Sweetpotato—*Ipomoea batatas*—a great health food

The sweetpotato is an easily grown and highly productive crop. It is also an excellent source of vitamins, minerals, antioxidants, lutein and other nutrients essential for health.

By S.L. Tan

Introduction

Sweetpotato (also written as sweet potato) features among the top seven staples in the world, following wheat, rice, maize, potato, barley and cassava.

The original home of sweetpotato is in the Americas—Central America and the western coast of South America, but the largest cultivated area for sweetpotato in the world today is in China, with more than 3.5 million hectares, which make up almost 43% of the world total. The area under this crop in Malaysia is miniscule at 3,041 ha.

New VitAto variety

Top ten sweetpotato producing countries in the world

Country	Production	
	Area (hectares)	Volume (tonnes)
China	3,524,505	79,090,068
Nigeria	1,115,000	34,000,000
United Republic of Tanzania	675,000	3,100,000
Uganda	550,000	2,587,000
Indonesia	161,850	2,386,729
Vietnam	135,900	1,364,000
Rwanda	112,346	1,081,224
India	111,800	1,132,400
United States of America	45,810	1,124,230
Ethiopia	39,076	1,354,911
WORLD	**8,240,969**	**110,746,162**
Malaysia	*3,041*	*50,748*

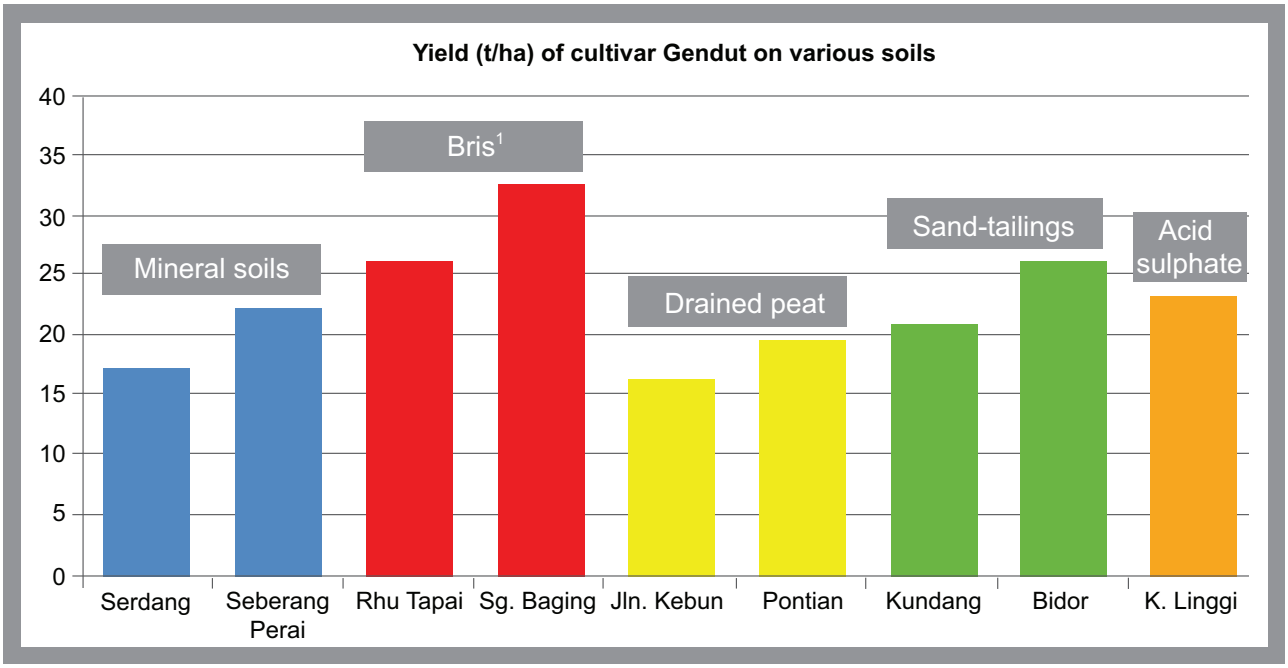
Botany

Sweetpotato is a member of the family Convolvulaceae, and is closely related to *Kangkung* (*Ipomoea aquatica*) and the ornamental morning glory (*I. indica* and other *Ipomoea* species). Indeed, these relatives can harbour the pests of sweetpotato.

Sweetpotato is a sprawling or trailing vine which can be harvested as early as 3½-4 months after planting in the tropics, or after 5-6 months in the temperate region during the summer. With this short crop cycle, this crop can be grown not only in the tropics, but also in the temperate zone during the summer months. Sweetpotato can also grow in a very wide altitudinal range, from sea level to 2,500 meters in the tropics.

While sweetpotato produces sexual seed, the crop is propagated vegetatively by the use of stem cuttings. Shoot cuttings are the preferred planting materials. As in other root crops, the economic part is the storage roots, formed by bulking of and starch deposition in the adventitious roots which form wherever the stem nodes make contact with the soil.

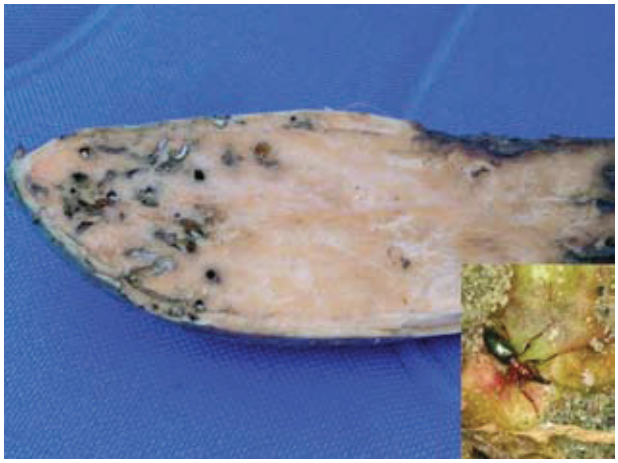
Sweetpotato has a great advantage in growing well on marginal soils such as bris[1], tin-tailings, acid sulphate soils and drained peat. All it needs is the adoption of certain recommended soil amendments (as exemplified by the yield performance of the cultivar Gendut). This means sweetpotato will not compete with other crops for fertile and better soils. Marginal soils in Peninsular Malaysia alone cover some 1.67 million hectares, with 870,000 ha of peatland and muck soils, 433,000 ha of idle paddyland, 165,000 ha of bris, 110,000 ha of acid sulphate soils and 91,000 ha of sand tailings.



[1] Beach ridges interspersed with swale, found as sandy deposits on the East Coast of Peninsular Malaysia

Having a ground-hugging plant habit, sweetpotato can be grown in areas with strong winds without worrying about lodging and crop loss.

While soils and climate do not pose limitations to sweetpotato cultivation, the weevil (*Cylas formicarius*) presents a major hindrance. This pest is found throughout the tropics and subtropics except in Africa, where it has only been reported in South Africa and coastal Kenya. The adult female lays her eggs singly in the vines or in the storage roots, preferring the latter. Infested storage roots are unfit for human or animal consumption, even when only a small proportion of the root is damaged. This is because the damaged tissues produce terpenes giving an unpleasant odour and bitter taste to the flesh. Weevil damage increases during storage if oviposition has taken place before the roots are harvested. Up to now, crop rotation with an unrelated crop (such as a cereal) is the only environment-friendly way of managing the weevil, without resorting to frequent chemical pesticide sprays.



Sweetpotato weevil damage

Food value

Sweetpotato has a trypsin inhibitor in the storage roots which interferes with protein metabolism. Happily, this anti-nutritional factor is readily destroyed by heat and so is a non-issue as sweetpotato is typically cooked before it is consumed.

Sweetpotato on *bris*

Although in Malaysia we usually associate sweetpotato with making desserts and snacks, there is in fact potential for it to be a supplementary staple to rice. Unlike cassava, it is nutritionally as good as rice, in terms of protein content, and is better in terms of

dietary fibre, certain minerals and vitamin contents. Dietary fibre has positive effects against diabetes, constipation, and possibly colorectal cancer. Potassium is effective against hypertension, and provides protection against cardio-vascular disease. Calcium builds strong bones, while iron is important for women in their child-bearing years. Vitamins A, C and E are powerful antioxidants which act against defects in the unborn foetus, certain cancers and the ravages of ageing. Vitamin E also reduces the risk of cardio-vascular disease and stroke.

Indeed, if you choose highly coloured sweetpotato, you will get in addition fantastic anti-oxidants!

Orange-fleshed sweetpotato are loaded with β-carotene, which converts to vitamin A in the body, while purple-fleshed ones are high in anthocyanin, a powerful anti-oxidant with good bioavailability

Eating only 125g of an orange sweetpotato is enough to provide the daily vitamin A needs of a preschooler.

Nutrient composition of sweetpotato compared with cassava, potato and white rice (100 g edible portion)

Nutrient	Unit	Sweetpotato[1]	Cassava[1]	Potato[1]	White rice[2]
		per 100 g edible portion			
Proximates					
Water	g	12.0	12.0	12.0	12.89
Energy	kcal	333	349	328	360
Protein	g	6.08	2.97	8.60	6.61
Total fat	g	0.19	0.61	0.38	0.58
Ash	g	3.83	1.35	3.41	0.58
Carbohydrate (by difference)	g	77.93	83.07	74.41	79.34
Total dietary fibre	g	11.6	3.9	9.4	N
Minerals					
Calcium	mg	116	35	51	9
Iron	mg	2.36	0.59	3.32	0.80
Magnesium	mg	97	46	98	35
Phosphorus	mg	182	59	243	108
Potassium	mg	1305	592	1793	86
Sodium	mg	213	31	26	1
Zinc	mg	1.16	0.74	1.24	1.16
Copper	mg	0.585	0.218	0.404	0.110
Manganese	mg	0.999	0.838	0.767	1.100
Selenium	mcg	2.3	1.5	1.4	N

Nutrient	Unit	Sweetpotato[1]	Cassava[1]	Potato[1]	White rice[2]
		per 100 g edible portion			
Vitamins					
Vitamin C	mg	9.3	45.0	83.9	0.0
Thiamin	mg	0.302	0.190	0.341	0.070
Riboflavin	mg	0.236	0.105	0.136	0.048
Niacin	mg	2.157	1.864	4.489	1.600
Panthotenic acid	mg	3.099	0.234	1.313	1.342
Vitamin B-6	mg	0.810	0.192	1.256	0.145
Folate, total	mcg	43	59	68	9
Vitamin B-12	mcg	0.0	0.0	0.0	0.0
Vitamin A, IU	mcg	54950	28	9	N
Vitamin A, RAE	mcg_RAE	2746	2	0	N
Vitamin E	mg	1.01	0.42	0.04	N
Vitamin K	mcg	7.0	4.2	8.1	N
β-carotene	mcg	32957	18	21	N
Amino acids					
Tryptophan	g	0.120	0.042	0.081	0.077
Threonine	g	0.322	0.061	0.283	0.236
Isoleucine	g	0.213	0.059	0.283	0.285
Leucine	g	0.356	0.085	0.424	0.546
Lysine	g	0.256	0.096	0.444	0.239
Methionine	g	0.112	0.024	0.141	0.155
Cystine	g	0.085	0.061	0.101	0.135
Phenylalanine	g	0.345	0.057	0.343	0.353
Tyrosine	g	0.132	0.037	0.202	0.221
Valine	g	0.333	0.076	0.444	0.403
Arginine	g	0.213	0.299	0.424	0.551
Histidine	g	0.120	0.044	0.141	0.155
Alanine	g	0.298	0.083	0.262	0.383
Aspartic acid	g	1.480	0.172	2.040	0.621
Glutamic acid	g	0.600	0.450	1.494	1.288
Glycine	g	0.244	0.061	0.242	0.301
Proline	g	0.201	0.072	0.262	0.311
Serine	g	0.341	0.072	0.323	0.347

[1] Converted to 12% moisture content from values for fresh roots

[2] White (polished) rice, medium grain

N = negligible

If you are wondering: how you can eat sweetpotato (which, as its name implies, is sweet) in the place of rice, there are varieties of "non-sweet" sweetpotato known as a staple sweetpotato.

Sweetpotato has a low glycaemic index (GI) of 50 whereas white rice has a GI of 70.

GI measures the rate at which an ingested food is converted to glucose in the blood, with glucose having a GI of 100 and white bread of 96. This makes sweetpotato a more suitable food for diabetics.

Comparison of glycaemic indices (GI)

Food	Glycaemic index
White rice	70
Sweetpotato	50
White bread	96
Glucose	100

Breeding and selection

The world's custodian for sweetpotato germplasm is the International Center for Potato (CIP) in Peru. Its genebank holds over 8000 accessions which represent more than 80% of the sweetpotato varieties in the world.

Because the sweetpotato can be propagated vegetatively, the multiplication of improved varieties is greatly facilitated. The main obstacle in the breeding and selection of sweetpotato is the small number of seed produced for each pollination event because the fruit contains a maximum of only four seed. By contrast, cereals such as rice and maize can generate 80 –100 and

Sweetpotato, Gendut variety

Sweetpotato on tin-tailings

300 –1,000 seed per pollination, respectively. This means that a lot more hand pollinations have to be made to get a reasonable amount of seed to carry out genetic studies or seedling selection. Breeders also have to work around the self- and cross-incompatible systems among certain genotypes.

Current Uses

Food and food products

Traditionally, sweetpotato is eaten more as a supplementary food than as a main staple. In Malaysia, it is steamed, boiled or fried in batter

(fritters), and also used for making traditional Malay and *nyonya* cakes, such as *keria* (a kind of doughnut), *kuih koci* and *onde-onde*. There are also small cottage industries making traditional snacks, e.g. *kerepek* (crisps), and *cakar ayam*. All these traditional forms of usage have rather a limited market, but there are far greater prospects in other forms of utilization.

Feedstuff

As a carbohydrate-rich food, sweetpotato can replace grain maize (the gold standard for energy-rich feedstuffs) up to 30% in pig and poultry feeds. If dry roasted sweetpotato meal is used, the replacement level rises to 50-100% of grain maize in broiler feeds. Probably, cooking improves sweetpotato starch digestibility while eliminating anti-trypsin activity associated with the raw storage roots. There is ample scope for replacing at least partially the imported grain by local production of this root crop.

New Uses

Bio-fuel

It is a given that in the not too distant future fossil fuels will have to be replaced by renewable fuel sources. In the search of renewable fuel sources, highly productive sugar or starch-producing crops can play important roles.

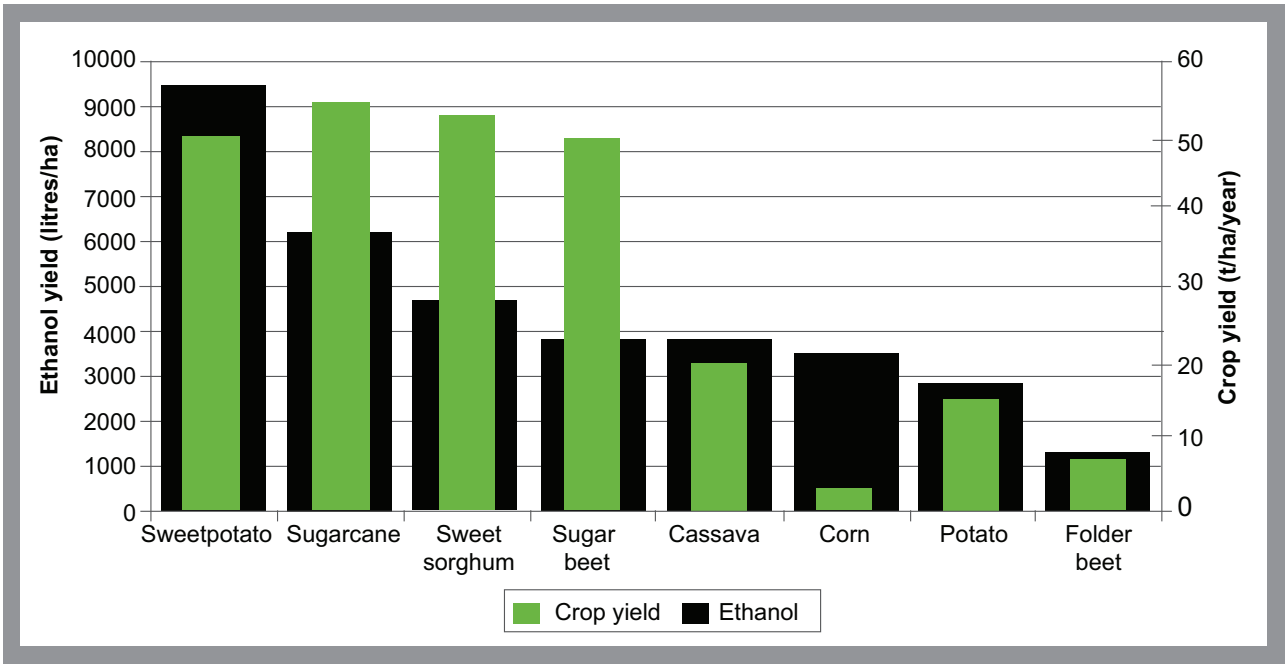
Currently, available data shows that sugarcane produces most fuel alcohol per hectare of land, followed by sweet sorghum, while sugar beet and cassava are at par with one another. However, because sweetpotato is a crop of relatively shorter duration, two crops may be produced within a year in the tropics. In this scenario, the alcohol yield from sweetpotato can surpass that of sugarcane.

Sweetpotato doughnuts


Sweetpotato fries


Sweetpotato muffins

Comparative crop and ethanol yields of selected crops (with double-cropping of sweetpotato on the same piece of land)



Source: Modified from Mays *et al.* (1990)

Contributing towards import substitution

While rice is the Malaysian staple, most people are unaware that we are also dependent on wheat as a secondary staple. Consider what many of us include in our daily diet: bread, buns, cakes, biscuits, noodles, *roti canai* and *chappati*, all of which are made from wheat flour. Annual imports of wheat amount to 4.5 million tonnes, valued at RM101.3 million. The good news is that sweetpotato with high starch content can be processed into flour which can then be used to produce a range of bakery products or pasta. At varying levels of wheat flour substitution, this flour can be used to prepare cakes (100% substitution), muffins (60%) and biscuits (50%). The flour can also be used to make extruded snacks as well as breakfast 'cereal' (somewhat like rice crispies) served with milk. Sweet buns can be made directly from sweetpotato,

Sweet buns

replacing 50% of the wheat flour in the original recipe, without the need to process the roots into flour first. Other products made directly from sweetpotato are nuggets and breaded sweetpotato.

As in the case of cassava, sweetpotato therefore offers an opportunity to tap on a range of foods

targeted for people suffering from coeliac disease, who are allergic to wheat gluten. Fries, traditionally prepared from imported 'Irish' potato, is another product which can be made from sweetpotato. Fries sold in fast-food restaurants and as frozen fries in supermarkets for home consumption are a favourite among Malaysian youth. It has been estimated that about half the imported 'Irish' potato (valued at RM229 million per year) are made into fries. Meat or vegetable pies and cheese bakes are yet other ways of replacing 'Irish' potato with sweetpotato.

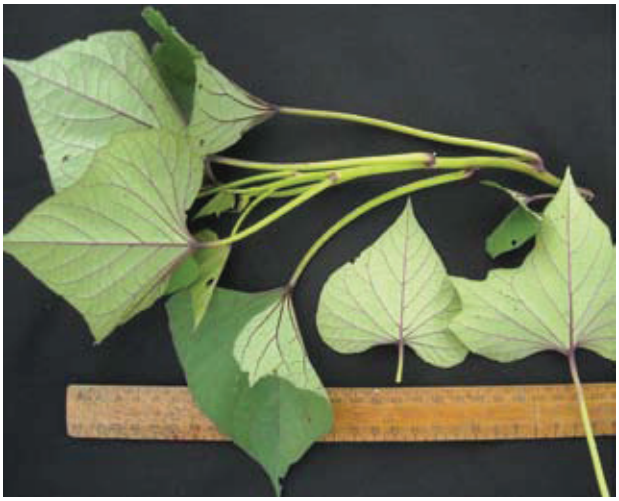
Health-promoting foods

Our preoccupation with the storage roots have led largely to our neglect of sweetpotato leaves. While eating the leaves as a vegetable is nothing new among the Chinese and Malays, most other people treat the vines and leaves as a crop waste, at best fed to farm animals (e.g. in Vietnam, they use them to feed cattle and pigs). Without doubt, as with many plant species, the shoots are rich in protein, and can make up for the low amount of protein in the roots.

Sweetpotato leaves are extremely rich in phytochemicals with beneficial health effects.

Work in Japan shows that these leaves are an excellent source of bioactive compounds; for example, 15 different anthocyanin compounds (mainly, acylated cyanidins and peonidins) have been identified.. Also six polyphenolic compounds have been found, namely, caffeic acid, chlorogenic acid (3-O-caffeoylquinic acid), 3,4-di-O-caffeoylquinic acid, 3,5-di-O-

Japanese sweetpotato



Sweetpotato shoot and leaves

Sweetpotato on peat

caffeoylquinic acid, 4,5-di-O-caffeoylquinic acid and 3,4,5-tri-O-caffeoylquinic acid. These polyphenolic compounds have significant medicinal value for certain human conditions.

One important phytochemical is lutein, a carotenoid with strong anti-oxidant properties which is found to be concentrated in the macula, a small area of the retina responsible for central vision. Several studies have shown that an increase in lutein in the macula decreases the risk of age-related macular degeneration. While marigold, several vegetables and egg yolk are known to contain lutein, the young leaves of sweetpotato can be even a richer source.

The young leaves of sweetpotato contain more lutein than the older leaves, petioles and stems. There are also obvious varietal differences in lutein content, and some of our local varieties appear have a higher content than a Japanese sweetpotato variety specially selected for this phytochemical. Particularly outstanding is variety Telong with 2336.5 μg lutein per gram of fresh leaves.

Thus, sweetpotato leaves should be promoted as a health-promoting leafy vegetable, or they can processed into leaf meal to be added to various food products or even into a tea-like beverage.

Natural colorants

Natural colour additives are classified by the FDA as "Exempt from Certification". These colours come directly from plants or animals such as seeds (annatto), roots (tumeric), vegetables (red cabbage, beet juice), algae (beta carotene), insects (carmine), fruits (grape juice), etc. These exempt colours are regulated by the Code of Federal Regulations Title 21 Part 73. There are 26 such natural colours permitted for use in food.

Lutein content (µg/g) of sweetpotato leaves compared with selected crops/foods

	Fresh weight	Dry weight
Sweetpotato, young leaves	294-2378.5	
Broccoli	42.0	
Sawi	323.5	
Tauge	32.5	
Capsicum	99	
Lettuce	80.5	
Kale[1]	147-396	
Spinach[1]	44-159	
Green pea[1]	11-24	
Marigold, orange	170-5700	323-8692
Egg[3]	120 μg/egg	
Designer egg[3]	1910 μg/egg	

[1] Mangels et al. (1993) ; [2] Sowbahgya et al. (2004);
[3] Goodrow et al. (2006)

Sweetpotato juice

Lutein content in the leaves, petioles and vines of several varieties of sweetpotato (fresh weight)

Variety		Leaf (μg/g)			Petiole (μg/g)			Stem (μg/g)
		Young	Medium	Old	Young	Medium	Old	Medium
Gendut	Range	294 - 1405	668 - 823.5	154.5 - 818.5	43.5 - 81.5	28.0 - 32.5	27.5 - 38.0	29.0 - 45.5
	Mean	849.5	745.75	486.5	62.5	30.25	32.75	37.25
VitAto	Range	1082 - 1678.5	1051.5 - 1148	561 - 653	108.5 - 144	72.5 - 90.0	45.5 - 63.5	106.5 - 143
	Mean	1385.5	1099.75	607	126.5	81.25	54.5	124.75
Telong	Range	2294.5 - 2378.5	806.5 - 1342.5	688 - 713	117 - 188	74 - 104	69.5 - 85	124 - 127
	Mean	2336.5	1074.5	700.5	152.5	89	72.25	125.5
Suioh*	Range	315-426			4-28			6-30
	Mean	368			16			18

*Ishiguro and Yoshimoto (2005)

Natural colorants from sweetpotato can be extracted from its carotenoids (ranging from yellow to deep orange) or flavonoids, specifically anthocyanin (giving a purple colour), if these are in high enough concentrations in the roots. Thus, orange-fleshed sweetpotato contains β-carotene while purple-flesh roots contain anthocyanin. Carotenoids are reported to counter coronary heart disease, while anthocyanins protect against cardiovascular disease, atherosclerosis and cancers (due to its antioxidant effect on lipids); they lower cholesterol, have platelet anti-aggregating activity, anti-thrombotic activity, beneficial ophthalmologics and capillary permeability, as well as promote wound healing.

Extracting these compounds from sweetpotato and using them in food and beverage products will not only add colour but also impart health benefits to the consumer. Japan leads in this area of product development as evidenced by the sale of noodles, ice cream, bread and other baked goods, confectionery, and bottle and canned drinks which are coloured by sweetpotato.

At any rate, even when eating sweetpotato in its original form, it makes good sense to buy those which are highly coloured to derive the most benefit.

Purple sweetpotato

MARDI sweetpotato varieties

(Available at the Seeds and Planting Materials Unit of MARDI at Serdang, Malaysia)

Variety	Root yield (t/ha)	Special characteristics	Suitability
Gendut	20-25	Yellow flesh; Fragrant and highly palatable	Roots: table use (boiled or steamed); making fries Shoots: vegetable
Telong	20-25	High dry matter content (30%) in roots; High lutein content in leaves	Roots: flour (possibly for biofuel production) Leaves: vegetable with high lutein
Jalomas	15-20	Orangey flesh; High dry matter content (25%) in roots	Roots: flour
VitAto™	25-40	Orange flesh, high in carotenoids (source of vitamin A)	Roots: carotene-rich flour; processing into various food products; juice

Conclusion

Long neglected as a poor man's food in research agendas, sweetpotato requires relatively little management and has the potential to make the leap to commercial production and processing. With its higher nutritional value and health-promoting properties compared with cassava and rice, it makes sense to confine the use of sweetpotato to human foods rather than channel it to feedstuff or biofuel for which the raw materials have to be cheap.

Best of all, it can easily be grown in Malaysia. Its short cropping cycle makes it ideal for intercropping or rotation cropping, and timing to avoid unfavourable weather conditions at certain times of the year (such as during the monsoons). It also will not displace many crops when grown in marginal soils which are under-utilized at the moment.

Finally, to alleviate the need to import about 30% of our rice demand, I would like to ask the reader to consider my proposal:

Replace the rice we eat at lunch or at dinner with sweetpotato just once a week. This will cut down rice demand by 14%, bringing the current self-sufficiency level to 84%. If we eat sweetpotato instead of rice twice a week, Malaysia will reach 98% self-sufficiency at the current rice production levels.

Suggested ways of replacing rice and wheat intake with sweetpotato

Breakfast	Lunch/Dinner	Snacks
Sweet buns	Fries	Cakes
Muffins Extruded breakfast "cereal"	Boiled/steamed sweetpotato Baked sweetpotato	Muffins Biscuits
Traditional kuih from sweetpotato premixes	Meat/vegetable pies	Extruded snacks
	Cheesy bakes	Traditional kuih from sweetpotato premixes
	Nuggets	Vacuum-fried kerepek
	Breaded sweetpotato	

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