International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(6): 112-117

Received: 24-09-2017
Accepted: 26-10-2017

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Evaluation of the elite strains of acid lime (*Citrus aurantifolia* Swingle) for the quality parameters

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Abstract
The research was carried out to evaluate the quality parameters of the elite strains of kagzi lime variety of acid lime in major growing parts of Vijayapura district. Among the 40 Kagzi lime trees selected in the present study, 'KLS-23' had the highest titratable acidity (8.85 %), ascorbic acid (31.65 mg/100g) and total soluble solids (7.56 ^{0}B). The highest shelf life of 10.75 days, lowest physiological loss in weight (5.04) was recorded in 'KLS-5'.

Keywords: Kagzi lime, Juice content, TSS, titrable acidity, shelf life

Introduction
Citrus is one of the major fruit crop in the world. It belongs to the family Rutaceae, genus *Citrus* that consists of dicotyledonous trees and shrubs. It is the most important fruit crop in India having socio-economic significance, due to its delicious quality of fruit and richness in vitamins and minerals. Acid lime (*Citrus aurantifolia* Swingle) is another commercially important citrus crop grown across different states of the country. It is cultivated mainly in Maharashtra, Gujarat, Seemandhra, Telangana, Uttarkhand, Bihar, Assam, Karnataka and Madhya Pradesh. Karnataka ranks 4th in production of acid lime with 2,83,470 tonnes and 8th in area (12,150 ha) and ranks first in productivity with 23.33 t/ha with a trade of worth 4,92,027 lakhs at current price (Anon., 2015) [1].
In the present investigation, to entail successful selection and acceptance by the consumers, directional selection for yield alone cannot be the criteria in crop like acid lime, instead, fruit qualities are equally essential component of decisiveness to be accepted by the consumers. Therefore, one has to ponder over the fruit quality of the seedling tree as a principal selection. In order to be more objective, it was felt to test for yield performance of seedling strains for the physico–chemical parameters. In order to address the above points, the survey and selections were carried out in Indi and Sindagi taluks of Vijayapura district which comes under Northern Dry Zone of Karnataka with the an aim to identify the superior strains of the acid lime by the evaluation of their fruit quality parameters.

Materials and Methods
Still there is an immense potential of locating superior clones for collection, evaluation, conservation and utilization for the future crop improvement works. Hence, the The investigation was carried through survey of forty orchards during the fruiting season from Indi and Sindagi taluks of Vijayapura district. The fruits were brought to the Department of Fruit Science, Kittur Rani Channamma College of Horticulture, Arabhavi, Karnataka and were used for studying the physicochemical characters. Ten fruits were collected from each of the selected elite trees from the farmers field in nine villages of Indi and Sindagi taluks of Vijayapura district. Fourty orchards were selected, each orchard is treated as one treatment. Two trees (replication) were selected randomly on morphological characters and data were obtained and statistically analysed by using RBD design.

Juice weight
The juice was extracted by using hand squeezer. After through extraction, juice was passed through a coarse muslin cloth to remove seeds and suspended debris of the pulp. Then the weight of the pure juice of each fruit was noted. The average was expressed in grams per fruit.

Juice volume
The juice volume of eight fruits from each strain was measured using measuring cylinder and expressed in milliliters.

Juice per cent
Juice per cent was calculated by using the formula given below:

$$\text{Juice percentage} = \frac{\text{Juice weight (g)}}{\text{Fruit weight (g)}} \times 100$$

Total soluble solids (°Brix)
Total soluble solids of the pulp was recorded with the help of Erma hand refracto meter and expressed in °Brix.

Titratable acidity (%)
The acidity was determined by titrating the known volume of fruit juice against 0.01 N NaOH solution using phenolphthalein as indicator and the value was expressed as gram of citric acid per 100 gram of sample as citric acid is the major acid found in lime fruits (Anon., 1984) [1].

Table 1: Tree details of Kagzi lime selections.

S. No	Strains	Place	Farmer Name
1	KLS-1	Lachyan	Mahantappa B. Lalasangi
2	KLS -2	Lachyan	Gudusava B. Athanur
3	KLS -3	Lachyan	Sangavva Basaveshwara
4	KLS -4	Lachyan	Shivappa S. Malashetti
5	KLS -5	Lachyan	Jattilingaraj K. Godekar
6	KLS -6	Mavinahalli	Vittal M. Karale
7	KLS -7	Mavinahalli	Sahebgoud S. Biradar
8	KLS -8	Mavinahalli	Tukaram S. Barani
9	KLS -9	Mavinahalli	Hanumant C. Hakki
10	KLS -10	Mavinahalli	Dhaarma Wader
11	KLS -11	Atharga	Siddram M. Metri
12	KLS -12	Atharga	Prabhu S. Hunagura
13	KLS -13	Atharga	Dullappa Irappa
14	KLS -14	Atharga	Bheemaraj S. H.
15	KLS -15	Atharga	Malkappa B.
16	KLS-16	Atharga	MallappaSiddappa C.
17	KLS-17	Tadawalga	Dalavayappa L. G.
18	KLS-18	Tadawalga	Sharanappa H. Garag
19	KLS-19	Tadawalga	Bheemashekar L. Gagagani
20	KLS-20	Tadawalga	Mallayappa L. Kundali
21	KLS-21	Harnal	Mallappa P. Hirekurabaragi
22	KLS-22	Harnal	Shrimanth S. Develamani
23	KLS-23	Harnal	Dundavva S. Walikar
24	KLS-24	Harnal	Shankarappa S. Develamani
25	KLS-25	Bandal	Lingappa D. Develanavar
26	KLS-26	Bandal	Dayananda Shankaralingappa
27	KLS-27	Bandal	Mallikarjun M. K.
28	KLS-28	Bandal	Parvathi L. Malagani
29	KLS-29	Bandal	Bagesh Lurade
30	KLS-30	Bandal	Bharavantharay T. Talawar
31	KLS-31	Bandal	Baramma S Tavalamani
32	KLS-32	Somapura	Siddappa Devalamani
33	KLS-33	Somapura	Sushilabai S. Hiremath
34	KLS-34	Somapura	Basayya Hoiremath
35	KLS-35	Somapura	Shivalingappa G. Bammagodi
36	KLS-36	Budihal	Siddappa M. Almel
37	KLS-37	Budihal	RavindrappaVadachan
38	KLS-38	Budihal	Mahanteyya S. Hiremath
39	KLS-39	Budihal	Shrishail B. Hiremath
40	KLS-40	Budihal	Siddramayya S. Hiremath

Ascorbic acid
It was estimated by 2, 6-dichlorophenol indophenols visual titration and the values were expressed in milligram per 100 millilitres of juice (Anon., 1984) [1].

Physiological loss in weight (PLW)
The physiological loss in weight is calculated by formula and expressed in percentage.

$$PLW = \frac{W1 - W2}{W1} \times 100$$

W1 - Initial weight of the fruit.
W2 - Final weight of the fruit.

Shelf life
The shelf life was determined by the number of days the fruits were edible and acceptable for consumption.

Specific gravity of fruit
Specific gravity of fruit was obtained by dividing volume with weight of corresponding fruits.

Statistical analysis

The data on various characters were subjected to Fisher's method of analysis of variance and the interpretation of data as given by Panse and Sukhatme in 1967. The level of significance used for 'F' and 't' tests was p=0.05. Critical difference (CD) values were calculated whenever the 'F' test was significant.

Result and discussion

Quality parameters of fruits

The maximum juice weight (20.54 g /fruit) and juice volume (25.71 ml /fruit) was recorded in the KLS-15. The highest juice weight and juice volume may be due to the juice content increased with the development of the fruit till they were ripe (Hittalmani and Rao, 1976) [7] which inturn influence the fruit weight. Similar results were also reported by Hittalmani (1975) and Athani and Hulamani (1999) [3] who observed the maximum juice weight of 19.93 g and 23.59 g per fruit in Kagzi lime and Bijapur strain of acid lime, respectively, and also juice volume of 18.45 ml and 25.70 ml was also observed in Kagzi lime and Bijapur strain of acid lime, respectively. Prasad (1989) [14] reported maximum juice weight of 18.00 g and juice volume of 18.12 ml among the 27 acid lime strains evaluated at IIHR, Bengaluru.

The maximum juice per cent (55.26%) was recorded in the KLS-10. However, KLS-7 and KLS-15 recorded 52.86% and 50.37% of juice which was on par with treatment number 10. Hittalmani and Rao (1976) [7] reported that the percentage of juice in Kagzi lime fruit increased continuously with fluctuation and the maximum value of 51.1 per cent was attained at maturity. Prasad (1989) [14] also observed juice per cent of 48.12 in clone no.15 of the 27 clones.

Table 2: Genetic variability of fruit quality traits in different strains of Kagzi lime

Strains	Juice Weight (gm)	Juice volume (ml)	Juice content (%)
KLS-1	12.21	15.25	32.43
KLS-2	12.48	15.59	31.03
KLS-3	10.96	13.69	29.10
KLS-4	13.92	17.38	37.17
KLS-5	12.31	15.40	38.90
KLS-6	11.40	14.23	27.85
KLS-7	15.08	18.84	52.86
KLS-8	10.84	13.54	29.19
KLS-9	13.07	16.34	36.11
KLS-10	18.85	23.55	55.26
KLS-11	11.74	14.67	40.64
KLS-12	10.84	13.54	30.01
KLS-13	12.29	15.36	34.87
KLS-14	11.23	14.03	42.39
KLS-15	20.54	25.71	50.37
KLS-16	12.00	15.01	36.41
KLS-17	11.92	14.90	36.13
KLS-18	12.27	15.34	38.79
KLS-19	12.11	15.14	42.06
KLS-20	14.11	17.62	43.34
KLS-21	12.25	15.30	47.79
KLS-22	18.01	22.48	48.06
KLS-23	12.60	15.74	40.54
KLS-24	11.04	13.79	37.71
KLS-25	11.46	14.35	29.40
KLS-26	13.10	16.38	38.58
KLS-27	11.71	14.61	34.16
KLS-28	12.84	16.06	34.82
KLS-29	11.98	14.97	29.63
KLS-30	16.14	20.16	47.14
KLS-31	18.76	23.43	55.40
KLS-32	12.12	15.16	37.38
KLS-33	12.06	15.06	31.58
KLS-34	11.77	14.70	38.75
KLS-35	12.25	15.31	34.53
KLS-36	13.10	16.39	40.19
KLS-37	12.44	15.54	45.89
KLS-38	11.02	13.77	45.42
KLS-39	13.48	16.84	35.00
KLS-40	11.39	14.25	29.99
SEm	0.48	0.65	2.78
CD at 5%	1.37	1.85	7.97

Chemical parameters of fruits

The data pertaining to the chemical parameters of the fruits are presented in table 3.The maximum total soluble solid (8.49 ^{0}Brix.) was recorded in the KLS-5. The increase in TSS might be due to conversion of starch and their insoluble carbohydrate into soluble form of sugar which is responsible for increasing the TSS content (Hulme, 1970) [8, 12]. In citrus fruits starch do not accumulate (Selvaraj and Edward, 2000) [16]. The increase in TSS content is mainly due to increase in total sugars (Randhawa *et al.*, 1964) [15]. These results are in

conformity with the earlier findings of Kakade (1982) [10] who observed TSS content ranging from 7.5 to 10 at maturity stage in different Kagzi lime cultivars. Prasad (1989) [14] evaluated the physico-chemical character of 27 clones of acid lime and found that the highest TSS 7.73 ^{0} Brix.

The maximum titratable acidity (8.47%) was recorded in the KLS-5. The acidity increases during development reaching levels below optimal for enzymatic activity. Prior to reaching vacuolar acid levels that can sustain physiological rates of acid hydrolysis imported sucrose must be catabolised to support growth and development in lemon (Ed. Echeverria, 1990) [5]. These results are in conformity with the earlier findings of Jature and Chakrawar (1981) [9] who studied physico-chemical characters of 89 Kagzi lime strains. They found highest acidity (8.5%) in ABD 7, followed by ABD 5 (8.40%) and PBN 1 (8.29%). Bagde and Patil (1989) [4] also reported that the highest acidity (8.29%) in Chakradhar lime.

The highest ascorbic acid (36.50 mg/100 ml juice) was recorded in KLS-36, the increase in ascorbic acid was associated with rapid increase in total sugar as the fruit synthesizes ascorbic acid from hexose sugar precursors (Mapson 1970) [12]. The respiration rate decreased with increasing maturity of fruit. The respiration activity is caused by the oxidation of carbon compound, principally as sugars and acids and there were changes in their constituents towards the end of the season (Soni and Randhawa, 1969) [17].

These results are in conformity with the earlier findings of Tirthakar *et al.* (2004) [19] who studied fruit quality characters of 48 acid lime genotypes at Akola District in which they recorded highest ascorbic (31.86 mg / 100 ml juice.) and Srinivas *et al.* (2006) [18] showed the highest ascorbic acid of 39.70 mg/100 ml in seedling strains of Kagzi lime.

Table 3: Genetic variability of biochemical parameters in different strains of Kagzi lime**.**

Strains	Total soluble solids (^{O} Brix)	Titrable acidity (%)	Ascorbic acid (mg/100ml)
KLS-1	7.98	8.01	24.21
KLS-2	7.44	8.02	35.32
KLS-3	7.45	7.04	33.82
KLS-4	6.04	5.86	27.50
KLS-5	6.98	8.47	34.83
KLS-6	7.50	6.12	26.13
KLS-7	8.12	7.74	25.71
KLS-8	5.68	8.34	23.86
KLS-9	6.02	7.93	32.29
KLS-10	7.67	6.61	32.87
KLS-11	6.35	8.34	25.31
KLS-12	6.33	7.96	30.22
KLS-13	6.97	6.39	31.45
KLS-14	7.89	5.88	34.24
KLS-15	6.21	7.35	29.21
KLS-16	5.79	5.83	24.79
KLS-17	6.31	7.73	28.25
KLS-18	6.35	7.86	30.04
KLS-19	6.12	6.45	30.53
KLS-20	7.59	5.95	34.39
KLS-21	5.49	8.76	29.58
KLS-22	5.61	7.80	33.19
KLS-23	7.56	8.85	31.65
KLS-24	5.56	7.38	30.28
KLS-25	7.57	8.11	27.51
KLS-26	7.48	8.08	23.56
KLS-27	7.43	7.28	25.58
KLS-28	6.43	7.16	26.84
KLS-29	5.48	7.86	23.57
KLS-30	7.08	5.84	27.21
KLS-31	5.53	5.65	27.29
KLS-32	8.49	6.63	36.26
KLS-33	6.10	6.48	31.47
KLS-34	8.27	7.95	27.87
KLS-35	6.15	7.02	35.93
KLS-36	6.64	5.96	36.50
KLS-37	7.09	7.55	23.50
KLS-38	6.10	8.70	30.64
KLS-39	6.17	7.46	28.29
KLS-40	6.40	7.15	23.20
SEm	0.26	0.37	1.53
CD at 5%	0.73	1.05	4.37

Post harvest parameters

The developing fruits increase in weight initially and reduce to some extent after ripening (Mannan *et al*., 2003) [11]. Factors like respiration, transpiration and biological aspects are responsible for the physiological loss in weight (PLW) in Kagzi lime during ripening. The PLW of Kagzi lime selections was in the range of 4.13 per cent in 'KLS-15' to 9.29 per cent in 'KLS-21' (Table 4).

The longer shelf life is beneficial character in selection of the good lime genotypes. The shelf life among Kagzi lime selections ranged from 10.75 days in 'KLS-5' to 9.50 days in 'KLS-32', 'KIS-26' and 'KIS-38', KLS-40 (Table 4).

There was significant difference among the Kagzi lime selections for specific gravity. However, the specific gravity ranged from 1.09 g per cc in 'KLS-8', 'KIS-23' to 0.75 g per cc 'KIS-7' in Table 4. The results are in accordance with earlier findings of Hittalmani (1975) [7] and Athani and Hulamani (1999) [3] who noticed maximum specific gravity of 0.97 and 0.95 in Kagzi lime fruits.

Table 4: Genetic variability of post harvest parameters in different strains of Kagzi lime**.**

Strains	PLW (%)	Shelf life (days)	Specific gravity (g/cc)
KLS-1	7.54	6.88	1.03
KLS-2	7.65	7.35	0.96
KLS-3	6.68	6.25	1.08
KLS-4	5.74	8.75	1.06
KLS-5	5.04	10.75	1.07
KLS-6	6.93	8.75	0.89
KLS-7	7.12	8.00	0.75
KLS-8	7.16	8.25	1.09
KLS-9	6.47	7.50	0.89
KLS-10	7.51	8.25	1.03
KLS-11	7.70	8.00	0.82
KLS-12	6.18	7.50	1.07
KLS-13	6.17	8.00	1.08
KLS-14	7.95	7.00	0.98
KLS-15	4.13	7.75	1.07
KLS-16	8.87	8.00	0.87
KLS-17	7.69	8.75	0.76
KLS-18	6.40	8.50	1.04
KLS-19	8.36	8.00	1.06
KLS-20	5.36	7.75	1.02
KLS-21	9.29	4.50	1.06
KLS-22	4.23	6.50	1.08
KLS-23	8.42	5.75	1.09
KLS-24	7.13	6.25	1.05
KLS-25	6.69	8.75	0.77
KLS-26	6.80	9.50	0.93
KLS-27	8.31	7.75	1.04
KLS-28	6.31	9.00	0.90
KLS-29	7.71	8.25	1.06
KLS-30	8.78	7.38	0.86
KLS-31	8.88	8.50	0.88
KLS-32	6.08	10.00	1.03
KLS-33	7.68	8.25	0.91
KLS-34	7.53	6.83	1.00
KLS-35	6.51	7.75	0.82
KLS-36	8.56	7.63	0.95
KLS-37	7.20	9.00	0.82
KLS-38	7.71	9.50	1.04
KLS-39	7.17	7.50	0.92
KLS-40	5.04	9.50	1.08
SEm	0.94	0.36	0.03
CD at 5%	2.69	1.02	0.08

Conclusion

Among the 40 Kagzi lime selections, 'KLS-5' 'KLS-14' 'KLS-22' 'KLS-23' 'KLS-34' were best for qualitative parameters. Whereas KLS-31 and KLS-10 had maximum juice content useful for juice extraction and 'KLS-23' ,'KLS-22' had highest titratable acidity, ascorbic acid and total soluble solids.

Acknowledgement

The kind cooperation of the residents of Indi and Sindagi is acknowledged**.**

Author contributions

Dr. Nagesh Naik, Professor and Head, Department of Fruit Science, Kittur Rani Channamma College of Horticulture, Arabhavi for the continuous support to my research including the selection of topic and procedure to conduct the research. Dr. Satish, Asst.Professor, Department of BCI, Kittur Rani Channamma College of Horticulture, Arabhavi has helped in laying out the design and analysis of the results. Mrs. Manjula Karadiguddi Asst. Professor, Department of Post Harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi has helped in the the biochemical analysis.

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