



A White Paper on the SawaTM 100% Pure *Wasabia japonica* rhizome powder as both a Food and a Nutraceutical Product.

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OVERVIEW



SawaTM is a 100% natural, and science-backed, dietary ingredient made from the plant rhizome of *Wasabia japonica*, more commonly known as wasabi or Japanese horseradish. This paper discusses its background as traditional health food, and data from basic and clinical research that supports SawaTM as a novel Nutraceutical ingredient with multiple health benefits. Suggested usage and dosage of SawaTM will also be noted.

This paper will familiarize the reader with this exciting Nutraceutical, provide a snapshot of current research, and discuss the potential of SawaTM to become a new stand-alone product or as a novel addition to an existing formulation.

WASABIA JAPONICA BACKGROUND

Wasabia japonica (wasabi) is best known as an ingredient in Japanese food, in particular, as a condiment for sushi and sashimi. Its characteristic bright green colour of wasabi can be immediately recognised, and its spicy flavour, similar to horseradish, can quickly clear out the sinuses. But what many people don't know is that wasabi harbors a wide spectrum of bioactive agents. The ingredients contained within the *Wasabia japonica* rhizome includes potent anti-oxidant, liver-protective, anti-inflammatory, anti-proliferative, immunomodulatory, neuritogenic (enhancing neurite growth), and anti-bacterial activities and continuing scientific research is underway to discover how these bioactivities are relevant to human health.

ABSTRACT

Wasabi, Japanese Horseradish (*Wasabia japonica*) is a perennial plant native to Japan, although China is now also claiming it as a native. It has been cultivated in Japan for more than a thousand years and is now being grown in a number of other countries including New Zealand, China, Vietnam, Canada, United Kingdom and Australia as interest in Japanese cuisine expands, and the health benefits of consuming *Wasabia japonica* become better known.

Wasabia japonica can be grown in a number of ways, in water (Sawa wasabi) or in soil (Oka wasabi). The unique flavour of *Wasabia japonica* comes from isothiocyanates (ITCs) which are produced by the action of water on a mixture of precursor Glucosinolates and the enzyme myrosinase when the tissue is disrupted. ITCs found in *Wasabia japonica* are volatile, possess strong pungent smells and are toxic at very high intakes [Allyl ITC is the infamous Mustard Gas of WWI]. The overall flavour of *Wasabia japonica* depends on the mixture of individual ITCs. Allyl ITC is found in the highest concentration in all tissues, ranging from 86 - 92% of the total ITC content. (22, 23) Apart from flavouring sauces and foods, the three unique *Wasabia japonica* Isothiocyanates (ITCs) have significant anticancer and health benefits for the human body. ITCs can also counter inflammatory conditions like asthma and anaphylaxis. ITCs have also been shown to inhibit platelet aggregation in the blood.

Wasabia japonica is a valuable crop that can be processed into a tasty condiment, and as a very useful dietary supplement for many ailments. Its production and consumption will continue to increase as it becomes more appreciated in Western cuisine and health circles.

INTRODUCTION

History

Wasabia japonica, known as Japanese Horseradish (*Wasabia japonica*) is a native condiment crop of Japan and is regarded as a National Treasure. It is not known when *Wasabia japonica* was first brought into cultivation but Japanese historical records indicate that *Wasabia japonica*, known originally as wild ginger, was introduced as a medicinal plant by Sukahito Fukae. The first Japanese medical encyclopedia called “Honzo-wamyo” was published in A.D. 918 and it states that “wild ginger” (*Wasabia japonica*) had been grown in Japan for at least a thousand years (1). During 1596-1615 A.D. *Wasabia japonica* cultivation began on the upper reaches of the Abe River in Shizuoka prefecture. Its use, however, was restricted to the ruling class by order of the Shogun Ieyasu Tokugawa (2). At present, the natural distribution of *Wasabia japonica* in Japan ranges from Russia’s Sakhalin island, north of Hokkaido (the most northern Japanese island) to Kyushu (the southernmost major Japanese island) (3). However, the Shimane region is the largest area of *Wasabia japonica* production and breeding research in Japan at present.

Wasabia japonica is now being grown in many countries in the world including New Zealand, Taiwan, Korea, Israel, Brazil, Thailand, Canada, United Kingdom and the USA. In New Zealand, the Ministry of Agriculture and Fisheries introduced *Wasabia japonica* for experimental cultivation in 1982 (4). Agronomic investigation of this crop was stimulated by commercial interest in 1986 (5,6).

[New Zealand Wasabi Limited](#)* started commercial development of a hydroponic growing system for wasabi in 1990, with their first commercial sales in 1994. This company has now grown into the largest supplier of Sawa (water grown) wasabi in the Southern hemisphere (49). The majority of their products are used in Nutraceutical products due to its high level of active constituents. Preliminary assessment of the growth and plant yield of soil-grown *Wasabia japonica* was carried out at Lincoln in 1995 (7). Yields of flavour compounds, as affected by fertilizer treatment, were carried out in 1997 (8, 9). Further research has been performed at Lincoln University to develop an understanding of *Wasabia japonica* growing in New Zealand, especially the agronomy, cultivation methods, ITC variation and stability (10).

* New Zealand Wasabi is now part of [World Wasabi Inc.](#)

Botany of wasabi

Wasabia japonica is a member of the *Cruciferae* family which also includes cabbage, cauliflower, broccoli, sprouts, water cress, radish, mustard and horseradish. The European horseradish (*Armoracia rusticana*) is a distant cousin of *Wasabia japonica* and is often coloured and mixed with mustard and other ingredients to produce a “fake” **wasabi** (50).

The genus *Wasabia* consists of two species, *Wasabia tenuis* (an uncultivated species) and *Wasabia japonica* (the cultivated species). These two species are distinguished primarily by their cytology, stem size, colour, leaf size and shape (3).

Wasabia japonica is a glabrous (free from hair or down; smooth), perennial herb that grows about 450 mm high, producing leaves on long petioles (leaf stalks) from the crown of the plant. As the plant ages the rhizomes start to form and, at maturity after 18 months, the *Wasabia japonica* plant has a distinctive thickened stem (or rhizome) connected to the heart shaped leaves by long, thin petioles (Figure 1).



Figure 1. A *Wasabia japonica* plant (with hair roots removed).

Rhizomes are the most favoured plant part of *Wasabia japonica*. Dependent upon the variety, the plants have one or more main rhizomes and can have a number of secondary stems (7).

The lengths and weights of rhizomes vary widely between variety e.g. for Daruma – the single rhizome length ranges from 50 to 200 mm long and weighs 4 to 120gm. [New Zealand Wasabi has exhibited Daruma rhizomes over 600mm long and weighing 1.2 Kg at a number of International Trade Shows]. *Wasabia japonica* leaves are simple, cordate-reniform, undulate-toothed and 80-250 mm in diameter. Petioles are vertical to oblique, 300 – 500 mm long, basally flattened and surround the rhizome. Whole fresh plants can weigh up to 6.0 kg (3).

Wasabia japonica flowers are white, bracteate, arranged on racemes, with ascending sepal, cruciform and obovate petals, perfect septum, elongate styles and simple stigma (3).

Fertilisation is mainly by cross pollination, and insects. Seeds must be stored in a cool moist environment, since dry storage will result in desiccation and loss of viability of the seed. Fresh seed is naturally dormant until it is vernalised by storing at a low temperature (5). Fresh seed is notoriously difficult to germinate, and germination methods are closely guarded by growers.

***Wasabia japonica* cultivars**

In Japan a cultivar is usually named after its region of cultivation and *Wasabia japonica* cultivars are considered regionally specific in Japan. Seventeen *Wasabia japonica* cultivars have been developed and each has a strict cultivation and climate requirement that limits major cultivation to distinct areas (3). Specific regions and individual farmers produce their own unique cultivars as a result of persistent inbreeding and selection. According to some Japanese farmers *Wasabia japonica* has eight well-known cultivars which are Mazuma, Daruma, Takai, Shimane, Midori, Sanpoo, Izawa Daruma and Medeka. These cultivars were developed in the Shizuoka and Shimane prefectures. Another important cultivar 'Hangen' comes from the Kanagawa prefecture.

Daruma is the most popular variety, known to grow well under marginal environmental conditions, such as warmer temperatures. It was developed by plant breeders based in the Shimane Research Station. This variety produces a single rhizome and can be stored longer than most of the other varieties. It also contains a lower amount of ITCs and is used mainly as a table vegetable, being freshly grated when required. A large amount is also used for processing purposes.

For poor quality locations the Shimane Wasabi Research Station developed Fuji Daruma, Izawa Daruma, Ozawa Daruma and Sanpoo in Shimane. However, all Shimane cultivars produce high quality rhizomes. Mazuma was developed in Shizuoka (but was originally grown in Wakayama and Okutama) and overseas research suggests that it has more heat tolerance than the Daruma cultivars although no published data can be found to verify this. In New Zealand, Daruma is the main commercial cultivar of *Wasabia japonica*.

[New Zealand Wasabi](#) has trialed all available varieties (some not mentioned above) in their hydroponic operations and selected the best variety for their own use of providing the maximum ITC concentration.

Cultivation of *Wasabia japonica*

In Japan, *Wasabia japonica* sometimes grows naturally in the gravel beds of mountain streams and is highly adapted to this environment. For commercial *Wasabia japonica* growing two types of cultivation methods are used. These are soil grown ***Wasabia japonica* (Oka)** and water grown ***Wasabia japonica* (Sawa)**. Japanese growers select the method depending on where they live and the particular end use of the plants after harvest. Most *Wasabia japonica* farms are kept in the family and the last *Wasabia japonica* growing bed was reputed to be built alongside a mountain stream over 200 years ago. Due to the effects of acid rain and the weather in the mountains of Japan, a number of family farms are now being abandoned as younger members of the family immigrate to the cities.

Wasabia japonica plants grown in the soil require large amounts of organic fertiliser added to the soil before planting, and also require ongoing herbicides and pesticides used to maintain the health of the plants. Being a member of the cabbage family it is susceptible to the diseases of that family. The ground also needs to be kept damp at all times as the plant is regarded as semi-aquatic in its growth characteristics. It is regarded as good practice that the growing plot be abandoned after three harvests and not returned to for at least ten years.

If *Wasabi japonica* is grown in running water then less fertilisation needs to be used, although it is known that some Japanese and Chinese farmers will put sacks of chicken manure or blood and bone upstream from their farms to make the *Wasabia japonica* grow faster. Less pesticides and herbicides are used with this growing method, although the environmental impact is just as great. Faster growing means lower ITC levels.

All parts of the plant can be used for a number of products. The rhizome is the preferred part of the plant as it has the most active ingredients, but the petiole, roots and leaves are also used in different products.

Most of the plant is used in food products, although now more and more of the rhizome is being used for Nutraceutical purposes. This was not the case in 1993 when the rhizome was only used for food products (3). The leaf and stem were pickled and only readily available in Japan, this is known as wasabi zuke.

The general consensus is that water grown *Wasabia japonica* (Sawa) produces larger rhizomes with more active ingredients, and for that reason is highly sought after and, therefore, command higher prices. It is also more difficult to obtain and grow to maturity.

Soil-grown *Wasabia japonica*

Wasabia japonica requires specific environmental conditions to thrive. Soil-grown ***Wasabia japonica*** requires an air temperature from 6 - 20°C with 8 - 18°C considered optimal. Soils containing well rotted organic material with a pH 6 - 7 are considered best. It is most often grown on well-drained soil under mulberry or plum trees in Japan, whereas in New Zealand and China soil-grown *Wasabia japonica* is usually grown in shade houses rather than under trees.

Water grown *Wasabia japonica*

Water grown *Wasabia japonica* requires air temperatures ranging from 8 - 18°C. However, a narrower range of temperatures (12 - 15°C) is considered ideal. An air temperature of less than 8°C inhibits plant growth and at less than 5°C plant growth ceases. Other environmental factors can have an effect on the growth of *Wasabia japonica* and need to be considered carefully e.g. light levels, stable water temperature, good nutrient supply, and well aerated, neutral or slightly acidic pH water containing a high dissolved oxygen level and a large supply of water to maintain consistent flow (this particularly depends upon the growing system being used).

Rainfall accumulation is also important, with an even distribution desirable to stabilize the water supply and temperature (3). Spring water is considered best because of its clarity, stable temperatures and high level of oxygen. At warmer temperatures the dissolved oxygen in the water decreases, which inhibits the growth of plants.

Silty or muddy water is undesirable as it may contain insufficient oxygen, but some silt in the water is considered beneficial as a source of nutrients. In Japan, *Wasabia japonica* grows on the wet banks of cool mountain streams and springs in specially built growing beds. Overall, construction, maintenance and establishment of a traditional growing bed was expensive and labour intensive, and the last traditional growing bed was reputedly built over 200 years ago in Japan.

Water grown *Wasabia japonica* is produced in 42 prefectures, and soil grown *Wasabia japonica* in 21 out of 47 prefectures in Japan, which indicates that flooded cultivation is popular and is considered to produce a high quality product. This has now changed due to the Fukushima Daiichi nuclear power plant disaster in 2011 and the associated radioactive contamination of groundwater and large land areas of Japan.

The unique environmental requirements and shortage of cultivatable lands limit *Wasabia japonica* production areas to 880 hectares in Japan (11) and 400 hectares in Taiwan, but demand for *Wasabia japonica* condiments is spreading from Japanese cuisine to modern western food. The increasing interest in *Wasabia japonica* and the inability to expand production in Japan has seen prices rise steadily since 1970 (3). High prices have stimulated research into soil production methods and the investigation of production areas outside Japan. The Japanese have invested heavily in soil-grown *Wasabia japonica* farms in China.

In 1982, the cultivation of *Wasabia japonica* was trialed in New Zealand (6) because of New Zealand's climate (appropriate air temperature range, high quality water, long sunlight hours), which meets the ideal requirements for growing quality *Wasabia japonica* outside Japan.

However, the area of soil grown *Wasabia japonica* is increasing in Taiwan, China, Vietnam, Colombia, Canada, Korea, Thailand and USA. The expansion in soil-grown *Wasabia japonica* is mainly to reduce the high initial cost of water-grown *Wasabia japonica* establishment and associated high labour costs. Although long term the costs are consistent with each other, with a higher return being obtained for the Sawa *Wasabia japonica*, the better long term investment is in becoming a [Sawa Wasabi Grower](#).

In 2010 the number of New Zealand growers has fallen to the point where there is one major grower, processor and marketer (49), with a few smaller growers growing under contract. The regulatory environment in New Zealand stifles the expansion of the industry there, even though the water growing systems developed there lead the world (49). It is anticipated that within the next decade the New Zealand production of high quality *Wasabia japonica* will cease and the fledgling industry will vanish, although the [technology is being licensed worldwide](#). All of the IP generated by New Zealand Wasabi and the Van Mellaerts family are now part of [World Wasabi Inc](#). All enquiries regarding this IP should be directed to [World Wasabi Inc](#).

Uses of *Wasabia japonica*

Wasabia japonica adds a unique flavour, heat and greenish colour to foods and, thus, it is a highly valued plant in Japanese cuisine. *Wasabia japonica* is described as having 'a sharp hot taste with a pungent smell' but the heat component in *Wasabia japonica* is different from chilies, and the hotness quickly dissipates in the mouth leaving an extremely pleasant mild sweet vegetable taste, with no burning sensation at all. *Wasabia japonica* adds aesthetic and culinary appeal to many foods and is considered a staple condiment in the Japanese diet. Recently, it has found widespread appeal in western cuisine due to its ability to change an ordinary dish to an extra special one by improving the taste (with addition of a spicy flavour) and eye appeal i.e. by decorative contrast of the light green colour. As a result, it has become a new culinary flavour for the rest of the world.

All the plant parts of *Wasabia japonica* possess some flavour but vary in the sharpness they deliver (8,12) and are, therefore, used for different purposes. Basically, *Wasabia japonica* can be used in five ways. Three of these relate to food, and the fourth relates to health. The fifth is its use in cosmetics and topical preparations. The food uses are as a condiment on the side of a dish, as a spice or herb in a dish and as *Wasabia japonica* flavour in processed foods. Rhizomes are grated using a fine grater (such as sharkskin) to prepare fresh paste to be placed in a mound on a dish next to sliced raw fish (sashimi), spread on the raw fish in sushi preparations, or served on a small dish to accompany a bowl of cooked noodles (3). Sometimes grated *Wasabia japonica* is mixed with other ingredients like soya sauce and vinegar to prepare a dip for use with raw fish or other dishes, according to individuals' choice. Tofu (soybean curd) is often decorated with grated *Wasabia japonica*.

Wasabia japonica petioles and leaves are pickled in sake brine or soya sauce and are popular accompaniments for white rice. Sometimes fresh leaves are used in salads and dried leaves are used to flavour cheese, salad dressings or crackers. *Wasabia japonica* petioles and leaves are also used in cosmetics and for Nutraceutical use for various ailments.

A *Wasabia japonica* wine is sold in some Japanese specialty stores. A [high alcohol content *Wasabia japonica* spirit](#) was released in London in May 2010 to high acclaim. This product which was developed in New Zealand is now being sold in the European Union (51) and worldwide.

All grades and parts of the *Wasabia japonica* plant are commonly mixed with European horseradish (*Armoracia rusticana*) powder, mustard and food colour to produce ‘fake wasabi’ paste in tubes or to sell as **fake wasabi** powder. Around the world, a variety of genuine *Wasabia japonica* flavoured quality products e.g. sauces, pastes and mayonnaise have been developed to add to snacks and foods, as well as being sold in their own right.

Genuine *Wasabia japonica* products contain only ***Wasabia japonica*** and are not diluted with European horseradish, beet extracts or mustard. If possible avoid **wasabi** products that are highly coloured with artificial additives (either bright green, blue or yellow) as many of these products also contain other sources of flavours which interfere with the clean taste of 100% Pure *Wasabia japonica*, and are known carcinogens. There are now a number of websites that review products that purport to be wasabi or contain wasabi (50, 52).

There is an interesting story of the arrival of wasabi into the Western diet on the <http://www.worldwasabiecouncil.com/info.html> website.

Wasabi paste preparation using fresh wasabi rhizome

In traditional Japanese cuisine, *Wasabia japonica* is prepared by grating the fresh stem against a rough surface, such as a ginger grater, in much the same way as horseradish is prepared (3). The traditional method in Japan is to use sharkskin or “oroshi” as a tool for grating *Wasabi japonica* rhizome and is still regarded as the preferred method of obtaining the best flavour, texture and consistency in freshly ground *Wasabia japonica*.

Using a sharkskin grater and keeping the rhizome at a 90° angle to the grating surface is reported to minimize the volatiles’ exposure to the air. It is also stated that, in this way, the volatile compounds are allowed to develop with minimal dissipation.

The use of sharkskin graters deplete the oceans of sharks and using a nutmeg grater produces just as fine a wasabi paste without killing any sharks.

In Japan and the rest of the world, **wasabi** paste is commercially prepared using mincers or grinders to finely grind the rhizomes and other parts of the plant, and then it is mixed with other ingredients depending on the end use of the paste (50).

Flavour constituents of *Wasabia japonica*

Isothiocyanates (ITCs) are a group of naturally occurring sulphur compounds responsible for the characteristic flavour of *Wasabia japonica* (13 -15). The compounds are volatile in nature and are evolved from plant tissues when they are disrupted, e.g. in the preparation of food, grating, cutting, chewing etc.

However, plant tissues do not contain ITCs, but contain Glucosinolates which are the precursors of ITCs. Glucosinolates (GSL) are a group of glucosides, (i.e. they contain glucose in the structure), stored within the cell vacuoles of all *Crucifereae* plants (14).

Glucosinolates are a complex group of β -D thioglucose compounds synthesised from amino acids (8). They contain a sulphonc group which is usually bound to sodium or potassium, making then anionic (16, 17, 18). The sulphate in the sulphonc group is attached through a C=N bond and different side groups (R) give a wide range of related glucosinolates. Each one

has its own characteristic odour or taste. Due to the presence of the glucose in the molecule glucosinolates are hydrophilic, non volatile compounds (17).

When plant tissues are mechanically disrupted or injured (e.g. by chewing, crushing or grating in the preparation of food or insect attack), the myrosinase is released from the cell wall and in the presence of adequate moisture, myrosinase rapidly hydrolyses the GSLs to yield glucose and a aglucone. Some of the intermediate steps have not been fully described (19, 20). The organic aglucone is unstable and undergoes Lossen Rearrangement (21) to produce sulphate and a variety of other products.

The nature of the products is dependent on the number of factors, including the structure of the GSL side chain, the reaction conditions (e.g. pH), the presence of cofactors (e.g. metal ions, specific proteins), temperature and duration as well as the age and condition of the plant tissues.

Isothiocyanates (ITCs) are formed from GSLs under neutral and alkaline conditions. However, GSLs that contain a α -hydroxyl group in their side chain, give rise to ITCs that spontaneously cyclize to form oxazolidinethiones. Some aromatic and heterocyclic GSLs produce ITCs which are unstable at pH 7 or higher and break down to release the corresponding alcohol and inorganic thiocyanate ions.

However, once formed, ITCs are more stable under acidic conditions. In weakly acidic pH or in the presence of Fe⁺² and/or endogenous nitrile factor, nitriles are produced from aglucone by autolysis instead of ITC, with the liberation of elemental sulphur (20). The relative proportion of ITC to nitriles can vary widely depending upon the conditions of autolysis (20).

Thiocyanate formation is believed to involve a cofactor, which may also be a protein, since it has been shown to be labile to both heat and polar organic solvents. Most of the sulphur containing end products formed by the enzymatic and non-enzymatic reactions of GSLs are volatile (14).

Several ITCs have been reported from previous investigations into *Wasabia japonica* and each ITC has a specific flavour profile (8, 15) with the complete taste of *Wasabia japonica* being derived from the combined tastes and odours of all the ITCs present. A summary of different ITCs reported from previous investigations into the ITC content of *Wasabia japonica* tissue is listed in Table 1.

Table 1: Glucosinolates relative to Isothiocyanates, also Molecular Weights for SawaTM 100% Pure *Wasabia japonica* Rhizome Powder

Glucosinolate	Glucosinolate Concentration (pmol/mg)	%	Corresponding Isothiocyanate	ITC Mol. Wt.	ITC Conc. (ppm)
sinigrin	64,181	73.9	Allyl	99	6,354
Glucohesperalin	7,990	9.2	6-methylsulphinylnhexyl	205	1,638
Glucobrassicinapin	4,913	5.7	4-pentenyl	127	624
Glucosiberin	2,904	3.3	7-methylsulphinylnheptyl	219	636
5-hexenyl	1,811	2.1	5-hexenyl	141	255
Glucoalyssin	1,662	1.9	5-methylsulphinylnpentyl	191	317
Gluconapin	1,489	1.7	3-butenyl	113	168
neobrassicin or 4 MeO brass brassicin	755	0.9	4-methoxy-3-indolylmethyl	218	165
Glucolesquerellin*	450	0.5	6-methylthiohexyl	189	85
neobrassicin or 4 MeO brass brassicin	382	0.4		218	83
Glucoiberin	113	0.1	3-methylsulphinylnpropyl	163	18
Glucoberteroin	86	0.1	5-methylthiopentyl	175	15
7 methylthio heptyl*	55	0.1	7-methylthioheptyl	203	11
Glucoraphanin	35	<0.1	4-methylsulphinylnbutyl	177	6
8-methylthiooctyl*	11	0.1	8-methylthiooctyl	477	5

* Unique to *Wasabia japonica*

Allyl ITC has the main effect on the overall taste of *Wasabia japonica* because it is the ITC found in highest concentration in the rhizomes and other plant tissues (9). Allyl ITC is also found in the highest concentration in horseradish (12). While Allyl ITC is the main flavour component of *Wasabia japonica* due to its pungency, other ITCs, e.g. 6-methylsulfinylhexyl ITC and 7-methylthioheptyl ITC, by giving their characteristic fresh greenish flavour, do contribute significantly to the total taste profile of *Wasabia japonica* (15, 24, 69).

Wasabi has unique myrosinase genes which can be related to vigorous system generating many isothiocyanates in wasabi (67).

Medicinal properties of Isothiocyanates

The medicinal value of chemicals extracted from *Wasabia japonica* were first documented in the Japanese medicinal encyclopaedia during the 10th century (24). Recently, medical research interest in ITCs has become more intense because of their potential to have a wide variety of medicinal, pharmacological or industrial applications. These exciting applications are at an early stage of investigation, most likely because of *Wasabia japonica*'s high present commercial value and scarcity. Because of this scarcity and the fact that the useful ITCs are natural (and can't therefore be patented), more effort is being put into trying to synthesize the ITCs for commercial gain instead of increasing the natural levels found in the wasabi plant.

An interesting use developed to date is the SaWasabi® Manuka Honey and Wasabi Soap that has been developed to assist those people suffering from psoriasis and similar skin problems. Originally, developed for a family member, it is now available over the Internet.

Anticancer effects

Medicinally, the most important feature of ITCs is evidence that they have a chemo preventive effect on cancer at a variety of organ sites including lung, mammary glands, liver, oesophagus, bladder, pancreas, colon and prostate (25). A case-control study in Los Angeles (26) showed that high consumption of *Cruciferae* vegetables containing ITCs reduced the risk of developing **colon cancer** (27 - 31).

Tests have been carried out on tumours in rats and it has been reported that some ITCs have a protective role against breast, stomach and colon cancers in rats (32, 33). Several mechanisms have been proposed and investigated for tumour inhibition by ITCs, for instance *Sulforaphane* (SFN) and phenylethyl ITC (PEITC) are reported as potent inducers of the phase II enzymes involved in detoxification of carcinogens (34). The inhibition of chemically induced lung tumorigenesis by PEITC was mediated primarily by the inhibition of metabolism which resulted in a decrease in O methylguanine in lung DNA, indicating that ITC targets cytochrome P450s (35, 36). Results from recent bioassays in A/J mice appear to support the mechanism of induction of apoptosis in lung by PEITC and butyl ITC (BITC) (37). Extensive research on ITCs commonly found in cruciferous vegetables such as *Wasabia japonica*, watercress, broccoli, Brussels spouts, radish and cabbage have been linked to the reduced risk of certain human cancers (27, 28).

While PEITC is not found in *Wasabia japonica*, the long chain methyl ITCs that are **ONLY** found in *Wasabia japonica* have been found to be 40 times more effective as anticancer agents (54, 55, 56, 57, 58) compared to the next best (*Sulforaphane*) which is found in broccoli and the use of which is controlled by John Hopkins University for commercial gain after the research was funded from the public purse.

From the chemoprevention point of view it is important to know whether the beneficial effects come, at least in part, from ITCs in the diet. In a cohort study it was clearly shown that individuals with detectable levels of ITCs in the urine were less likely to develop lung cancer (38). It has been suggested that normal dietary levels of ITCs derived from *Wasabia japonica* or other fresh cruciferous vegetables eaten regularly can protect against the low levels of carcinogens encountered in everyday life (25). As a result, the American Cancer Society recommends that cruciferous vegetables should be part of every person's daily diet to reduce the risk of several cancers.

Effects of isothiocyanates on blood

The ITCs in *Wasabia japonica* have been tested for inhibition of platelet aggregation mediated by arachidonic acid (39), and for disaggregation. ITCs showed a ten times higher response than is reported for aspirin. In the case of heart attacks, where aspirin is commonly prescribed, ITCs have been shown to have a more rapid action at low levels than the thirty minutes for aspirin.

In this regard, the most potent ITCs reported are -methylthioalkyl ITCs, especially 6-methylthiohexyl followed by 7-methylthioheptyl and 5-methylthiopentyl ITCs. The anticoagulant property of ITCs could be used in the treatment of elderly people and during surgery where preventing platelet aggregation is vital for the well being of the patient. The mechanism by which the ITCs inhibit platelet aggregation from occurring has not been precisely determined but may be through a specific inhibition of the arachidonic acid cascade (40). This therefore raises the possibility of using ITCs to limit inflammation in tissues, as anecdotal evidence describes relief for arthritis sufferers.

Anti-asthmatic and anti-inflammatory properties

Benzyl and Allyl ITCs from onion extracts showed anti-asthmatic effects when studied by Dorsch *et al.* (41). Thromboxanes (generated by lung tissue and by aggregating platelets during lung anaphylaxis) and prostaglandins (generated by mast cells during activation) are known to cause bronchial obstruction and generally play a role in the pathogenesis of bronchial asthma.

The isothiocyanates prevented bronchial obstruction caused by subsequent inhalation of ovalbumin but did not prevent obstruction caused by inhalation of histamine acetylcholine. This indicates that the anti-asthmatic effect of ITCs are not due to an anti-histamine effect but act by inhibiting the inflammatory process at an earlier stage, possibly the production or action of other inflammatory molecules such as thromboxanes or prostaglandins. Thus, ITCs could potentially be used to counter inflammatory conditions such as asthma or even anaphylaxis.

Traditionally, horseradish and mustard have been used as a remedy for clogged sinuses, relief of congestion, muscular pain and inflamed joints (40).

De-toxification effect

There has been a great deal of work done on the ability of ITCs contained in *Wasabia japonica* to stimulate and assist the liver into detoxifying the body.

Unique compounds within *Wasabia japonica* induce Phase I and Phase II detoxification systems in the liver. These compounds have been found to be 40 times more effective than other similar compounds. Toxins acted upon by these systems are converted to more water-soluble forms, which the body eliminates through urine or stool.

A healthy liver is important to enjoy a healthy lifestyle. *Wasabia japonica* also exhibits antioxidant and free radical scavenging activities.

Coupled with a healthy liver you have the best means of enabling the natural defenses of the body to combat the toxins and other stresses imposed by today's lifestyle. (53)

Antibiotic effect

Masuda (42) has suggested that *Wasabia japonica* could contribute to a healthy smile by inhibiting the growth of the bacteria on teeth and gums in the mouth. *Streptococcus mutans* is known to cause dental caries and the consumption of *Wasabia japonica* can reduce bacterial activity. This was explained by *Wasabia japonica*'s ability to interfere with the sucrose-dependent adherence of cells to the surface of teeth and gums.

Overall

Nutraceutical grade 100% Pure *Wasabia japonica* rhizome powder complete with certificates of Analysis (both micro and active ingredient levels) is now available on a worldwide basis. It is expected that this use will overtake the food sector as the general public and medical practitioners realise the health benefits that consuming the true *Wasabia japonica* products can bring. (53)

Other industrial applications

ITCs extracted from *Wasabia japonica* can be used to make antibiotics, fungicides, insecticides, nematocides and as wood preservatives (43). ITCs are said to act as an antidote to food poisoning bacteria, one factor that has led to the use of *Wasabia japonica* with raw fish dishes in Japan (44 - 46). It is also reported that ITCs may have a role in protecting against diarrhoea (47).

ITCs have also been used as antifouling compounds to stop seaweed growing on ships' hulls.

Recently it has been shown that *Wasabia japonica* contains anti-fungal metabolites that can render plants resistant to virulent isolates of the blackleg fungus (48). This fungus can devastate commercially important crops such as the oilseed plants rapeseed and canola. There is a potential to develop a natural fungicide using *Wasabia japonica* extracts.

Conclusions

Wasabia japonica is a valuable crop that can be made into a tasty condiment. In Japanese cuisine freshly ground *Wasabia japonica* is used to add a clean spicy flavour directly to foods. *Wasabia japonica* is also made into a paste which is stabilised by the addition of a number of other ingredients. In Western cuisine where hot spicy tastes are a recent addition to the diet, milder sauces and mayonnaises containing *Wasabia japonica* are more often appreciated. The problem arises in the fact that the consumer finds it difficult to tell the difference between true *Wasabia japonica* products and those made from the "fake wasabi" mixture of European horseradish, mustard, and artificial colours and flavours. Unless pressure can be brought to bear upon Government to enforce the various labeling and consumer guarantee laws that abound to stop "fake wasabi" products being called Wasabi, then *Wasabia japonica* will always remain a niche product for the connoisseurs.

While the previous main reason for consuming *Wasabia japonica* was the unique taste, it is interesting to note that the active components, the Isothiocyanates appear to have some positive anti-cancer and health benefits in the body. This will lead to increased production and consumption of this interesting perennial crop, but as a Nutraceutical (health food) – not as a food flavour. This will require a lot more growers who are prepared to use the Sawa growing method. More information can be obtained here on becoming a [Sawa Wasabi Grower](#).

DIFFERENCE BETWEEN WASABI AND *WASABIA JAPONICA*

In most people's minds these words are interchangeable.

But, the reality is totally different. It is like comparing chalk to cheese.

The words are similar and yet that is where the similarity ends.

Wasabi is the word used to describe the pungent green paste that really clears out your sinuses when you eat a lot of it in one go. Have a look on YouTube and other websites to see the stupidity that some people inflict on themselves and others relating to the consumption of wasabi.

Wasabia japonica is a plant that can be grown in water or in the soil, is green in colour, is shaped like a knobbly carrot and grows on top of the ground.

So, I ask myself why is it that people seem to think they are interchangeable?

After all, even the Scientists who carry out research and publish "learned" papers in peer reviewed journals on *Wasabia japonica* have difficulty in using the correct word/phrase when dealing with either item (green paste or plant) when writing their "learned" paper!

How does this confusion come about?

After all the word "Wasabi" is now part and parcel of everyday language irrespective of what language or dialect you may speak. Who doesn't know about "Wasabi Peas" for instance?

The fact is that the word Wasabi has now entered the normal vocabulary of entire nations, and the populations understanding of that word is that it is a food condiment, usually used with Japanese food, but now being used as a spice in almost everything.

The acceptance of Wasabi is similar to the way that Pork was introduced to the English by William the Conqueror back in the 11th Century. As they were French-speaking nobles, they used the word "Porc", which is French for pig to describe some cooked meat dishes. The servants picked this up and started referring to cooked pig as Pork. From these small beginnings pork entered the English language.

A similar thing has happened with Wasabi. Instead of the word coming from the French, this time it came from the Japanese via the Allied soldiers going home after World War II. However, in my view this was not an unintentional language mistranslation, but a deliberate misdirection, as the plant *Wasabia japonica* was (is) regarded as a national treasure in Japan and needs to be protected.

Wasabi has been shortened from *seiyō wasabi* which means Western Wasabi. This is the powder that the Allies brought back from Japan after the war as the new spice they had discovered overseas. The real *Wasabia japonica* was hidden away in the mountains, far from the eyes of the foreigners.

The *seiyō wasabi* was (is) exactly what it says. It is dried western horseradish (*Armonicia rusticana*) that was mixed with dried seaweed to change the colour and make it look different to plain dried horseradish powder.

These days Wasabi powder is still made from *Armonicia rusticana*, and now it is still unlikely to contain any *Wasabia japonica* but may contain mustard powder, corn starch, various colours and other flavours – such as chilli.

From the man in the streets point of view, it doesn't matter what it is made from. So long as it has the accepted taste and action of Wasabi, namely the nose tingling rush and eye watering ability, then it is regarded as Wasabi no matter what the ingredients are.

Now this is where the *Wasabia japonica* differs.

Wasabia japonica is a plant that has a large number of species that are grown in a number of places throughout the world.



This is True Wasabi (*Wasabia japonica*)

This is a plant that grows either in the ground or in water.

Variations in Species of *Wasabia japonica*

Each species has a different chemical makeup, although a definitive series of scientific studies have never been undertaken to determine what (if any) these differences might be. From a purely subjective taste test, my experience is that the tastes and eye watering abilities are significantly different.

A number of scientific papers claim that the *Wasabia japonica* plant always contains three unique Isothiocyanate compounds. These compounds are listed as;

6-methylthiohexyl isothiocyanate,

7-methylthioheptyl isothiocyanate, and

8-methylthiooctyl isothiocyanate.

Once again there have not been any definitive studies to show that this is the case for each species within the *Wasabia japonica* group of plants.

A White Paper on the Health Benefits Derived from *Wasabia japonica*.

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Also there is another scientific paper which scientists claim shows that there is **NO** 2-phenylethyl Isothiocyanates to be found in *Wasabia japonica* and yet is present in European Horseradish. If these scientists chose to read the actual paper, what it says is “Not detected”. This is totally different to NOT being there.

A final point to mention is that all the scientific papers about *Wasabia japonica* have been carried out on **fresh *Wasabia japonica*** and **on one species (or very few) only**.

Once you turn it into powder then everything changes. The concentration of all the chemicals increase (naturally), and then the “Not detected” chemicals might be detectable. Also the action of turning the *Wasabia japonica* plant into a concentrated powder may make other chemicals not detectable. The variability due to species type, growing method, growing area(s), and the environmental conditions together with processing methods and the lack of organised scientific research into *Wasabia japonica* ensure that scientists are still working in the dark, and their conclusions need to be taken with a great deal of suspicion.

What does this mean?

It means that we cannot rely on the scientists with their fancy equipment and reports to definitively state if Wasabi powder actually contains *Wasabia japonica* or not. There are now DNA tests available to determine if the plant DNA the laboratory has isolated is the same as the reference sample they have on file. The problem here is that the reference sample may be a different species to the actual product being tested.

Some Studies

The discovery of health and medicinal properties of many common botanicals and foods often comes from epidemiologic studies that report on differences in disease prevalence and health statistics across populations and countries. For many traditional Asian foods and botanicals such as soy, green tea, and now *Wasabia japonica*, it is this important epidemiologic data demonstrating differences in cancer incidence, cardiovascular health benefits, and even longer life expectancies that spawn an extraordinary amount of basic and clinical research on the foods and their ingredients (59 - 62). Such is the case for *Wasabia japonica*, a customary Japanese food ingredient, which is only now being uncovered as a potent, health-promoting Nutraceutical.

Some of the epidemiologic studies focusing on the Asian diet and in particular, the Japanese diet, include a recent study of nutrition effects on mortality in the Japan Collaborative Cohort Study (JACC). In this analysis, multivitamin and vitamin E use was found to be associated with lower mortality from cerebrovascular disease and intake of the Japanese-style breakfast was associated with lower mortality from all causes for men. Other analysis of the JACC study demonstrated that the intake of fresh fish was associated with lower mortality from all causes for both men and women and intake of fish paste products and condiments such as *Wasabia japonica* was beneficial. (63)



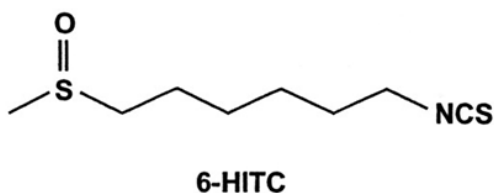
Wasabia japonica is a member of the *Brassicaceae* or cruciferous vegetable family which includes broccoli, cauliflower and Brussels sprouts, many of which are already valued for anti-proliferative activity and various healing potential. In general, all parts of the *Wasabia japonica* plant are harvested but it is the wasabi rhizome that has the most flavour, and is the storehouse for most of its active properties

Chemical analysis of *Wasabia japonica* reveals the presence of a variety of bioactive compounds such as isothiocyanates (ITCs), vitamins, essential oils, and minerals. However, it seems that ITCs are the most potent and active components and the primary reason for a multitude of physiological effects of *Wasabia japonica*.

[<https://wasabi.org/articles/the-past-present-and-future-of-wasabi-japanese-horseradish>]

What are Isothiocyanates?

Isothiocyanates (ITCs) are sulphur-containing phytochemicals that have the general formula $R-N=C=S$



There are many different molecules that belong to ITC group and most of its members are shown to have strong anti-proliferative activities in vitro. Some of the common ITCs include phenylethyl isothiocyanate (PEITC), benzyl isothiocyanate (BITC), 3-phenylpropyl isothiocyanate (PPITC), and sulforaphane. **6-**

methylsulfinylhexyl isothiocyanate (6-MITC or 6-HITC) has been identified as a major and unique form of ITC in *Wasabia japonica* extract. ITCs occur naturally as glucosinolate conjugates in many of the *Brassicaceae* vegetables including *Wasabia japonica*, broccoli, cauliflower, kale, Brussels sprouts, cabbage, and radishes. ITCs are also responsible for the typical flavour of these easy to identify vegetables.

There are 3 unique ITC's in *Wasabia japonica*. They are;

- 6-methylthiohexyl isothiocyanate (6-MITC)
- 7-methylthioheptyl isothiocyanate
- 8-methylthiooctyl isothiocyanate.

Recent Research on *Wasabia japonica*

Since *Wasabia japonica* is known to harbour a high concentration of ITCs as well as a large number of other potentially beneficial compounds, extensive research has been done and much more is currently in progress. Scientific data strongly suggests that *Wasabia japonica* stimulates Nrf-2, which induces a series of cytoprotective genes, offering a variety of potential health benefits, including:

- Potent liver-detoxifying activity
- High antioxidant activity
- Promoting healthy immune responses by COX-2 modulation
- Enhancing brain health via neurite growth
- Immunomodulatory effect via activation of natural killer cells
- Prevents Colitis

[See full list below]

Below, we will highlight research on *Wasabia japonica* and also on Sawa™, a freeze-dried powder of *Wasabia japonica* rhizome, grown, processed and distributed by World Wasabi Inc. (formerly New Zealand Wasabi Limited), and potential mechanisms leading to a variety of health benefits.

Powerful activation of genes

The *Wasabia japonica* plant has a naturally activated defense system called the glucosinolate-myrosinase system, which produces isothiocyanates (ITCs). ITCs naturally protect the plant from dangerous pathogens and plant-destroying fungi. ITCs from the cruciferous plants have been extensively researched and have been found to be greatly beneficial for human health.

Wasabia japonica's key active compound called 6-methylsulfinylhexyl isothiocyanate (6-MITC or 6-HITC) has been shown to possess various biological properties including induction of a **reduction–oxidation** reaction (redox) switch, Nrf2. Nrf2 induction is required to turn on many genes such as glutathione S-transferases (GST) and NQO-1 that are involved in stress-responses and cytoprotection.

World Wasabi Inc. (formally New Zealand Wasabi Limited) has taken careful measures to ensure that Sawa™ are made from the finest harvest available. The leaves and petioles are carefully removed from the rhizome which is concentrated and freeze dried to preserve the maximum level of beneficial constituents in the Sawa™ 100% Pure *Wasabia japonica* powder.

Liver Protective Activity of 6-MITC

Liver is the primary detoxification site in our body. It has recently been reported that a variety of cruciferous vegetables including Wasabi may have potent liver protective activities which include induction of a detoxifying enzyme, glutathione S-transferases (GST). GST converts oxidized glutathione disulfide (GSSG) to its reduced state (GSH) (**Figure 1**), leading to an overall reduction of systemic oxidative stress. This activity can be both liver-protective and anti-proliferating, likely

through affecting levels of reactive oxygen species. (64)

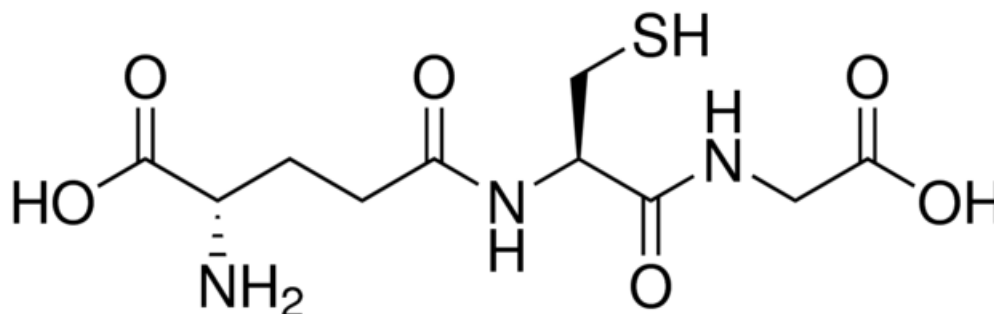


Figure 1 – Structure of Reduced Glutathione – GSH

Several laboratory studies have suggested that GSH is a critical factor in protecting organisms against toxicity and disease. (65, 66)

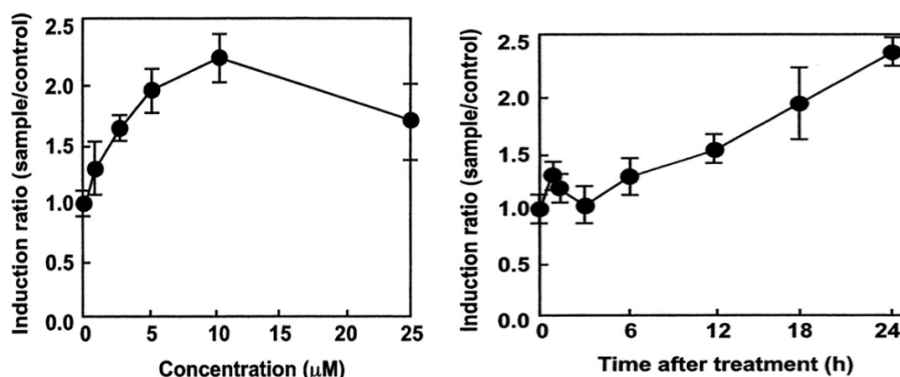


Figure 2 - Induction of GST by 6-MITC. Dose-(A) and time-(B) quinone reductase (Morimitsu et al., J Biol Chem 2002)

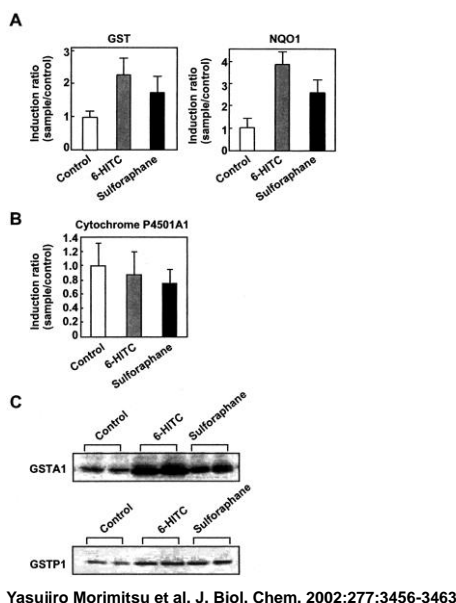
Morimitsu et al. screened vegetable extracts extensively searching for chemoprotective compounds that conferred resistance to carcinogenesis through induction of the phase II detoxification enzymes. Figure 2 shows that 6-MITC abundant in *Wasabia japonica* is a potent inducer of both class alpha and class pi GST isozymes (GST A1 and GST P1) in rat liver epithelial cells RL34.7

They were able to show that 6-MITC was quickly absorbed after oral intake into the circulatory system reaching maximum concentration in plasma within 30 minutes, and that 6-MITC was more potent than sulforaphane (from broccoli) in inducing hepatic phase II detoxification enzymes such as GST and a quinone reductase, NQO1 (NAD(P)H:(quinone-acceptor) oxidoreductase).

Possible molecular mechanism for 6-MITC's bioactivities including liver detoxification was proposed. It has been established that antioxidant response element (ARE) or electrophile response element in the promoters of the phase II enzyme genes are required for the induction of the

enzymes. Nrf2 (NF-E2-related factor 2) is considered to be involved in the activation of the element. **Figure 3** shows that 6-MITC stimulated the activation of the antioxidant response element through the induction and translocation of Nrf2 into the nucleus.

Effect of 6-MITC and sulforaphane administrations on mouse hepatic detoxification enzyme activities.



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Figure 3 - Effect of 6-HITC compared to sulforaphane on mouse hepatic detoxification enzyme activities. (A) GST and NQO1 activities. (B) cytochrome P450 1A1 activity. (C) Immunoblot analysis of GST isozymes. (Morimitsu et al., J Biol Chem 2002)

ANTIOXIDANT ACTIVITY OF SAWATM

Free radicals such as superoxide and hydroxyl radical are formed in our body to play an important role in many physiological processes.

However uncontrolled formation or insufficient removal of these unstable and highly reactive molecules generated by stress, environmental factors, and consumption of smoke and alcohol is closely associated with aging process and development and progress of various health problems. Excessive amount of free radicals leads to oxidative damage on proteins, lipids, and DNA, interfering with normal cellular metabolism.

Our analysis showed that SawaTM contains a minimum of 24,000 ppm of glucosinolates, which is a significantly higher amount than other *Wasabia japonica* products in the market.

HEALTHY IMMUNE RESPONSES THROUGH MODULATION OF COX-2

Another important mechanism for *Wasabia japonica*'s diverse health benefits is associated with promotion of healthy immune responses specifically through the modulation of cyclooxygenase-2 (COX-2).

Cyclooxygenases (COX-1 and COX-2) are responsible for formation of important biological mediators called prostanoids including prostaglandins. Pharmacological inhibition of COX provides relief from the symptoms of inflammation and pain as NSAIDs such as aspirin and ibuprofen exert their effects through inhibition of COX. Thus, the COX enzymes may be an important target for controlling unhealthy, persistent inflammation.

COX-2 is rapidly induced in activated macrophages and other cells at sites of inflammation in the presence of various inflammatory stimulants. Normally, COX-2 activity decreases to its pre-activation level after the removal of the stimulant. However, chronic activation of COX-2 can lead to a range of harmful effects on liver, kidney, gastrointestinal tract, and central nervous systems.

***Wasabia japonica* extract contains an activity to modulate COX-2**

A number of studies have shown that *Wasabia japonica* modulates COX-2 activity and may be beneficial in restoring healthy immune response. Uto et al. (67) reported that an active compound from *Wasabia japonica* suppressed COX-2 expression. They isolated 6-MITC (also called 6-HITC) from *Wasabia japonica* rhizome and examined its effect on COX-2 expression in macrophage RAW264 cells in the presence of pro-inflammatory molecules such as LPS, IFN-gamma, or 12-O-tetradecanoylphorbol-13-acetate (TPA). They showed that 6-MITC suppressed COX-2 over-expression induced by LPS and IFN-gamma, but not by TPA, and the suppression was in a dose-dependent manner. These results suggest that *Wasabia japonica* ITCs may be used as potent anti-inflammatory agents.

ENHANCING BRAIN HEALTH VIA NEURITE GROWTH

As discussed above, there has been a growing body of scientific evidence supporting diverse health benefits of *Wasabia japonica*. Recent report from Shibata et al. (68) shed a unique light on *Wasabia japonica*'s potential benefits towards neurodegenerative disorders.

Neurotrophins such as nerve growth factor (NGF), a molecule for the Nobel Prize in Physiology or Medicine in 1986, induce the growth, survival, differentiation, and functional maintenance of nerve cells in both the central and peripheral nervous systems. They help to prevent neuronal cell death. NGF is critical for the survival and maintenance of target neurons, and its binding and activation of its receptor, TrkA (neurotrophic tyrosine kinase receptor, type 1), is required for NGF-mediated neuronal survival

and differentiation.

Shibata et al. (68) investigated the effect of *Wasabia japonica* extract on growth attenuation in rat PC-12 cell line, a well-established and useful cell model for the investigation of signal transduction pathways of neuronal differentiation. They tested if NGF-dependent neuritogenesis of PC-12 could be enhanced by any of the ITCs present in *Brassicaceae* vegetables. First, they screened a number of these vegetables and found that *Wasabia japonica* was the richest source of ITCs. They identified 6-MITC as one of the major neuritogenic enhancers present in *Wasabia japonica*.

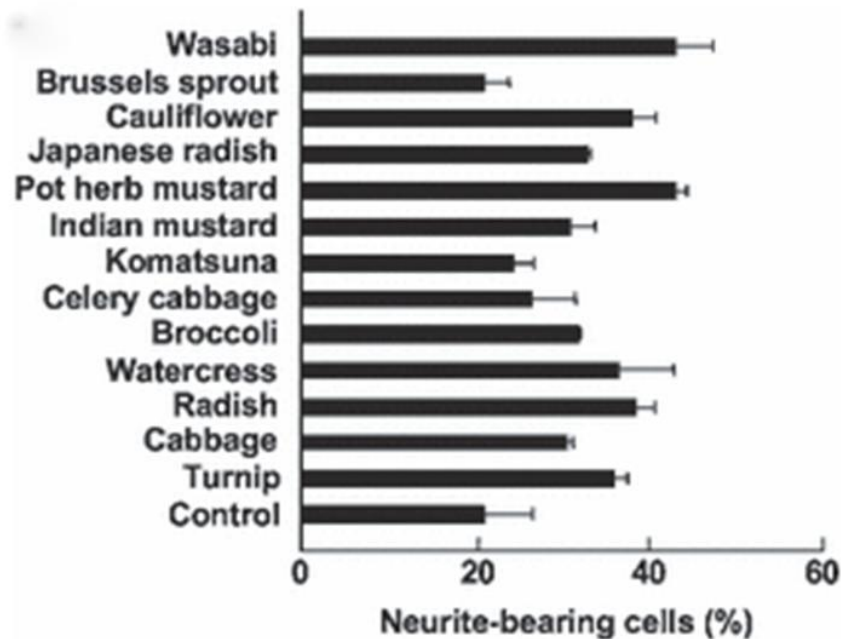


Figure 4: Wasabi most powerful of all Brassicas

Figure 4 demonstrates that *Wasabia japonica* was one of the most potent neuritogenic enhancer for PC-12 cells among the vegetables when the PC-12 cells were treated with 1 g/mL of each extract in the presence of NGF for 72 hours.

Figures 5A and 5B show that the 6-MITC fraction could enhance NGF-induced neurite outgrowth in the presence of NGF in a dose-dependent manner. In addition, expression of light neurofilament-L (NF-L), a neuronal differentiation marker, was enhanced and/or affected by the *Wasabia japonica* extract, as shown by Western blot analysis (Figures 5C and 5D).

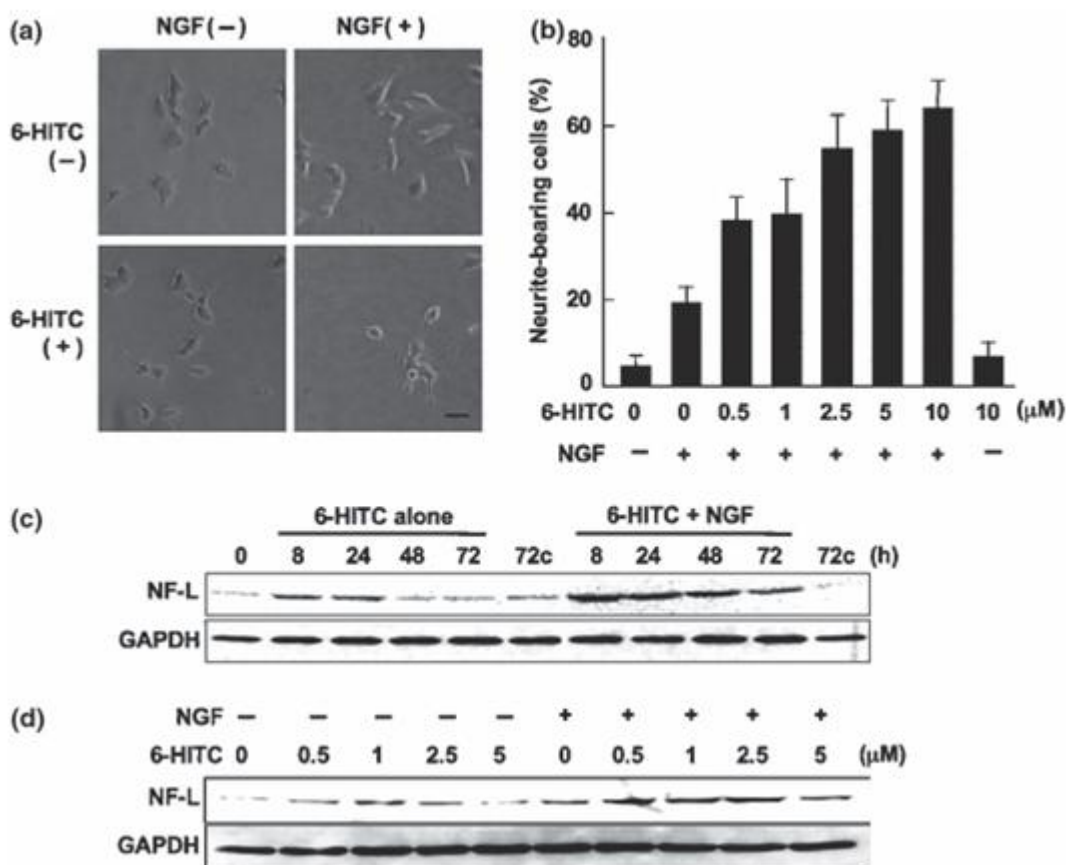


Figure 5: NGF-induced neurite outgrowth

Interestingly, the investigators identified the protein tyrosine phosphatase (PTP) 1B as a key regulator of the NGF receptor-initiated signal transduction, and its ability of dephosphorylating Tyr-490 of TrkA appeared to be inactivated by 6-MITC. This implies that the *Wasabia japonica* extract containing 6-MITC may facilitate the sustained phosphorylation of the extracellular signal-regulated kinase and the autophosphorylation of the NGF receptor TrkA, resulting in enhanced neuritogenesis. The potential effects of 6-MITC on brain health needs further investigation particularly involving animals and human subjects. However, enhancing neurite growth stimulated by 6-MITC and delineation of molecular mechanism involving the protein tyrosine phosphatase implies the utility of *Wasabia japonica* and SawaTM as a beneficial dietary supplement to promote brain health.

SAWATM AS A NUTRACEUTICAL

In summary, recent studies on *Wasabia japonica* and its bioactive component, isothiocyanates (ITCs), suggest that consumption of *Wasabia japonica* and other cruciferous vegetables may be highly protective for the human body. It is likely that *Wasabia japonica* among these vegetables is on the fast track to becoming the next prime example of how a traditionally used herb turns out to have powerful phytochemical components with a variety of potential health benefits.

World Wasabi Inc (formally New Zealand Wasabi Ltd.) Technology's Sawa™, a freeze-dried powder derived from *Wasabia japonica* rhizome, harbors a higher amount of the key compound, 6-MITC, than other commercially available wasabi products in the market. As discussed above, our initial studies demonstrated that Sawa™ possessed strong antioxidant anti-inflammatory ,and immunomodulatory activities, while published studies suggest that 6-MITC promotes liver and brain health. Further research on Sawa™ in human subjects will reveal how much nutraceutical potential of *Wasabia japonica* has been hiding behind the unique flavour and taste.

Current Use of *Wasabia japonica* Dosage Form and Suggested Use

Although dosage varies depending on its intended use, the general recommendation for daily intake of standalone *Wasabia japonica* supplements is 400 mg taken 1-3 times per day. It is noted that Sawa™ can be formulated in various forms including capsules, tablets, and softgels. With a wide spectrum of biological activities, Sawa™ has broad applications, depending on whether it is used as a single supplement or a main ingredient in a combination formula.

Potential Uses (from Scientific Reports and Studies)

Atopic Dermatitis

Bacterial Infection

Bladder Cancer

Blood Clotting

Blood Pressure

Bowel Cancer

Breast Cancer

Colitis

Colorectal Cancer

Compromised Immune System

Diabetes

Gastric Cancer

H. pylori

Hematoma

Immune System Booster

Inflammation

Leukemia

Liver Cancer

Low Liver Function

Lung Cancer

Lymphoma

Mouth Cancer

Non-small cell Lung Cancer

Osteoporosis

Ovarian Cancer

Pancreatic Cancer

Prostate Cancer

Reduced Liver Function

Skin Cancer

Stomach Cancer

Throat Cancer

Thrombosis

Tooth Decay

Ulcers

Ulcerative Colitis

ABOUT AUTHOR

Michel Van Mellaerts holds a B.E. in Mechanical Engineering, several degree equivalents in Applied Physics. He acquired his MBA from Auckland University. Michel Van Mellaerts and his wife Jennifer have been growing, processing, investigating and marketing *Wasabia japonica* around the World since 1990. Originally based in New Zealand, they now regard the world as their oyster and are willing to travel and help people set up and operate their own *Wasabia japonica* farm. Contact Michel at Michel@wasabi.co.nz.

REFERENCES

- 1 - Hodge WH. 1974. *Econ Bot* 28: 118-129.
- 2 - Kojima M. 1981. *Nogyo Oyobi Engei*, 56(5): 113-118.
- 3 - Chadwick CI, Lumpkin TA and Elbersen LR. 1993. *Econ Bot* 47: 113-135.
- 4 - Forde B. 1982. Department of scientific and Industrial research discussion paper no. 7. Wellington, NZ, 25p.
- 5 - Palmer J. 1990. *N Z J Crop Hort Sci* 18: 161-164.
- 6 - Douglas J.A. and Follett JM. 1992. *Proc Agron Soc* 22: 57-60.
- 7 - Martin RJ and Deo B. 2000. *N Z J Crop Hort Sci* 28: 45-51.
- 8 - Sultana T, Savage GP, McNeil DL, Porter N and Martin RJ. 2000. *Proc Nutr Soc NZ* 25: 95-106.
- 9 - Sultana T, Savage GP, McNeil, DL, Porter, N, Martin RJ and Deo B. 2002. *J Sci Food Agric* 82:1477-1482.
- 10 - Sultana T, Porter NG, Savage GP McNeil DL 2003. *J Agric Food Chem* 51: 3586-3591.
- 11 - Adachi S. 1987. Wasabi cultivation. Shuijyunsha Co. Ltd., Tokyo, Japan. P 199.(Translated).
- 12 - Sultana T, Savage GP, McNeil DL, Porter N and Clark B. 2002. *Inter J Food Sci Nutr* (Submitted).
- 13 - McGregor DI, Mullin WJ and Fenwick GR 1983. *J Ass off Anal Chem* 66 : 825-849.
- 14 - Delaquis PJ, Mazza G. 1995. *Food Technol* 73-84.
- 15 - Masuda H, Harada Y, Tanaka K, Nakajima M, Tebata H, Takeoka GR, Teranishi R, Williams PJ and Kobayash IA 1996. *Biotech improved foods flavours*. ACS Symposium Series No. 637 25: 67-78.
- 16 - Prestera T, Fahey JW, Holtzclaw WD, Abeygunawardana C, Kalchinski JL and Talalay P. 1996. *Anal Biochem* 239: 168-179.
- 17 - Larsen PO. 1981. Glucosinolates in the biochemistry of Plants. A comprehensive Treatise, Stumpf PK and Conn, EE Eds, Vol 5, pp 502-525, Academic press, N Y.
- 18 - Warton B, Matthiessen JN, Shackleton MA. 2001. *J Agric Food Chem* 49: 5244-5250.
- 19 - Fahey JW, Zalcman AT and Talalay P. 2001. *Phytochem* 56: 5-51.
- 20 - McGregor DI 1993. In: Encyclopaedia of Food Science Food Technology and Nutrition, Macrae R, Robinson RK and Sadler MJ. Eds, Vol 4, Academic press, Harcourt Brace Jovanovich publishers.
- 21 - Fenwick R, Heaney RK, Mullin WJ. 1983. *CRC Crit Rev Food Sci Nutr* 18: 123-201.
- 22 - Kumagai H, Kashima N, Seki T, Sakurai H, Ishii K, Ariga T. Analysis of volatile components in essential oil of upland wasabi and their inhibitory effects on platelet aggregation. *Biosci. Biotech. Bioch.* 58: 2131-2135 (1994)
- 23 - Etoh H, Nishimura A, Takasawa R, Yagi A, Satio K, Sakata K, Kishima I and Ina K. 1990. *Agric Biol Chem* 54: 1578-1589.
- 24 - Ina K, Sano A, Nobukuni M and Kishima I. 1981. *Nippon Shokuhin Kogyo Gakkaishi* 28: 365-370.
- 25 - Chung FL. 2002. Chapter 7 in *Phytochemicals in Nutrition and Health* edited by Meskin MS, Bidlack WR, Davies AJ and Omaye ST, CRC Press USA.
- 26 - Lin HJ, Probst-Hensch NM, Louie AD, Kau IH, Witte JS, Ingles SA, Frankl HD, Lee ER and Haile RW. (1998). *Cancer Epid Biomark Prev* 7: 647-652.
- 27 - Verhoeven DTH, Goldbohm RA, van Poppel G, Verhagen H and van den Brandt PA. 1996. *Cancer Epid Biomark Prev* 5: 733-748.
- 28 - Steinmetz KA and Potter JD. 1991. Vegetables, fruit, and cancer. II: Mechanisms. *Cancer Causes Control* 2: 427-442.
- 29 - Tanida N, Kawaura A, Takahashi A, Sawada K and Shimoyama T. 1991. *Nutr Cancer* 16: 53-58.
- 30 - Fuke Y, Haga Y, Ono H, Nomura T and Ryoyama K. 1997. *Cytotech* 25: 197-203.
- 31 - Fuke Y, Ohishi Y, Iwashita K, Ono H and Shinohara K. 1994. *J Japanese Soc Food Sci Technol* 41:709-711 (In Japanese with English summary).
- 32 - Wattenberg LW. 1977. *J Nat Cancer Inst* 58: 359-398.
- 33 - Wattenburg LW. 1981. *Cancer Res* 41: 2991-2994.
- 34 - Zhang Y and Talalay P. 1994. *Cancer Res* 9 (suppl.), 54: 1976-1981.

- 35 - Morse MA, Amin SG, Hecht SS and Chung FL. 1989. *Cancer Res* 49: 2894-2897.
- 36 - Morse MA, Eklind KL, Hecht SS, Jordan KG, Choi CI, Desai DH, Amin SG and Chung FL. 1991. *Cancer Res* 51: 1846-1850.
- 37 - Yang YM, Conaway CC, Wang CX, Dai W, Chiao JW, Albino AP and Chung FL. 2002. *Cancer Res*
- 38 - Seow A, Shi C-Y, Jiao D, Hankin JH, Lee H-P, Coetzee GA and Yu M. 1998. *Cancer Epid Biomark Prev* 7:775-781.
- 39 - Kumagai H, Kishima N, Seki T, Sakurai, H., Ishii K and Ariga T. 1994. *Biosci Biotechnol Biochem* 58: 2131-2135.
- 40 - Depree JA Howard TM and Savage GP. 1999. *Food Res Inter* 31: 329-337.
- 41 - Dorsch W, Adam O, Weber J. And Ziegeltrum T. 1985. *Euro J Pharmacol* 107: 17-25.
- 42 - Matsuda H. 2000. *Sci News* 159: 29.
- 43 - Brown PD and Morra MJ. 1997. *Adv Agron* 61: 167-231.
- 44 - Ono H, Tesaki S, Tanabe S and Watanabe M. 1998. *Biosci Biotech Biochem* 62(2): 363-365.
- 45 - Shin IS and Lee JM. 1998. *Bull Korean Fish Soc* 31: 835-841.
- 46 - Hasegawa N, Matsumoto Y, Hoshino A and Iwashita K. 1999. *Internat J Food Microbiol* 49: 27-34.
- 47 - Nakayama H, Suzuki T and Suzuki Y. 1998. *Nippon Nogeikagaku Kaishi* 72: 499-507.
- 48 - Soledade M, Pedras C and Sorensen JL. 1998. *Phytochem* 49: 1959-1965
- 49 - New Zealand Wasabi website (now World Wasabi) <http://www.wasabi.co.nz>
- 50 - Reviews of Wasabi based products <http://www.wasabireviews.com>
- 51 - Namida Wasabi Spirit website <http://www.wasabispirit.com>
- 52 - World Wasabi Council website <http://www.worldwasabicouncil.com>
- 53 - Sawasabi Nutraceutical grade 100% Pure Wasabi Powder website <http://www.sawasabi.com>
- 54 - Bhattacharya A, Tang L, Li Y, Geng F, Paonessa JD, Chen SC, Wong MKK, Zhang Y. Inhibition of bladder cancer development by allyl isothiocyanate. *Carcinogenesis* 2010; 31(2):281-286
- 55 - Bhattacharya A , Li Y , Wade KL , Paonessa JD , Fahey JW , Zhang Y. Allyl isothiocyanate-rich mustard seed powder inhibits bladder cancer growth and muscle invasion. *Carcinogenesis* 2010; 31(12):2105-2110
- 56 - Bhattacharya A, Li Y, Geng F, Munday R, Zhang Y. The principal urinary metabolite of allyl isothiocyanate, N-acetyl-S-(N-allylthiocarbamoyl)cysteine, inhibits the growth and muscle invasion of bladder cancer. *Carcinogenesis* 2012; 33(2):394-398
- 57 - *Biofactors* 13:271-276 (2000)
- 58 - *J. Biol. Chem.* 277:3456-3463 (2002)
- 59 - Umesawa M, et al. *Am J Clin Nutr.* 2008 Jul;88(1):195-202.
- 60 - Iwasaki M, et al. *J Clin Oncol.* 2008 Apr 1;26(10):1677-83.
- 61 - Sun CL, et al.. *Carcinogenesis.* 2007 Oct;28(10):2143-8.
- 62 - DeLellis HK, et al. *Nutr Cancer.* 2007;58(2):136-45.
- 63 - Iso H, et al. *Asian Pac J Cancer Prev.* 2007;8 Suppl:35-80.
- 64 - Antosiewicz J, et al. *Planta Med.* 2008
- 65 - Morimitsu Y. et al.. 2002. 277 (5): 3456-3463.
- 66 - Determination of Blood Total, Reduced, and Oxidized Glutathione in Pediatric Subjects
Anna Pastore, Fiorella Piemonte, Mattia Locatelli, Anna Lo Russo, Laura Maria Gaeta, Giulia Tozzi, Giorgio Federici - Published August 2001
- 67 - Uto T, et al. Effects of 6-(methylsulfinyl)hexyl isothiocyanate on cyclooxygenase-2 expression induced by lipopolysaccharide, interferon- γ and 12-O-tetradecanoylphorbol-13-acetate *Oncol Rep.* 2007;17(1):233-8.
- 68 - Shibata T, et al. A food-derived synergist of NGF signaling: identification of protein tyrosine phosphatase 1B as a key regulator of NGF receptor-initiated signal transduction. *J Neurochem.* 2008
- 69 - Hideo Etoh and Masakazu Hara, *Foods Food Ingredients J. Jpn.*, Vol. 212, No.11, 2007

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