

Characterization of Yellow-Fruited and Red-Fruited Strains of Miracle Fruit [*Synsepalum dulcificum* (Schum & Thonne) Daniell]

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Five strains of miracle fruit consisting of the yellow strain and four red-fruited strains grown in Mabacan, Calauan, Laguna, Philippines were characterized. All strains showed similar growth patterns, flowering and fruiting periods, and stages of reaching maturity. The plant is evergreen, grows slowly, and reaches gestation period in 2.5 yr. It grows intermittently through a cyclical pattern of vegetative and reproductive periods. The yellow-fruited strain is unique, or one of its kind. Its flushes and fruit skin are light yellow. The leaves are acuminate with acute apex and acuminate base, glabrous, and cluster in the terminal of the shoots. The leaf margin is slightly undulating. Each leaf weighs from 0.13–0.17 g, and measures 4.9–7.0 cm long, 1.5–2.9 cm wide. The fruit is axillary, ellipsoid, weighs 0.9–1.8 g and measures 17.5–19.8 mm long, 8.1–10.2 mm wide, and forms clusters with other fruits in the shoot terminal. The seed weighs 0.3 g, and measures 13.1–15.1 mm long, 5.1–6.8 mm wide. The peel weighs 0.1–0.25 g, and the mucilage, 0.4–1.25 g. Of the total fruit weight, 14.8% is peel, 61.6% is mucilage, and 24.0% is seed. Among the red-fruited strains, strains 2 and 4 are highly promising because of their larger fruits and resistance to cracking. Their leaves are glabrous, obovate, and entire, with sub-obtuse apex and acuminate base. Their flushes are reddish. The fruit of strain 2 is red and weighs 1.95 g; strain 4 is red and larger at 2.21 g. Of the total fruit weight of strain 2, 20.51% is peel, 18.92% is seed and 62.58% is mucilage, whereas the percentages in strain 4 are 19.46% peel, 19.46% seed and 61.09% mucilage. Strains 1 and 3 produce smaller fruits and crack easily after heavy rainfall during their development during the dry season. Among the fruit features, fruit width is a strong determinant of fruit size ($r = 0.91$) compared with length ($r = 0.71$). Mucilage content is strongly correlated with fruit weight ($r = 0.96$) but not seed weight ($r = 0.55$).

Key Words: glycoprotein, miracle fruit, miraculin, *Synsepalum dulcificum*

Abbreviation: Da – Dalton

INTRODUCTION

Miracle fruit [*Synsepalum dulcificum* (Shum & Thonne) Daniell] belongs to the family Sapotaceae. It was introduced into the Philippines from Hawaii (Coronel et al. 2009) as a novel fruit whose unique trait is to condition one's palate and to allow one to drink sour juices even without sugar. According to Whitman (1997), it makes sour-tasting food taste sweet within 30 seconds after tasting the soft semi-sweet pulp of the fruit.

The crop was mentioned by Chevalier des Marchais, a French explorer, in 1725. An English physician and botanist, Daniell (1852) first described the crop after his travel in Ghana and observed that the natives take the fruit before eating acidulated bread and drinking sour wine. He called it miraculous berry. As early as 1968, Brouwer et al. extracted and purified its active ingredient, a glycoprotein called miraculin. The largest known macromolecule that affects taste perception (Kurihara

1992), miraculin has a molecular weight of 24,600 Da and includes 86.1% polypeptide and 13.9% carbohydrate (Theerasilp and Kurihara 1988; Theerasilp et al. 1989). Theerasilp et al. (1989) characterized it as having a single polypeptide with 191 amino acid residues. The miraculin binds with the sweet receptor in the tongue, which explains the long-lasting effect of the fruit that, according to Kurihara (1992), extends from 1 to 2 h. Misaka (2013) explained that miraculin binds specifically to sweet-taste receptor T1R2–T1R3 in the tongue's epithelium plasma membrane and activates its acidic conditions (pH 4.8–6.5). The effect ends after that period as the glycoprotein is gradually hydrolyzed by enzymes in the saliva.

Because of its modulating effect on taste, miracle fruit was evaluated to alter the bad taste of patients undergoing chemotherapy (Wilken and Satiroff 2012). Results indicate the fruit's ability to improve a patient's taste perception, a finding that helps cancer patients meet their nutritional requirements while undergoing treatment.

The plant is a shrub. Its height when full-grown ranges from 1 to 3.5 m under humid tropical conditions in the Philippines, but it could reach 5 m tall under ideal conditions (Adansi 1970). A drought-tolerant crop having been discovered in West Africa (Joyner 2000), the plant grows slowly, and reaches gestation period in 2.5 yr after planting. Its canopy is compact due to overlapping development of shoots and leaves which remain evergreen even after four to five flushing periods.

Miracle fruit is grown in well-drained clay loam soil with a pH of 4.5–5.8. It is propagated from seeds and can also be successfully rooted by stem cuttings and air layering. Flowers and fruits cluster in the leaf axils at the terminal of the shoots. The plant develops flowers from dormant shoots either singly or in clusters along the leaf axils. Under local conditions, the plant exhibits two flowering seasons, one in December to January and the other in February to May. This observation is corroborated by Kurihara (1992) who reported that the plant manifests two flowering seasons. Hardy and tolerant to dry soils and high temperature, the plant has a peak harvest that coincides with the peak of the dry season from March to May in the tropical humid conditions of the Philippines.

The flowers are solitary but were described by Coronel et al. (2009) as appearing in small clusters, typically because of the clustering of the leaves toward the shoot terminals. The fruit is a berry, ellipsoidal (Bartoshuk et al. 1969; Hellekant et al. 1985) and matures in 3 mo (Coronel et al. 2009). It has a thin pulp and a large seed (Inglett et al. 1965) and thin skin which turns red at maturity (Du et al. 2014). About 50% of the fruit weight is seed (Fang-Yi Cheng et al. 2015) which contains high amounts of multi-antioxidants.

When the plant was introduced into the Philippines, its morphological features were generally similar to those reported in the literature (Joyner 2000; Whitman 1997). However, having been propagated from seeds, plant variants with typical leaf and fruit characteristics developed. Strains with expanded leaves or with typical undulating leaf margin were produced. Some strains have rounder, elongated and bigger fruits, while others have elongated and smaller fruits. One such variant is the yellow-fruited strain.

The present study was conducted to characterize the yellow-fruited strain and compare it with selected red-fruited strains in terms of typical morphological characteristics.

MATERIALS AND METHODS

Of the 23,000 full-grown miracle fruit plants in the Miracle Fruit Farm in Mabacan, Calauan, Laguna, Philippines, one outstanding strain producing yellow berries developed prominently. It was one rare trait

which came out more likely by mutation. This strain was characterized together with four red-fruited strains. The shrubby miracle fruit plants were 12–13 yr old and raised in a 3.5-ha farm previously planted to sugarcane. The farm has a flat terrain with well-drained clay loam soil. Its climate is more pronounced, wet from June to October and dry for the rest of the year. Miracle fruit plants were raised from seedlings and planted at 1.5 × 1 m apart. The choice of the red-fruited strains was based on fruit color, leaf size, and fruit size.

From each strain, 20 fruits and 20 leaves were randomly sampled from around the tree. Immediately after sampling, each fruit was weighed before its length and width were measured, then manually peeled and depulped. The skin and pulp were weighed using a digital weighing balance. The clean seeds were individually weighed and their length and width were measured using a digital caliper. The color and shape of the fruits were noted.

The fresh leaves were individually weighed and their width at the widest portion and length was determined. Leaf length to width ratio was also computed. Their shape, apex, base, margin, and surface were described. The color of the flush was also described.

Characteristics of leaf, fruit and seed were correlated. Standard deviation of fruit, leaf, and seed parameters were also determined. Descriptive statistical ranking was used to rank the strains according to fruit, leaf and seed characteristics.

Cracking of the fruits was described based on the senior author's 10 yr of experience of growing the fruits. It was described as simply sensitive or less sensitive to cracking as influenced by change in water potential gradient.

Samples of five shoots from each strain were also obtained and the leaves per shoot were counted.

RESULTS AND DISCUSSION

The plant is a slow-growing shrub. It grows from a single stem which is covered with multiple branches arising from about 10–30 cm above the ground. The canopy is compact with highly persistent leaves which remain evergreen even after the third or fourth flushing periods. It grows by flushes arising from one or more buds from the previous season's shoots. The flush is held by a long leafless stem which terminates at the apex where leaves arise from very short internodes. As such, the flush appears to be a crown of six or more leaves.

Leaf Characteristics

The leaves are clustered at the shoot terminals. They vary in size and margins, but with similar leaf base. All except the big-fruited strains no. 2 and 4 have oblanceolate leaf (Table 1). Strains 1 and 5 (yellow) have acute leaf apex

while the rest are sub-obtuse; all strains have acuminate leaf base. Leaf margins are either slightly undulating (strains 1, 3 and yellow) or entire (strains 2 and 3) (Fig. 1). All leaves are glabrous. The growth pattern is intermittent, characterized by cyclical development of flushes which develop after harvest. Under climatic conditions in Calauan, Laguna, flushing occurs in June to July or during the onset of the rainy season. Leaves are green in all varieties except in immature leaves where the yellow strain has yellowish and the red strain reddish flushes (Fig. 2). The number of leaves in the current season's flush was highest in strain 1, producing smaller leaves, and lowest in strain 5 producing the bigger leaves. The yellow strain ranked 4th in terms of number of leaves with 7 per shoot.

Leaf size varies. The big-fruited strains 2 and 4 produce bigger leaves weighing 0.2 g and 0.21 g, respectively (Table 2). They also have longer and wider leaves. This is within the range reported in the literature (Duke and DuCellier 1993). The shape of the leaves can be determined. Leaf weight is significantly correlated with leaf length and width with $r = 0.69$ and $r = 0.65$, respectively (Table 3).

Fruit Characteristics

The fruit is red except for the yellow strain (Table 4). Generally ellipsoid in shape, the fruits vary in their susceptibility to changes in water potential. During the dry months of March to May, a sudden downpour often leads to cracking of fruits, and in most cases, fruits of strains 1 and 3 crack.

Strains can also be characterized in terms of fruit size, a parameter that determines quality in the highly discriminating Japanese market which prefers bigger fruits. Strain 4 ranked 1st in having larger fruits weighing



Fig. 1. Leaf shape of miracle fruit (*Synsepalum dulcificum*). Leaf at extreme right is that of the yellow strain.



Fig. 2. Flush color of red-fruited strain (left) and yellow-fruited strain (right) of miracle fruit (*Synsepalum dulcificum*).

Table 1. Leaf shape, margin, and color of flushes of yellow and selected red strains of miracle fruit (*Synsepalum dulcificum*).

Strain No.	Leaf Shape			Leaf Margin	Leaf/Shoot	Rank	Color of New Leaves
	Whole Leaf	Apex	Base				
1	Oblanceolate	Acute	Acuminate	Slightly undulating	8.4	1	Red
2	Obovate	Sub-obtuse	Acuminate	Entire	6.2	5	Red
3	Oblanceolate	Sub-obtuse	Acuminate	Slightly undulating	7.8	2	Red
4	Obovate	Sub-obtuse	Acuminate	Entire	7.2	3	Red
5 Yellow	Oblanceolate	Acute	Acuminate	Slightly undulating	7.0	4	Yellow

Table 2. Leaf size of yellow and selected red strains of miracle fruit (*Synsepalum dulcificum*).

Strain No.	Leaf Size									
	Weight, g	Rank	Std dev	Length (A), cm	Rank	Std dev	Width (B), cm	Rank	Std dev	A/B
1	0.14	4	0.05	5.21	4	0.57	2.08	3	0.27	2.50
2	0.20	2	0.07	6.64	1	0.66	2.60	2	0.25	2.55
3	0.10	5	0.02	3.87	5	0.40	1.55	5	0.22	2.50
4	0.21	1	0.06	6.03	2	0.79	3.25	1	0.30	1.86
5 Yellow	0.15	3	0.01	5.94	3	0.63	2.04	4	0.31	2.91

2.21 g and strain 3 ranked 5th, the smallest weighing 0.93 g (Table 5). The yellow strain ranked 4th and may be classified as small. Of secondary importance in terms of market preference are fruit length and fruit width. Fruit length ranges from 17 to 22 mm and width from 9 to 13 mm. The yellow strain ranked 3rd in fruit length and 5th in fruit width. The relative shape of the fruit can also be determined from the ratio of the fruit length and width with strains 4 and 1 having the lowest ratio of 1.45 and 1.54, respectively, and therefore rounder than the other strains. Small in size, the yellow strain has the most elongated fruit.

Table 3. Correlation coefficients (r) among leaf characteristics (n = 100) of miracle fruit (*Synsepalum dulcificum*). All r values are highly significant at 1%.

Parameter	Correlation Coefficients		
	Leaf Weight	Leaf Length	Leaf Width
Leaf weight	1.00	0.69	0.65
Leaf length	0.69	1.00	0.69
Leaf width	0.65	0.69	1.00

Table 4. Fruit color, shape and sensitivity of cracking of yellow and selected red strains of miracle fruit (*Synsepalum dulcificum*).

Strain No.	Color	Shape	Fruit Cracking
1	Red	Ellipsoid	+
2	Red	Ellipsoid	-
3	Red	Ellipsoid	+
4	Red	Ellipsoid	-
5	Yellow	Ellipsoid	-

+ Cracks with change in water potential
Seldom cracks with change in water potential

Table 5. Fruit size of yellow and selected red strains of miracle fruit (*Synsepalum dulcificum*).

Strain No.	Weight, g	Rank	Std dev	Length (A), mm	Rank	Std dev	Width (B), mm	Rank	Std dev	A/B
1	1.51	3	0.16	18.11	4	1.31	11.76	3	0.66	1.54
2	1.95	2	0.22	22.14	1	1.73	12.55	2	0.52	1.76
3	0.93	5	1.16	16.99	5	1.32	9.59	4	0.54	1.77
4	2.21	1	0.42	19.69	2	1.79	13.60	1	0.91	1.45
5	1.25	4	0.26	18.57	3	0.78	9.48	5	0.49	1.96

Yellow

Table 6. Seed size of yellow and selected red strains of miracle fruit (*Synsepalum dulcificum*).

Strain No.	Weight, g	Rank	Std dev	Length (A), mm	Rank	Std dev	Width (B), mm	Rank	Std dev	A/B
1	0.26	5	0.05	12.74	5	0.70	6.69	3	0.46	1.90
2	0.33	2	0.07	14.7	1	0.63	6.82	2	0.33	2.16
3	0.28	4	0.08	12.85	4	1.12	6.22	4	0.53	2.07
4	0.43	1	0.06	14.32	2	0.87	7.64	1	0.38	1.87
5	0.30	3	0.00	13.84	3	0.89	5.79	5	0.49	2.39

Yellow

Table 7. Seed color, shape, peel and mucilage weight of yellow and selected red strains of miracle fruit (*Synsepalum dulcificum*).

Strain No.	Color	Shape	Peel Weight, g	Rank	Std dev	Mucilage Weight, g	Rank	Std dev
1	Dark brown	Ellipsoid	0.24	3	0.05	1.02	3	0.16
2	Dark brown	Ellipsoid	0.40	2	0.02	1.22	2	0.20
3	Dark brown	Ellipsoid	0.19	4	0.02	0.46	5	0.15
4	Dark brown	Ellipsoid	0.43	1	0.09	1.35	1	0.47
5	Dark brown	Ellipsoid	0.19	4	0.05	0.77	4	0.25

Yellow

Seeds are dark brown and ellipsoid in shape. The hilum and the area around it where the mucilage adheres the most is whitish. Ranking 1st and 2nd, respectively, in terms of fruit weight, strains 4 and 2 also ranked 1st and 2nd in terms of seed weight (Table 6). The yellow strain ranked 3rd weighing 0.3 g against the ranking strain 4 with 0.43 g. Seed length ranges from 12.74 to 14.7 mm, while width is 5.79 to 7.64 mm. Among the strains, the yellow strain is rounder with a length/width ratio of 2.39. Strain 4, which ranked 1st in terms of seed size, has a more rounded seed with a length/width ratio of 1.87. Peel and mucilage weight is also high in strain 4 (Table 7). The yellow strain and strain 3 ranked 4th in peel weight with 0.19 g each, and strain 3 ranked 5th in mucilage weight with 0.46 g. Among strains, strain 4 ranked 1st in mucilage content whereas the yellow strain ranked 4th.

The miracle fruit is known to have thin mucilage. Although slightly sweet, the fruit is far from being a food item that can satisfy one's hungry stomach. Because of its unique properties, it is easily considered as a food supplement. Against the claim that the miracle fruit is largely seed, our data show that the heaviest seed part is the mucilage comprising between 49.46% and 67.55% of the total fruit weight (Table 8). Although very prominent, the seed is only three to four times smaller than the mucilage. The yellow strain has 61.6% mucilage, 24% seed and 14.8% peel.

Among the fruit characteristics, fruit width is a strong determinant of fruit size (r = 0.91) compared with fruit length (r = 0.71) (Table 9). On the other hand, seed weight is weakly determined by its length and width (r = 0.57 and r = 0.59, respectively). Because mucilage encloses the

seeds, it does not follow that a strain having bigger seeds would have higher mucilage content as the correlation coefficient ($r = 0.35$) between the two characters would show.

Fruit weight is a function of the weights of fruit parts. What determines fruit weight is primarily its mucilage content with the highest correlation coefficients of $r = 0.96$, followed by peel weight $r = 0.72$ and seed weight $r = 0.55$.

Characteristics of the Strains

The fruit morphological features are presented in Fig. 3.

Strain 1. The fruit is red, axillary, glaucous, ellipsoid, weighs 1.1–1.9 g, measures 16.1–21.3 mm long, 10.2–12.9 mm wide and has a length/width ratio of 1.54. The seed is dark brown, glossy, weighs 0.2–0.3 g, and measures 11.8–14.0 mm long, and 5.8–7.5 mm wide. The peel is thin, red and weighs 0.2–0.3 g. The mucilage is thin, whitish, semi-sweet, and weighs 0.7–1.3 g. The peel, mucilage and seed comprise 15.89%, 67.55%, and 16.89% of the total seed weight, respectively. The fruit easily cracks with sudden surge in soil moisture to the plant. The leaf is reddish when immature and green when mature; it clusters in the shoot terminal and is persistent, glabrous, oblanceolate with slightly undulating margin, acute apex, and acuminate base. It weighs 0.1–0.3 g, and measures 7–7.4 cm long and 2.5–3.8 cm wide.

Strain 2. The fruit is red, ellipsoid, axillary, glaucous, weighs 1.5–2.5 g, and measures 19.0–26.6 mm long and 11.27–13.4 mm wide. The seed is dark brown, glossy, with whitish hilum, weighs 0.2–0.4 g, and measures 13.6–15.6 mm long and 6.26–7.41 mm wide. The peel is thin, red, and weighs 0.3–0.4 g. The mucilage is thin, semi-sweet, whitish, and weighs 0.8–1.7 g. The peel, mucilage and seed are 20.51%, 62.56%, and 16.92% of the total weight,

respectively. The fruit seldom cracks with sudden surge in soil moisture to the plant. The leaf is reddish when immature and green when mature, persistent, glabrous, clusters in the shoot terminal, obovate, with entire leaf margin, sub-obtuse base and acuminate apex. It weighs 0.1–0.4 g, and measures 5.7–8.5 cm long and 2.1–3.3 cm wide.

Strain 3. The fruit is red, ellipsoid, axillary, glaucous, weighs 0.8–1.3 g, and measures 14.8–19.52 mm long and 8.3–10.5 mm wide. The seed is dark brown, glossy with whitish hilum, weighs 0.1–0.4 g, and measures 10.7–14.8 mm long and 5.2–7.0 mm wide. The peel is thin, red and

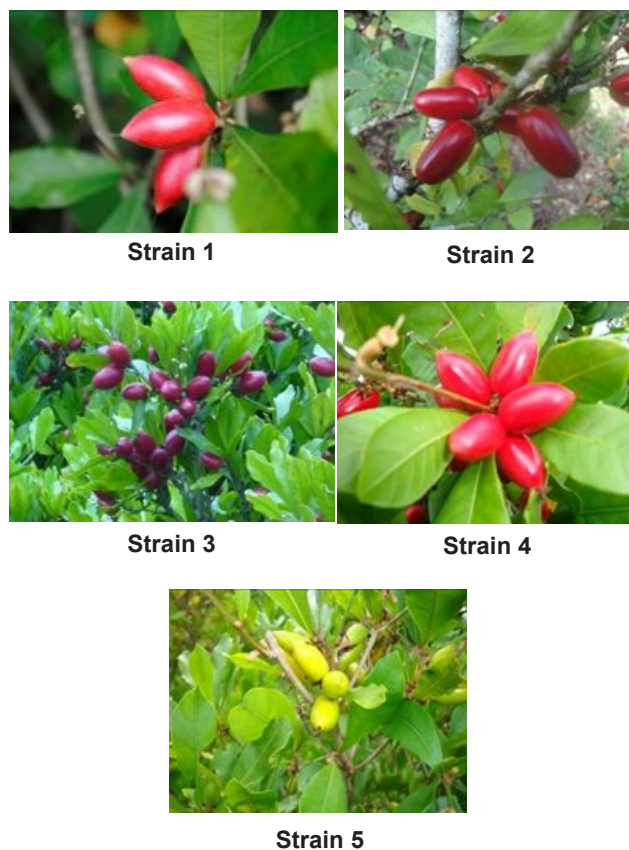


Fig. 3. Comparison of yellow-fruited strain with red-fruited strains of miracle fruit (*Synsepalum dulcificum*).

Table 8. Proportion of peel, seed and mucilage to the total fruit weight of miracle fruit (*Synsepalum dulcificum*).

Strain No.	Proportion of Different Parts of Fruits to the Total Weight (%)		
	Peel	Seed	Mucilage
1	15.19	16.89	67.55
2	20.51	18.92	62.58
3	20.43	30.11	49.46
4	19.46	19.46	61.09
5	14.8	24.00	61.60
Yellow			

Table 9. Correlation coefficients (r) among fruit and seed characteristics of miracle fruit ($n = 100$). All r values are highly significant at 1%.

Parameter	Correlation Coefficients							
	Fruit Weight	Fruit Length	Fruit Width	Peel Weight	Seed Weight	Seed Length	Seed Width	Mucilage Weight
Fruit weight	1.00	0.71	0.91	0.72	0.55	0.48	0.64	0.96
Fruit length	0.71	1.00	0.57	0.54	0.31	0.51	0.30	0.69
Fruit width	0.91	0.57	1.00	0.75	0.52	0.38	0.75	0.84
Peel weight	0.72	0.54	0.75	1.00	0.53	0.48	0.68	0.52
Seed weight	0.55	0.31	0.52	0.53	1.00	0.57	0.59	0.35
Seed length	0.48	0.51	0.38	0.48	0.57	1.00	0.41	0.37
Seed width	0.64	0.30	0.75	0.68	0.59	0.41	1.00	0.50
Mucilage weight	0.96	0.69	0.84	0.52	0.35	0.37	0.50	1.00

weighs 0.15–0.2 g. Mucilage is thin, semi-sweet, whitish, and weighs 0.2–0.8 g. The peel, mucilage and seed are 20.43%, 49.46%, and 30.1%, of total seed weight, respectively. The fruit cracks easily with sudden surge in soil moisture to the plant. The leaf is reddish when immature and green when mature; it clusters in the shoot terminal, is persistent, glabrous, oblanceolate, with slightly undulating margin, sub-obtuse base and acuminate apex. It weighs 0.08–0.12 g, and measures 3.2–4.6 cm long and 1.1–2 cm wide.

Strain 4. The fruit is red, ellipsoid, axillary, glaucous, weighs 1.6–3.0 g, and measures 15.9–22.7 mm long and 12.2–15.7 mm wide. The seed is dark brown, glossy with whitish hilum, weighs 0.3–0.5 g, and measures 12.8–16.0 mm long and 7.0–8.6 mm wide. The peel is thin, dark red, and weighs 0.3–0.5 g. Mucilage is thin, semi-sweet, whitish, and weighs 0.5–2.2 g. The peel, mucilage and seed are 19.46%, 61.09%, and 19.46% of the total weight, respectively. The fruit seldom cracks with surge in soil moisture to the plant. The leaf is reddish when immature and green when mature; it clusters in the shoot terminal, is persistent, glabrous, obovate, with entire margin, sub-obtuse base and acuminate apex. It weighs 0.1–0.3 g, and measures 4.7–7.4 cm long and 2.5–3.8 cm wide.

Strain 5. The fruit is yellow, ellipsoid, axillary, glaucous, weighs 0.9–1.8 g, and measures 17.5–19.8 mm long and 8.1–10.2 mm wide. The seed is dark brown, glossy, with whitish hilum, weighs 0.3 g, and measures 11.1–15.1 mm long and 5.1–6.8 mm wide. The peel is thin, yellow, and weighs 0.1–0.25 g. Mucilage is thin, semi-sweet, whitish, and weighs 0.4–1.25 g. Peel, mucilage and seed are 14.8%, 61.6%, 24.0%, of the total fruit weight, respectively. The fruit seldom cracks with sudden surge in soil moisture to the plant. The leaf is light yellow when immature and green when mature; it clusters in the shoot terminal, is persistent, glabrous, oblanceolate with slightly undulating margin, acute base, acuminate apex, weighs 0.13–0.17 g, and measures 4.9–7.0 cm long and 1.5–2.9 cm wide. The fruit, peel and seeds of the yellow miracle fruit are presented in Fig. 4.

CONCLUSION

The yellow-fruited strain has a typical growth pattern similar to that of the red-fruited strains. It is slow-growing, with a single stem covered with closely spaced branches and evergreen leaves which remain persistent in the current and previous season's shoots. Its leaves are acuminate in shape, slightly undulating, with sub-obtuse apex and acuminate base. The flowers develop at the leaf axils singly or in small clusters. The fruits are of medium size, ellipsoid, and seldom crack with sudden surge in soil moisture due to heavy rainfall. It has potential ornamental value and is suitable for wine processing.

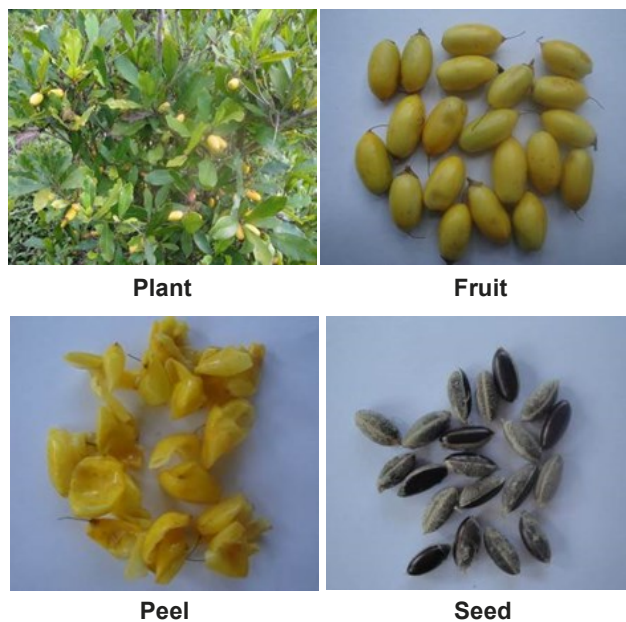


Fig. 4. Plant, fruit, peel and seed of yellow-fruited miracle fruit (*Synsepalum dulcificum*).

Among the red-fruited strains, strains 2 and 4 are superior because of their size and lower tendency to crack with sudden increase in soil moisture. Among the fruit characteristics, fruit width is a strong determinant of fruit size ($r = 0.91$) compared with length ($r = 0.71$). Mucilage content is not a function of seed weight ($r = 0.35$) but a function of fruit weight ($r = 0.96$).

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