Selection of sweetpotato clones with high β-carotene content

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Abstract

β-carotene, a precursor of Vitamin A, can be easily found in sweetpotato germplasm. While carrot, one of the traditional sources of ?-carotene, cannot grow in the tropical humid lowlands of Malaysia, sweetpotato thrives. In an attempt to partially substitute the imports of carrot and to popularize the use of orange sweetpotato in wholesome food products, a breeding and selection programme for sweetpotato clones with β-carotene has been initiated by MARDI. A preliminary series of trials was carried out on 13 clones together with two checks over four locations, sited on upland mineral soils, sandy beach deposits, tin-tailings and acid sulphate soils. A combined analysis of variance showed that clones Merah Manis, Tainung No. 64, Guan and Caromex all gave root yields in excess of 14 t/ha after 3?-4 months, with Merah Manis (31.8 t/ha) and Guan (19.8 t/ha) significantly outyielding the check Gendut (16.6 t/ha). Caromex had a higher ?-carotene content (6.18 mg/100 g) than the check Kuala Bikam 2 (5.81 mg/100 g). Initial testing of the four shortlisted clones for making juice showed promise in terms of taste and colour. With further product development work, this may lead to popularizing orange sweetpotato juice in place of carrot juice. Similarly, there is potential in using sweetpotato flour in place of wheat flour in making a more nutritious cake. Sweetpotato as a source of ?-carotene. Selection of sweetpotato clones with high ?-carotene content can replace imported carrot in Malaysia as a vitamin A source, and save valuable foreign exchange.

Key words

sweetpotato, selection, ?-carotene, juice

Introduction

Sweetpotato (*Ipomoea batatas*) is currently a minor root crop, grown in Malaysia mainly for the fresh market. This market is somewhat limited because of the perishable nature of the crop, but there is good potential for processing sweetpotato into food products.

Currently, most of the local cultivars in Malaysia have root flesh which is white or pale yellow in colour. High ?-carotene (a precursor of vitamin A) types, characterized by orange flesh, are easily found in sweetpotato germplasm. It has been reported that the ?-carotene content of sweetpotato can be higher even than in carrot (Holland *et al.* 1991), which cannot be grown in the lowlands of tropical Malaysia. Carrot imports into Malaysia amount to more than 15,000 tonnes a year, valued at USD17 million. The VITAA (Vitamin A for Africa) project coordinated by the International Potato Center has been showing success in overcoming vitamin A deficiency among children (Anderson *et al.* 2003). While vitamin A deficiency is not a critical issue in Malaysia, nevertheless, breeding and selection for cultivars with high ?-carotene may serve two purposes:

- Fresh use in cooking, juices, etc. as a partial substitute of carrot
- Processing into nutritious flour for subsequent processing into food products

Materials & Methods

Sweetpotato accessions with ?-carotene content were assembled from introductions as well as local germplasm. Preliminary evaluation and selection shortlisted the entries to 13, and these were tested against two local checks, Gendut (for yield) and Kuala Bikam 2 (for ?-carotene content) in a series of trials sited in contrasting agro-ecologies. These were Serdang on upland mineral soils, Telong on sandy beach deposits (known as *bris*), Kuala Bikam on tin-tailings (specifically on the sand-tailings fraction) and Kuala Linggi on acid sulphate soils. The last three locations are considered marginal areas for crop cultivation. The trials were each replicated four times, and for each entry used a plot size of 20 m^2 with a plant spacing of 25 cm and rows spaced 1 m apart. Standard fertilizer rates and soil amelioration practices for the different agro-ecologies were used (Tan 2002).

Data on total fresh root yield as well as yield of marketable roots (150 g each) and harvest index (root weight divided by total plant weight) were analysed in a combined ANOVA, using the SAS statistical package. ?-carotene contents of the four best entries and the ?-carotene check, Kuala Bikam 2, from the trial on acid sulphate soils were also determined. Preliminary testing of the root samples of these five clones for suitability in making juice (3 parts of sweetpotato to 1 part of water + citric acid) was carried out. Flour made from the highest yielding clone was used in a cake recipe to replace wheat flour.

Results & Discussion

The combined ANOVA (Table 1) showed that the clone Merah Manis was highest yielding in all locations (Table 2), followed by Guan and Tainung No. 64. The same trend was observed for marketable root yields. All three had significantly higher total and marketable root yields compared to Kuala Bikam 2, the ?-carotene check, while Merah Manis and Guan outperformed Gendut, the yield check, for these two traits. Of the four selected clones, Merah Manis, Caromex and Tainung No. 64 had superior harvest indices compared to the checks, implying a more efficient channelling of dry matter towards the organs of economic importance, namely the storage roots.

Table 1. Performance of 15 sweetpotato clones with ?-carotene content over four contrasting environments

Clone	Total fresh root yield (t/ha)	Marketable root yield (t/ha)	Harvest index
Bugs Bunny	8.3 def	4.9 def	0.32 ef
Caromex	14.3 c	7.2 d	0.61 a
Tainung No. 64	16.6 c	12.2 c	0.54 ab
440001	5.1 g	2.5 f	0.32 ef
440008	6.2 fg	2..9 f	0.34 def
440141	8.6 def	3.0 f	0.40 d
440006	6.5 efg	2.9 f	0.27 f
440135	11.0 d	3.9 ef	0.59 ab
W 219	11.1 d	5.7 de	0.37 de

Benihayato	10.7 d	6.7 d	0.36 de
PP INA	9.6 de	5.8 de	0.52 c
Merah Manis	31.8 a	23.3 a	0.64 a
Guan	19.8 b	17.4 b	0.53 bc
*Gendut**	16.6 c	12.1 c	0.47 c
*Kuala Bikam 2**	9.8 d	7.1 d	0.37 de
Mean	12.4	7.9	0.44
CV (%)	32.7	45.0	20.2

*Checks
Note: Means within the same column bearing the same letter are not significantly different from one another at p=0.05 according to Duncan's Multiple Range test

Merah Manis and Guan are local clones among those which were collected from farmers' fields, while Caromex and Tainung No. 64 originated from U.S.A. and Taiwan, respectively.

Despite their contrasting edaphic characteristics, the trial locations on upland mineral soils, *bris* and acid sulphate soils produced similar mean root yields (Table 2). Only the tin-tailings location (Kuala Bikam) recorded a significantly lower mean root yield.

In terms of ?-carotene content, only Caromex had a higher value than Kuala Bikam 2, the check for ?-carotene content (Figure 1). Nevertheless, these values compare favourably with the ?-carotene content of carrot at 3.2 to 6.6 mg/100 g (Tee et al. 1997; http://dcb-carot.unibe.ch/carrot.htm). Furthermore, juices made from the five clones were generally acceptable in taste, with Guan ranking highest, followed by Tainung No. 64 and Caromex. Juice made from Kuala Bikam 2 was rather bland. Figure 2 shows the range in intensity of orange colour in the juices.

Table 2. Yields (t/ha) and ranking of top five sweetpotato clones with ?-carotene content in the four locations of testing

Clone	Serdang (upland mineral)	Telong (*bris*)	Kuala Bikam (tin-tailings)	Kuala Linggi (acid sulphate)
Merah Manis	28.2 (1)*	41.1 (1)	23.8 (1)	36.0 (1)
Tainung No. 64	18.6 (4)	16.0 (3)		28.4 (2)
Guan	23.5 (3)	18.9 (2)	17.5 (2)	

Caromex			12.3 (4)	23.2 (3)
Gendut	25.0 (2)		12.5 (3)	18.8 (4)
Kuala Bikam 2	13.4 (5)			
440006		14.9 (5)		
440135		16.0 (4)		
440141				18.3 (5)
Benihayato			10.5 (5)	
Location mean	13.4 a	13.7 a	8.4 b	14.0 a

*Figures in parentheses refer to the ranking
Note: Location means bearing the same letter are not significantly different from one another at p=0.05

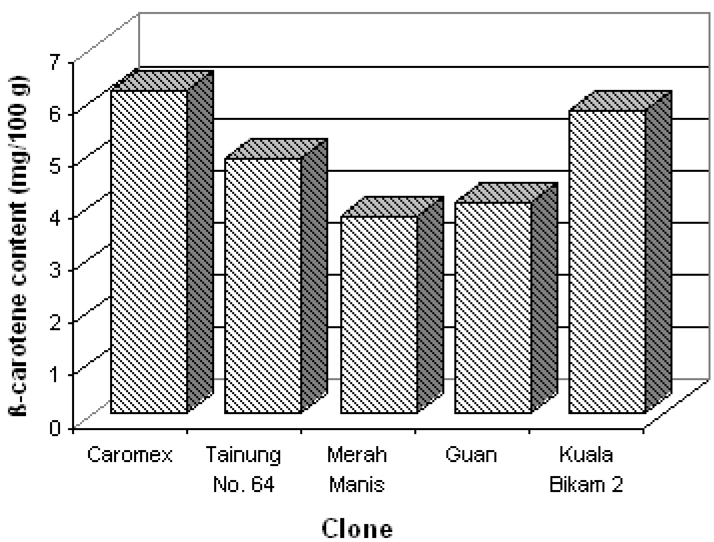

Figure 1. ?-carotene content of the top four clones including the check Kuala Bikam 2 in root samples collected from the location Kuala Linggi

Flour was made from the highest yielding clone, *viz.* Merah Manis, and used to replace wheat flour in a cake recipe. The nutrient compositions of both the flour and cake compared to wheat flour and its corresponding cake are given in Table 3. Compared to a cake made from wheat flour, the sweetpotato cake appears to be moister, have equivalent protein and fat contents, and have the added bonus of containing dietary fibre and ?-carotene, both of which are not present in wheat flour.

Figure 2. Juice made from shortlisted sweetpotato clones (From left to right: Caromex, Kuala Bikam 2, Tainung No. 64, Merah Manis, Guan)

Table 3. Nutrient composition of sweetpotato and wheat flours and their corresponding cakes

Type of flour/cake	Moisture	Crude protein	Crude fat	Crude fibre	Dietary fibre	Vitamin C	?-carotene	Energy (kcal)
			(g/100 g)			(mg/100 g)		
SP* flour	6.6	2.9	0.5	4.5	9.7	18.0	7.48	362
W** flour	12.5	12.0	1.6	2.0	n.a.	0.0	0.00	345
SP cake	40.1	6.0	18.1	0.89	5.08	n.a.	2.48	321
W** cake	14.8	7.1	19.8	0.00	n.a.	n.a.	0.00	435

*SP = sweetpotato
**W = wheat (data from Tee et al. 1997)

Conclusion

Preliminary screening over four locations of sweetpotato clones having roots with high ?-carotene was successful in shortlisting four which have reasonable root yields compared to the check, Gendut. While only Caromex had a ?-carotene content higher than the second check, Kuala Bikam 2, all four outyielded this check significantly. Initial testing also showed the possible use of these clones for making juice. A more nutritious cake can be made from sweetpotato flour compared to wheat flour. Such favourable results pave the way to developing orange-fleshed sweetpotato into a range of high-carotene food products.

The marginal locations on *bris*, tin-tailings and acid sulphate soils were able to produce sweetpotato yields at par with the location on upland mineral soils.

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