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Physico-chemical attributes of watery rose apple (*Syzygium aqueum* (Burm.) Alston) and Malay apple (*Syzygium malaccense* (L.) Mernil and Perry)

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Abstract
Watery rose apples and Malay apples belong to the group of under-exploited fruit crops with a high potential to be put to various uses. A study was conducted to analyse the Physico-chemical attributes of watery rose apples (pink and white) and Malay apples and identify the product suitability of different types. The collected fruits were grouped based on colour, and Physico-biochemical characters were analysed separately. The evaluation revealed the variation among the three types (pink watery rose apple, white watery rose apple and Malay apple) and among accessions within types. Mean fruit weight was higher for Malay apple. No significant variation was observed among the accessions of white and Malay apple in the percentage recovery of pulp. Variation among different size groups was significant only in Malay apple. The suitability of fruits for preparing various products was selected based on their biochemical characteristics.

Keywords: Watery rose apple, Malay apple, Titrable acidity, TSS, sugar content, ascorbic acid

1. Introduction
Watery rose apple (*Syzygium aqueum* (Burm.) Alston) and Malay apple (*Syzygium malaccense* (L.) Mernil and Perry) are grown widely in the home steads of Kerala, and the fruits are consumed mainly in their fresh form. They still remain in the category of under-exploited fruit crops (Peter *et al*., 2006) [6], which have a high potential for utilization through processing and value addition. A single tree bears 21 to 85 kg per tree per year, providing a good quantity of raw materials for processing. But a major chunk of this natural resource is being wasted due to lack of scientific know-how about its phytonutrient properties as well as lack of technology for handling, processing and value addition. Unlike other fruit crops, in watery rose apple released varieties are not available. However, types possessing distinct and variable characters have been reported in rose apple (Mazumdar, 1979) [4] and in Malay apple (Whistler and Elevitch, 2006) [10].
The physicochemical attributes of the fruits primarily determine their suitability for the preparation of various products. Very little is known about the physicochemical attributes of watery rose apples and Malay apples, and it is very important to bring out this basic information for future use. Hence, the present study was undertaken to collect different accessions of watery rose apple and Malay apple and analyse their physico-chemical attributes.

2. Materials and Methods
Fruits were collected from watery rose apple accessions - pink-AC.5 and white- AC.1 to 5 and Malay apple accessions -AC.3 and 4 from the college orchard maintained at Vellanikkara. The trees are well managed. About 2 kilograms of fruits were collected from each tree at physiologically mature stage. Accessions (AC.1 to 4 and AC. 7 and 8 in pink, and AC.1 and 2 in Malay apple) were collected from farmers' plots in different parts of the Thrissur district. Colour of the fruits and the physico chemical attributes of the fruits *viz*.; mean weight of fruits, percentage recovery of pulp, total soluble solids (TSS), titrable acidity, ascorbic acid content and sugar content (reducing, nonreducing and total) were evaluated (Ranganna, 1997; Sadasivam and Manickam, 1996) [7, 8]. The fruits were classified as big, medium and small statistically based on the quartiles.

If the mean weight fell below the first quartile it is classified as small and above the third quartile it is classified as big. All those which fell between first and third quartile were classified as medium. Physico chemical attributes of the fruits in relation to their size were studied. Based on the physico chemical attributes of the fruits, the types suitable for the production of quality pulp and juice and also for the preparation of various products were selected. Based on previous records, trees with uniform bearing capacity were selected. Wherever necessary the comparison of treatments was made as CRD. Accessions having an above average yield was purposefully selected for the study.

2.1. Results and Discussion

The fruit colour ranged from pinkish red to pink in pink watery rose apple and light pink to pink in Malay apple. There was no colour variation among accessions of white watery rose apple.

2.1.1. Grouping based on size

The grouping of fruits belonging to different sizes is given in Table 2. Those weighing 145g and above were classified as big, between 80.6 and 145g were classified as medium and between 50 and 80.6g were grouped as small for pink watery rose apple. In white watery rose apple, those weighing 135g and above were classified as big, between 122.5 and 135g were grouped under medium and between 100 and 122.5 were grouped as small. In Malay apple, fruits weighing above 970g were classified as big, between 505 and 970g were classified as medium and those weighing between 390 and 505g were grouped as small.

2.1.2. Variation among types and sizes

In general, the mean fruit weight recorded for Malay apple (592.5g) was higher compared to other two types (Table 1). The titrable acidity ranged between 0.37 and 1.7 among the three types on an average. Fruits which are sour in taste can be used for preparation of variety of pickles. Joy (2003) [3] utilized bilimbi fruit which exhibited an acidity of 2.5% for preparing pickle. There was no significant difference between accessions of white and Malay apple with respect to percentage recovery of pulp (Table 1). In pink watery rose apple maximum percentage recovery of pulp was recorded for AC.4 (98.2%) and the least in AC.6 (60%). The pulp recovery of watery rose apple and Malay apple was almost the same as that recorded for oblong types of jamun fruits (Singh *et al*., 1999) [9]. Total soluble solids did not differ significantly between the different accessions within types. There was significant difference in acidity among accessions within the types. Many underutilized fruits are good source of vitamins. The present study also highlights the fact that watery rose apple and Malay apple are good sources of vitamin C, which is in concordance with the studies of Bolarin *et al* (2016) [1]. There was a significant difference in ascorbic acid content among accessions of pink watery rose apple and Malay apple. Maximum reducing sugar (2.12%) was recorded for AC.5 and AC.6 showed the least content of 1.2% in the pink watery rose apple. In white watery rose apple, AC.1 recorded the maximum reducing sugar content of 1.45% and AC.2 recorded the least (0.58%). In Malay apple, AC.2 recorded the maximum reducing sugar content of 1.61% and the minimum was in AC.3 (0.51%). Significant difference for non reducing sugars was noticed among the accessions. It ranges from 0.42-1.26% among the accessions of pink watery rose apple, 0.73- 1.47% in white watery rose apple and 0.34- 2.32% in Malay apple. In a study conducted by Joy (2003) [3] for utilization of selected underexploited fruits for product development *viz*; bilimbi, watery rose apple and Lovi-lovi, watery rose apple was inferior in terms of reducing and non reducing sugars (1.7 and 1.32% respectively). Nunes *et al* (2016) [5] and Fontan *et al* (2017) [2] assessed the physico chemical characterisation of Malay apple and the content of reducing sugar varied between 0.54 – 4.91% where the differences are caused by geographical, genetic and environmental factors. Total sugars did not differ significantly in pink watery rose apple but significance was noticed in white watery rose apple and Malay apple.

The physico chemical attributes of fruits in relation to their size are given in Table 3. The size of fruits assumed significance only in Malay apple, since there was significant difference among the three size groups *viz*; big, medium and small in percentage recovery of pulp, titrable acidity, ascorbic acid content, non reducing sugar and total sugar content. The suitability of fruits for preparation of products depends upon their physico chemical attributes. Accessions with high pulp recovery (AC.4 in pink watery rose apple, AC.5 in white watery rose apple and AC.1 in Malay apple) were selected for preparing pulp and juice-based products. Similarly for preparation of osmodehydrated products accessions possessing big fruits (AC.1 in all types) were selected. For pickle, size and acidity of fruits were given prime concern and small fruits with high acidity were identified and used for preparation of pickle (AC.2 from pink watery rose apple and Malay apple and AC.5 from white watery rose apple). Fruits with high vitamin C and sugar content were used for preparation of wine (AC.1 in pink and Malay apple and AC.4 in white watery rose apple). For table purpose accessions with big fruits and high sugar acid ratio (AC.1 in three types of fruits) were selected.

3. Tables

Table 1: Physico chemical attributes of different accessions of fruits

Accession	Fruit colour	Mean weight of 10 fruits (g)	Recovery of pulp (%)	TSS (°Brix)	Titrable acidity (%)	Ascorbic acid content mg/100g	Reducing sugars (%)	Non reducing sugars (%)	Total sugars (%)
Pink watery rose apple									
AC.1	Pink	145^{a}	86.50^{b}	5^{a}	0.92^{dc}	83.87^{a}	1.52^{cd}	0.95^{bc}	2.47^{a}
AC.2	Pink	50^{f}	85.18^{b}	4^{a}	1.84^{b}	48.38^{b}	1.56^{bcd}	0.49^{d}	2.05^{a}
AC.3	Pinkish red	145^{a}	78.32^{c}	5^{a}	1.54^{bc}	9.60^{g}	1.78^{abcd}	0.42^{d}	2.20^{a}
AC.4	Pinkish red	103^{b}	98.20^{a}	4^{a}	2.86^{a}	19.30^{e}	1.45^{c}	0.60^{cd}	2.05^{a}
AC.5	Pinkish red	65^{e}	95.60^{a}	5^{a}	0.82^{d}	38.71^{c}	2.12^{a}	1.26^{a}	3.38^{a}
AC.6	Pink	85^{c}	60.00^{d}	5^{a}	1.74^{b}	19.30^{e}	1.20^{d}	1.05^{ab}	2.25^{a}
AC.7	Pink	75^{d}	80.00^{c}	5^{a}	2.20^{ab}	22.59^{d}	1.60^{bcd}	1.26^{a}	2.86^{a}
AC.8	Pink	75^{d}	82.15^{bc}	4^{a}	1.69^{b}	16.12^{f}	1.93^{ab}	1.08^{ab}	3.01^{a}
Mean values		**92.87**	**83.24**	**4.63**	**1.70**	**32.23**	**1.64**	**0.90**	**2.53**
White watery rose apple									

AC.1	White	145[a]	87.80[a]	4[a]	0.36[b]	6.45[b]	1.45[a]	0.73[c]	2.17[ab]
AC.2	White	125[bc]	85.65[a]	5[a]	0.26[c]	16.13[a]	0.58[b]	1.02[bc]	1.59[bc]
AC.3	White	120[c]	89.08[a]	5[a]	0.36[b]	12.90[a]	0.60[b]	0.80[c]	1.40[c]
AC.4	White	133[b]	90.50[a]	3[a]	0.51[a]	16.13[a]	1.32[a]	1.26[ab]	2.58[a]
AC.5	White	100[a]	91.56[a]	3[a]	0.38[b]	12.90[a]	1.14[a]	1.47[a]	2.61[a]
Mean values		124.60	88.92	4.00	0.37	12.90	1.02	1.05	2.07
Malay apple									
AC.1	Pink	970[a]	92.56[a]	4[a]	0.15[d]	42.20[a]	1.01[b]	2.32[a]	3.33[a]
AC.2	Pink	390[c]	85.40[a]	5[a]	1.38[c]	19.30[b]	1.61[a]	0.34[d]	1.95[b]
AC.3	Light pink	545[b]	91.60[a]	3[a]	2.20[a]	16.13[c]	0.51[c]	1.66[b]	2.16[b]
AC.4	Light pink	465[c]	90.96[a]	3[a]	1.84[b]	12.90[d]	1.35[a]	1.01[c]	2.36[b]
Mean values		592.50	90.13	3.75	1.39	22.63	1.12	1.33	2.45
CD for comparing types		293.3	20.34	1.87	1.04	43.97	0.88	1.17	1.29

Figures with even letters form a homogenous group

Table 2: Classification of accessions based on size

Type	Classification	Mean weight of 10 fruits (g)	Accession
Pink watery rose apple	Big	145	1 and 3
	Medium	80.6	4, 5, 6, 7 and 8
	Small	50	2
White watery rose apple	Big	135	1 and 4
	Medium	122.5	2 and 3
	Small	100	5
Malay apple	Big	970	1
	Medium	505	3 and 4
	Small	390	2

Table 3: Group means of important attributes of watery rose apple and Malay apple types with respect to size of fruits

Type	Classification	Recovery of pulp (%)	TSS (°Brix)	Titrable acidity (%)	Ascorbic acid content (mg/100g)	Reducing sugars (%)	Non reducing sugars (%)	Total sugars (%)
Pink watery rose apple	Big	82.40[a]	5.0[a]	1.23[a]	46.73[a]	1.65[a]	0.69[a]	2.34[a]
	Medium	83.19[a]	4.6[a]	1.86[a]	23.20[a]	1.66[a]	1.05[a]	2.71[a]
	Small	85.18[a]	4.0[a]	1.84[a]	48.38[a]	1.56[a]	0.49[a]	2.05[a]
White watery rose apple	Big	89.19[A]	3.5[A]	0.26[A]	11.29[A]	1.39[A]	0.99[A]	2.38[A]
	Medium	87.36[A]	5.0[A]	0.31[A]	14.52[A]	0.59[A]	1.82[A]	1.49[A]
	Small	91.56[A]	3.0[A]	0.38[A]	12.90[A]	1.14[A]	1.47[A]	2.61[A]
Malay apple	Big	92.56[a]	4.0[a]	0.15[c]	42.20[a]	1.01[a]	2.32[a]	3.33[a]
	Medium	91.28[b]	3.0[a]	2.02[a]	14.51[c]	0.93[a]	1.34[b]	2.26[b]
	Small	85.40[c]	5.0[a]	1.38[b]	19.30[b]	1.61[a]	0.34[c]	1.95[c]

Figures with even letters form a homogenous group

4. Conclusion

There exists adequate variation among the different accessions of watery rose apples and Malay apples with respect to different physicochemical attributes. Hence selection can be enforced for getting ideal types for processing and product development. Apart from the colour of fruits, their size also assumes significance in this context. The types chosen can be vegetatively propagated for further multiplication and use in future. The present attempt, first of its kind done in watery rose apple and Malay apple, helped to identify a few accessions of watery rose apple and Malay apple suitable for product development.

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