches equally long or the anterior main branch shorter than the posterior main branches (subpedate); rhachises unbranched, overtopped or one or more pseudodichotomously branched; secondary rhachises simple or variously branched; rhachises naked, narrowly or broadly winged and often carrying supernumerary leaflets on the proximal parts. Sometimes bulbils develop on the leaves, either epiphyllar, intercalary or half-epiphyllar; distal leaflets obovate, elliptic, elongate-elliptic, elongate, oblong, lanceolate or linear, sessile or rarely petiolulate, base often asymmetric and decurrent on one side, apex acute, acuminate or rarely caudate, margin entire rarely erose, often undulate, upper side green or dark green, rarely with reddish margin or variegation. (Hetterscheid & Ittenbach, 1996)

Typical of the Arum family, this genus develop an inflorescence consisting of an elongate or ovate spathe (a sheathing bract) which usually envelopes the spadix. The inflorescence is always solitary, usually flowering singular without leaves, rarely with the leaves. Peduncle is short or can be long in some species, often sculptured and patterned as petiole, when it is short, fruit is always elongating. Spathe shape is elongate-triangular, triangular or ovate to broadly ovate, variously shaped, often cymbiform or campanulate, more rarely funnel-shaped, outside of the spathe is variously coloured but often shades of brownish-purple or whitish-green, mostly paler on the inside than outside but base within often dark maroon. The base is complicated, rarely open or connate, not or clearly separated from the limb by a constriction, oval, rounded, lanceolate or funnel-shaped in longitudinal section, inside smooth or clothed with ridges or warts, the latter small or large, short or hairlike, sometimes forming ridges; limb rim shaped or broadly or elongate triangular, erect, spreading, oblique, or fornicate, margin entire or rarely lobed, flat, undulate or rarely plicate, apex acute, rarely acuminate or rarely cordate (Hetterscheid & Ittenbach, 1996).

Spadix is sessile or shortly stipitate, shorter than, equalling or longer than spathe; female zone cylindric, fusiform, conic or obconic, contiguous with male zone or separated by a sterile zone, flowers congested or rarely distant, sometimes surrounded by staminodes. The sterile zone consisting of staminodes, rarely mixed with pistillodes, rarely partly or entirely naked. Male zone is cylindric, fusiform, conic or obconic, the flowers are congested, rarely distant, often variously fused in the upper part of the zone, sometimes fused into vertical rows or helically or verticillate, sometimes mixed with staminodes; appendix rarely absent, contiguous with male zone or separated by a constriction or a short stipe, erect, rarely horizontal, arching, nodding or pendulous, outline conic, fusiform, triangular, ovate, subglobose or globose, sometimes with large longitudinal folds or deep cracks, surface smooth, rugulose, or with distinct, variously shaped staminodes, often found only at the base, It will produce heat during female anthesis and exuding strong scents, sometimes emitting droplets of a clear fluid, apex acute or obtuse, wall thin or massive, inside a narrow canal or a large cavity. (Hetterscheid & Ittenbach, 1996).

The female flowers consist of one pistil. The ovary is sessile or shortly stipitate, globose, subglobose, depressed or ovate, rounded or angulate in cross-section, 1-, 2-, 3-, or 4-locular, one ovule per locule, basifixed, or rarely axillary circa halfway up the ovary. Style sometimes present or sometimes absent, cylindric or rarely slightly conic or obconic, clearly separated from the ovary or less so, equalling or shorter or longer than ovary, sometimes with apical projections extending beyond the stigma. The stigma is indistinct or sometimes large, terminal or rarely subterminal, globose, hemispheric, concave or flattened, entire or variously lobed, surface spongy, papillate, scabrate or echinate, during anthesis, it is covered with a sticky fluid. The male flowers are consisting of (1-3) to (6-8) stamens.

Stamens are depressed or elongate; filaments present or nearly absent, massive or rarely thin, separate or partly or entirely fused within one flower. Anthers can be short or sometimes elongate, rarely subglobose or globose, truncate, rarely rounded, connective indistinct or massive, sometimes with one or more projections, pores apical, rarely lateral or subterminal, rounded, reniform or elongate; staminodes of sterile zone shield-like, globose or hairlike, those on the appendix shield-like, hairlike, rounded or conic warts, or papillae. The pollen is globose or elliptic, the exine is rarely absent, and it is psilate, striate, or foveolate in shape. (Hetterscheid & Ittenbach, 1996).

Infructescences are usually long-peduncled, rarely short-peduncled. The fruiting part is globose or elongate. The berries are usually globose or elongate, with red, orange-red, white, white-and-yellow, blue in colour. Seeds are always globose, subglobose, ovate, elliptic, or saucer shape and it is usually with a distinct raphe. (Hetterscheid & Ittenbach, 1996). All plant parts contain varying concentrations of an acrid factor, which appears to be carried on the surface of the needle-like calcium oxalate raphide crystals. It is believed to be either a cysteine proteinase or a glucoside that causes considerable irritation or swelling of affected tissues. (O'Hair & Maynard, 2003).

2.2 WORLD DISTRIBUTION

The present geographical distribution of *Amorphophallus* largely comprises the paleotropics. Western Africa is the westernmost limit whereas the easternmost limit lies in Polynesia. *Amorphophallus* species shows a very high degree of endemism including the species from Peninsular Malaysia.

Figure 2.1: World distribution of *Amorphophallus* spp. (Extracted from Mayo, Bogner & Boyce, 1997)

2.3 CLIMATE of PENINSULAR MALAYSIA

Peninsular Malaysia experience tropical rainforest climate in which there is no distinct dry season. The characteristic features of tropical rainforest climate are uniform temperature, high humidity and copious rainfall. Winds are generally light. Situated in the equatorial doldrums area and it is extremely rare to have a full day with completely clear sky even during periods of severe drought. On the other hand, it is also rare to have a stretch of a few days with completely no sunshine except during the northeast monsoon seasons. (Malaysian Meteorological Department, unpublished)

2.3.1 Sunshine and Surface Temperature

Peninsular Malaysia naturally gets direct sunlight all year. The cloud cover cuts off a substantial amount of sunshine and thus solar radiation. On the average, Malaysia receives about 6 hours of sunshine per day. There are, however, seasonal and spatial variations in the amount of sunshine received. Surface temperature in Peninsular Malaysia has been studied by Dale (1963). The annual mean temperature for the country as a whole is around 26.5 °C. Being located in the equatorial region, the annual temperature range is small and mainly falls within 2°C to 3°C. (Lim & Azizan, 2004).

2.3.2 Rainfall Distribution

The seasonal wind flow patterns coupled with the local topographic features determine the rainfall distribution patterns over the country. During the northeast monsoon season, the exposed areas like the east coast of Peninsular Malaysia, experience heavy rain spells. On the other hand, inland areas or areas which are sheltered by mountain ranges are relatively free from its influence.

The seasonal variation of rainfall in Peninsular Malaysia is of three main types:

(a) Over the east coast states, November, December and January are the months with maximum rainfall, while June and July are the driest months in most districts.

(b) Over the rest of the Peninsular, with the exception of the southwest coastal area, the monthly rainfall pattern shows two periods of maximum rainfall separated by two periods of minimum rainfall. The primary maximum rainfall generally occurs in October - November while the secondary maximum generally occurs in April - May.

Over the northwestern region, the primary minimum occurs in January - February with the secondary minimum in June - July while elsewhere the primary minimum occurs in June - July with the secondary minimum in February.

(c) The rainfall pattern over the southwest coastal area is much affected by early morning "Sumatras" from May to August with the result that the double maximum and minimum rainfall pattern is no longer distinguishable. October and November are the months with maximum rainfalls and February the month with the minimum rainfall. The March - April - May maximum and the June -July minimum rainfalls are absent or indistinct. (Malaysian Meteorological Department, unpublished).

However, weather patterns in Peninsular Malaysia will also be affected by climate change and global warming, like temperature, precipitation, sea level rise and more frequent catastrophic events. So, we cannot predict weather conditions in Peninsular Malaysia nowadays.

Figure 2.2: *Amorphophallus* sp. **A**. vegetative habit x 1/20 **B**. flowering habit x 1/18 **C**. fruiting habit x 1/0 **D**. part of leaf x 1/6 **E**. detail of leaf x 2/3 **F**. part of leaf x 1/6 **H**. detail of petiole x 2/3 **J**. detail of petiole x 2/3 (Extracted from Mayo, Bogner & Boyce, 1997)

Figure 2.3: *Amorphophallus* sp. flowering **A**. inflorescence x 1/3 **B**. inflorescence x 1/3 **C.** spadix x 2/3 **D**. inflorescence x 1/3 **E**. inflorescence x 2/3 **F.** detail of fertile part of spadix x 3 **G**. inflorescence x 1/8 **H**. Inflorescence x 1/6 **J**. detail of spadix appendix x 2/3 **K**. inflorescence x 2/3 **L**. inflorescence x 2/3 **M**. detail of fertile part of spadix and base of appendix x 3 **N**. Inflorescence x 1/6 (Extracted from Mayo, Bogner & Boyce, 1997)

2.4 ECOLOGY AND CONSERVATION of *Amorphophallus*

The majority of *Amorphophallus* species seems to be pioneers in disturbed vegetations and secondary forests. Many are found at forest margins, on steep slopes, in disturbed parts of primary forest, sometimes in very exposed parts in limestone areas, also in waste places or areas in human habitation (Mayo et al. 1997). Only a few species are known to live in dense forest. Species may be found in soils on granitic bedrock, but more often in limestone areas. (Hetterscheid & Ittenbach, 1996). In this research, we will find out more especially common species from Peninsular Malaysia.

The altitudinal range varies from sea level to about 3,000 meters. Flowering starts mostly just prior to the onset of the rains. In Asia, flowering specimens that are effectively pollinated will not develop leaves anymore in that season except for three 'evergreen' species, namely *A. paeoniifolius*, *A. oncophyllus* and *A. prainii*. However, observations on pollination are scarce for *Amorphophallus* species. Equally little is known about the distributors of *Amorphophallus* seeds, although no one doubts that birds are the main group of dispersal agent. This is due to the quite strongly and brightly colored berries of the infructescence. (Hetterscheid & Ittenbach, 1996).

2.5 CULTIVATION

The majority of *Amorphophallus* species are quite easy to grow, provided a minimum of conditions are met. These are roughly a soil rich in organic matter and sufficient trace elements, the use of additional fertilizer, shading against direct sunlight, a minimum temperature of 22ºC during the day time and 19 ºC during the night, a well defined resting period, and a severe regimen against pests, preferably aimed at prevention. With these requirements, roughly 80% of all *Amorphophallus* species can be grown successfully. The age of *Amorphophallus* species is measured by the increase of the size of the tuber every season, especially in young to submature plant. The tuber may increase its weight up to three times per season. (Pitojo, 2007).

In Southern China, *Amorphophallus konjac* (konjac) has been traditionally intercropped with tall grain crops such as maize and sorghum (Long, et al., 2003), to protect the plant from direct sunlight. In mountainous regions of Japan (Gunma Prefecture) where konjac is not truly hardy, it is overwintered by mulching heavily with grain straw or wild herbs (Brown, 2000). The bacterial soft rot erwinia (*Erwinia carotovora*) is the main disease problem with konjac. In Japan, soils are fumigated prior to planting in conjunction with crop rotation to control such soil-borne diseases (Follett & Douglas, 2002).

The content of glucomannan, the storage carbohydrate within the developing tuber, changes throughout the growing season and is highest just before the foliage dies off, prior to dormancy (Brown, 2000). In modern Japanese practice ("Uedama"), older tubers are sold after harvesting and the remainder are kept frost free (5–7 ◦C) during the winter months in aerated storage rooms (Douglas et al., 2006; Follett & Douglas, 2002; Kurihara, 1979). In Southern China, the tuber may be left all year in the field to continue growing to the next season (Brown, 2000; Kurihara, 1979) and are usually harvested for domestic use when they weigh 200 g, which may occur after one year of growth, or are left for three years and harvested when the tuber is approximately 2 kg in weight for commercial processing (Brown, 2000). *Amorphophallus* species needs to be grown for one or more years to achieve a marketable crop which is dependent on the size and quality of the planted tuber.

2.6 PLANTING of *Amorphophallus* spp.

The top surface of an *Amorphophallus* spp. tuber must be below the soil surface, since the roots emerge from the top and must secure the tuber to hold the long leaf or inflorescence. For this purpose the first roots grow very fast and horizontal. After they have reached full length, they start to contract and so secure and stabilize the corm and the developing leaf. This is necessary because the developing leaf depletes most or the entire old corm. This entire structure is very unstable and has a great need for the contractile roots. Those species producing elongated corms need very deep and huge pots to accommodate the strong vertical growth. When the pot is not deep enough, the base of the corm will get cramped against the bottom of the pot and becomes deformed. This however does not usually impede the health of the corm. The problem may occur when the excess water in the bottom of the pot may cause local rotting of parts of the corm. (Hetterscheid & Ittenbach, 1996)

Like some other genera of the family, species of *Amorphophallus* does not produce the leaves and the inflorescences together. The inflorescence is produced first and lasts only for a short period on the matured plants.

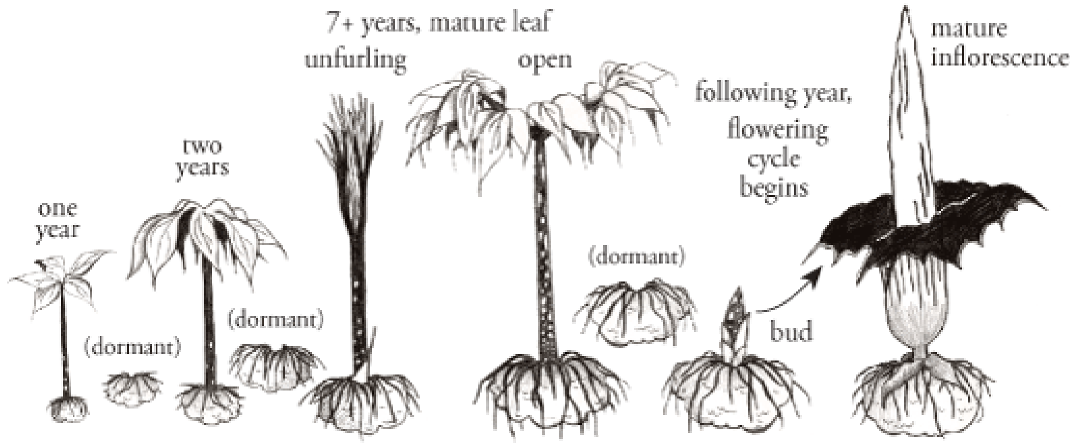

Figure 2.4: Growth stages of *Amorphophallus* spp.
(Adopted from http://greenhouse.ucdavis.edu/conservatory/)

2.7 GLUCOMANNAN (GM)

The edible part of *Amorphophallus* sp. is the tuber or better known as corm. The corm can be eaten when it is peeled and thoroughly boiled or baked to remove the itchy crystal part that contains calcium oxalate. This substance is toxic when fresh and, if eaten, makes the mouth, tongue and throat feels as if hundreds of small needles are digging into them. *Amorphophallus* sp. has long been used in China, Japan and South East Asia as a food source. One of the most valuable component found in the *Amorphophallus* sp. tuber is glucomannan (GM). Glucomannan is a water-soluble dietary fibre that is derived from idioblast cell inside the *Amorphophallus* sp. tuber. The glucomannan content was about 5–9% (w/w) of original *Amorphophallus* sp. tubers. (Tien An et al. 2009) Glucomannan has been used in Asia for centuries as traditional foods, such as noodles, tofu and heat stable gelled food products. Glucomannan is a natural vegetable gum, also called Konjac glucomannan, be affirmed as GRAS (generally recognize as safe) for use as food ingredient since 1997. It is generally used in the food industry as a gelling agent, thickener, film former, emulsifier, stabilizer and soluble fiber source. GM has applications in many areas of the food industry as a food additive including bakery products, beverages, breading and batters, candies and confections, condiments, dairy products, processed foods, salad dressings, soups and gravies, snack foods, frozen & refrigerated entrees, and many other products (Chua et al. 2010).

Table 2.1: Glucomannan as a valuable natural food additive. (Extracted from http://www.worldfoodscience.org/ cms/?pid=1003556)

Application	Main function
Pharmaceutical	
Capsule	Gelling and elasticity
Tablet	Binder
Syrup	Conditioner
Flour Products	
Noodle and pasta	Moisture Control; increase elasticity
Frozen dumpling wraps	Resist damage from freeze/thaw cycles
Dairy	
Yoghurt	Stabilization
Pudding	Gelling
Ice-cream	Resist freeze/thaw deterioration
Bakery	
Bread	increase bread volume
	Dough extender and conditioner;
Water Gel Dessert	Gelling
Edible Films	Film Forming
Drinks	
Still drinks	Thickening, mouth feel
Juices	Thickening, mouth feel
Meat and Fish	
Canings	Gelling
Minced Meat	Meat particle adhesion
Sausage	Meat adhesive and fat substitute
Meat Substitute	Oil and fat replacer

The unique rheological and gelling properties of GM are broadly used in emulsifier and stabilizer products for the food, drink, cosmetic and pharmaceutical industries. Since 1994, GM has been approved as a food additive by the U.S. Food and Drug Administration (FDA) (Takigami, 2000; Zhang et al. 2005). In 1996 it was also passed as a binder in meat and poultry products by the U.S. Department of Agriculture (USDA). In Europe, GM has been given an E425 agreement number by the European Food Safety Authority (EFSA) (FSA, 2007).

The development of commercial *Amorphophallus konjac* processing technologies originated in Japan. Nakajima (1745–1826) developed a technique to produce konjac flour by pulverising dried chips of the tuber. This was further improved by Mashiko (1745–1854) who developed the methodology to produce purified *Amorphophallus konjac* flour, commonly known as GM (Takigami, 2000).

GM (Figure 2.5) is composed of β-1,4-linked D-glucose and D-mannose residues as the main chain, with branches through β -1,6-glucosyl units. The degree of branching is estimated at approximately 3 for every 32 sugar units. It consists of mannose and glucose units in a molar ratio of 1.6:1 and the acetyl groups along the GM backbone which contribute to solubility properties which are located at every 9 to 19 sugar units at the C-6 (Nishinari et al. 1992). The molecular weight of GM ranges from 200 to 2000 kDa, varying with cultivars, origin, processing method and storage time (Sugiyama et al. 1972). GM is dispersible in hot or cold water and forms a highly viscous solution in a pH range between 4.0 and 7.0 (Vanderbeek et al. 2007). Solubility is increased by heat and mechanical agitation (FCC, 1996). The viscosity of GM solution will reduce upon storage, possibly by bacterial or enzymic (β-mannanse) hydrolysis (Nishinari et al. 1992).

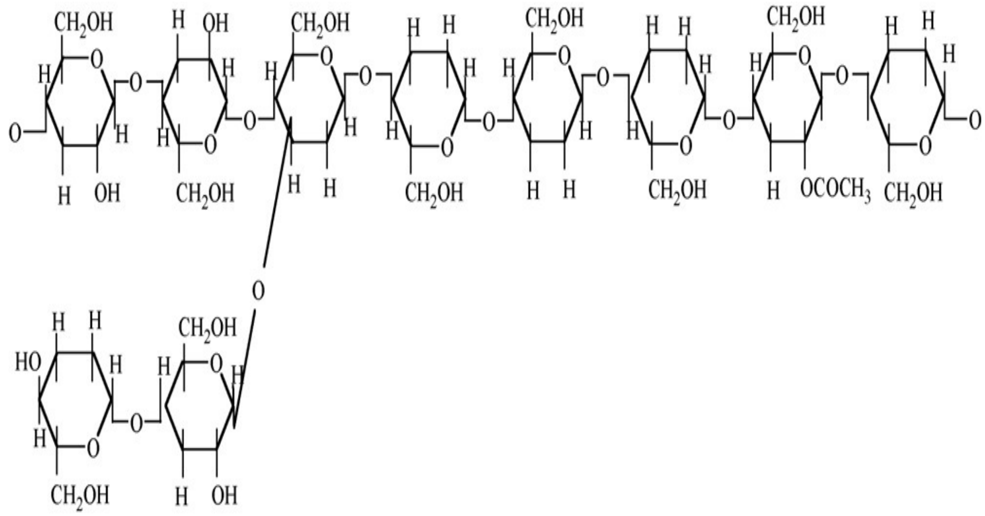

Figure 2.5: Chemical structure of Glucomannan (Adopted from Okimasu & Kishida, 1982).

Table 2.2: Nutrient content in *Amorphophallus* sp. corm compared to sweet potato (*Ipomoea batatas*) and cassava (*Manihot esculenta*) (Extracted from Pitojo, 2007)

No	**Nutrient/ Species**	***Amorphophallus* sp.**	***Ipomoea batatas***	***Manihot esculenta***
1	Calory (cal)	69	101	123
2	Protein (g)	1.0	2.0	1.8
3	Fat (g)	0.1	0.2	0.7
4	Carbohydrate (g)	15.7	19.8	27.8
5	Calcium (mg)	62	45	30
6	Fosforus (mg)	41	280	49
7	Iron (mg)	4.2	1.8	0.7
8	Vitamin A (SI)	0	0	60
9	VitaminB1 (mg)	0.07	0.1	0.09

10	Vitamin C (mg)	5	9	22
11	Water (g)	82	75	68.5
12	Parts can be eaten (%)	86	86	86

2.7.1 Medicinal Uses of Glucomannan (GM)

Since early 1960's, many scientists worldwide studied the functional health properties of dietary fiber and its possible role in relation to certain diseases such as cardiovascular disease, coronary heart disease (CHD), stroke, sudden death, hyperlipidemia, hypercholesterolemia, diabetes, obesity, and colon cancer. While the causes may vary from one person to the next, diet is considered to be one factor and there is increasing evidence that intake of dietary fiber is a beneficial factor. American Diabetes Association, Cancer Association, National Cancer Institute and the other international food and nutrition organization have presented various scientific papers to advocate the advantages of increasing intake of food fiber. This viewpoint was firstly accepted by the developed countries, giving rise to large demand for food fiber and related health products.

The main quality requirements of Konjac Soluble Fibre are ; High viscosity of 1% aqueous solution, over 18,000 cps, no odour, sulphur dioxide less than 20 ppm, and close to zero plate count.

Konjac soluble fiber can be consumed in powder or capsule form. Generally, other potential benefits are (Extracted from http://www.worldfoodscience.org/cms/?pid=1003556):

- Regulation of lipid metabolism, reduce blood lipid and cholesterol.
- Reduction of blood glucose.
- Reducing risk of constipation and cancer of lower digestive tract.
- Improvement of diet for diabetics.

In traditional Chinese medicine (TCM), a gel prepared from the flour has been used for detoxification, tumour-suppression, blood stasis alleviation and phlegm liquefaction; and for more than 2,000 years has been consumed by the indigenous people of China for the treatment of asthma, cough, hernia, breast pain, burns as well as haematological and skin disorders. (Melinda et al. 2009).

2.7.1.1 Anti-obesity Activity of Glucomannan (GM)

A study by Walsh et al. (1984) showed a significant mean weight loss using glucomannan over an eight-week period. Serum cholesterol and low-density lipoprotein cholesterol were also significantly reduced in the glucomannan treated group. There are also no adverse reactions to glucomannan reported in the study.

The highly purified form of *Amorphophallus* sp. soluble fiber with a neutral taste is an excellent fiber source. Its ability to absorb 200 times its weight of liquid is advantageously enabling it to act in the digestive tract to absorb bile acid. It also contributes a feeling of satiety which helps in dieting for weight reduction. The GM also behaves as a prebiotic in the intestine for *Bifidus* (gut bacteria) growth. (Gallaher et al. 2000)

A review of studies (seven clinical trials with an average sample size of 39 participants) using GM for the treatment of obesity as well as studies of its mechanism(s) of action (Keithley & Swanson, 2005), concluded that GM has the properties that promote weight loss when used in conjunction with either a normal caloric or a hypocaloric diet. The possible mechanisms of action of GM for weight loss are by promotion of satiety via induction of cephalic and gastric-phase signals, delayed gastric emptying and slowed bowel transit time due to the increased viscosity of gastrointestinal content, as well as reduced rate of food absorption in the small intestine leading to attenuated postprandial glucose and insulin surges (Keithley & Swanson, 2005; Kraemer et al. 2007). Kraemer et al. (2007) studied the effects of adding a total body exercise program to an eight week diet supplemented with GM (3 g/day) on weight loss, body composition and blood lipid parameters in overweight men and woman. A dietary intervention with GM alone promoted reductions in body mass, fat mass and total cholesterol (TC). The inclusion of exercise three days per week resulted in further improvements in body composition and significantly improved high-density lipoprotein cholesterol (HDL-C)/TC ratio. In addition, the authors also pointed out that the addition of exercise to a diet containing glucomannan significantly augmented the reduction of leptin, an adipose derived hormone produced by the adipocytes, which regulates body mass via energy expenditure and intake (Kraemer et al. 2007)

2.7.1.2 Laxative Effect of Glucomannan (GM)

Chronic constipation is a very frequent disease in western countries but fibers can often solve the problem. A study by Passaretti et al. (1991) showed the efficacy and the acceptability of glucomannans, a hydrophylic carbohydrate, with a high degree of viscosity showing a statistically significant improvement in 93 patients affected with chronic constipation. Glucomannans were well accepted and devoid of relevant side-effects such as fecal impaction.

Mann and Truswell (2007) reported that dietary fiber has a significant role to play in the management of constipation and an average intake of about 18–27 g/day of fiber has shown to be effective in treating constipation. The mechanism(s) responsible for the laxative effects of dietary fibers include the increase of colonic content leading to colonic propulsion which promotes defecation; the stimulation of colonic motility by fibers and end products of fiber fermentation as well as an increase in bowel movement (Chen et al., 2006). Chen et al. (2006, 2008) concluded that 1.5 g GM powder per meal could be an optimum supplementation dosage and that the ability of GM supplements to promote defecation frequency results primarily from the increased stool bulk and improved colonic ecology.

2.7.1.3 Anti-hyperglycemic and Hypercholesterolemia Activities of Glucomannan (GM)

A study by Huang et al. (1990) showed that GM food is very useful in the prevention and treatment of hyperglycemia. The rheological properties of dietary fiber are proposed as an important mechanistic factor in reducing postprandial increases in plasma glucose and insulin concentrations in both normal and diabetic individuals. Vuksan et al. (2001) evaluated the use of GM as an alternative therapy for type 2 diabetes mellitus by comparing the viscosity of GM with other soluble fibers such as psyllium and xanthan at 1% (v/v) concentration. The flattening of postprandial glycemia following 20 g of glucose challenge and 3 g of each fiber added, closely mirrored the relative viscosity of the fibers with GM demonstrating the greatest effect followed by xanthan and psyllium.

Another study by Brighenti et al. (1999) to examine whether GM fiber improves metabolic control as measured by glycemia, lipidemia, and blood pressure in high-risk type 2 diabetic patients, showed that GM fiber added to conventional treatment may ameliorate glycemic control, blood lipid profile, and systolic blood pressure (Sbp) in high-risk diabetic individuals, possibly improving the effectiveness of conventional treatment in type 2 diabetes.

2.7.2 Other Uses of Glucomannan (GM)

Glucomannan and its derivatives were also used in many other applications. They can be used as biodegradable resin compositions (Tokiwa & Tsuchiya, 2003), soil modifier (Wakisaka et al., 2000), in soil amendment (Takada-Oikawa et al., 2000), and a surface size composition for the surface sizing of paper, board or other similar material (Kimpimaki et al., 2001). Glucomannan can also be used as fish lure (Igarashi et al., 2001). In addition, glucomannan powder can be mixed with powdery or granular charcoal and water and press-molded to charcoal shaped products having excellent properties in dehumidification, deodorization, sound absorption, and electromagnetic shielding and are suitable for building materials, water treatment, and pet care products. (Morita et al., 2001). In recent years, greater attention has been focused on the development and exploitation of glucomannan and its derivatives.