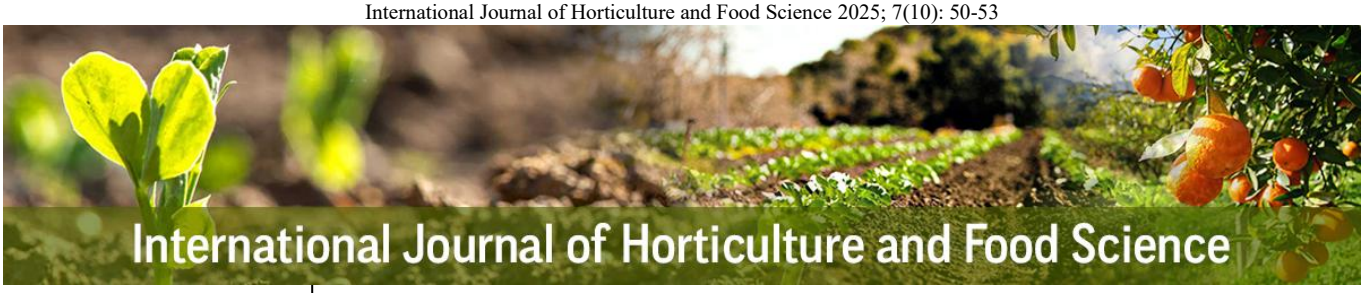

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Evaluation of parents and hybrids of tomato (*Soolanum lycopersicum* L.) for their suitability to prepare ketchup

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Abstract
A set of 18 F1 hybrids developed as a result of line x tester mating design involving six lines and three testers were evaluated in randomized block design in three replications for their suitability to prepare ketchup. Acidity of the ketchup was highest in the hybrids LE-65 x Punjab chhuhara (2.34 %), EC - 165749 x Pant T-3 (2.05 %) and LE-65 x Pant T-3 (1.95 %). The hybrid LE-62 × Punjab Chhuhara (18.64 %) recorded significantly highest reducing sugars followed by LE-62 × Pant T-3 (16.43 %) and EC-165749 × Pusa Gaurav (16.25 %). The hybrids LE-62 × Punjab chhuhara (20.70 %) recorded the significantly highest total sugars in the ketchup followed by EC-165749 × Pusa Gaurav (18.67 %) and LE-62 × Pant T-3 (17.94 %). The highest ascorbic acid content of ketchup was recorded in the hybrids LE-64 × Punjab Chhuhara (78.25 mg/100 g), LE-56 × Pusa Gaurav (74.03 mg/100 g) and LE-56 × Pant T-3 (72.42 mg/100 g). The hybrid LE-56 × Punjab Chhuhara (24.83 mg/100 g) recorded significantly highest total carotenoid content followed by LE-64 × Pusa Gaurav (23.12 mg 100 g) and LE-56 × Pusa Gaurav (21.85 mg/100 g). Considering the lycopene content, the hybrids LE-56 × Punjab Chhuhara (22.47 mg/100 g), LE-64 × Punjab Chhuhara (21.20 mg/100 g) and LE-62 × Punjab Chhuhara (20.62 mg/100 g) recorded the significantly highest lycopene content in the ketchup. Organoleptic score of the ketchup was recorded highest in the hybrids LE-56 × Punjab Chhuhara (4.73), LE-64 × Punjab Chhuhara (4.63), LE-62 × Punjab Chhuhara (4.60) and LE-56 × Pusa Gaurav (4.57) and these hybrids are best suited for processing.

Keywords: Tomato, Parents, Hybrids, ketchup

Introduction
Tomato **(***Solanum lycopersicum* L.**)** is one of the most important vegetable crops grown throughout the world because of its wider adaptability, and high yielding potential. The fruits are available year round and eaten raw or cooked. It is a rich source of health building subatances, particularly vitamins and minerals. In many tomato breeding programmes carried out in India, fruit quality has received little or no attention. Nevertheless, there is growing interest in recent times to improve the quality of tomato fruits. Though there is a negative relationship between yield and fruit quality in general, with more research and greater experience, it should be possible to optimize both yield and quality of fruits. The future of tomato processing in India is bright due to rapidly increasing domestic consumption and the export potential for the products like ketchup and paste. With these views in the background, an investigation was carried out in tomato to identify genotypes suitable for the above processed products.

Materials and Methods
The present investigation was undertaken at an experimental farm of Vegetable Research Station, Agricultural Research Institute, Rajendranagar, Dr. Y.S. Horticultural University, Hyderabad. The experimental material consist of nine parents *viz*; EC-165749 (L_1), LE-56 (L_2), LE-62 (L_3), LE-64 (L_4), LE-65 (L_5), LE-67 (L_6) used as lines (females) and Punjab Chhuhara (T_1), Pant T-3 (T_2) and Pusa Gaurav (T_3) as testers (males) and mated as per Line x Tester mating model of Kempthorne (1957) [1]. The treatment details comprising of the 18 F_1s along with 9 parents (6 lines and 3 testers) and 2 commercial hybrids and a variety as checks. Ketchup was prepared for all the treatments. The experimental design was complete

randomized block design. From the freshly prepared ketchup observations were recorded for the titrable acidity (%), ascorbic acid (mg/100 g), total carotenoid content (mg/100 g), reducing sugars (%), total sugars (%) and lycopene content (mg/100 g). Titrable acidity, ascorbic acid, total carotenoid content, reducing sugars, total sugars and lycopene content was estimated by procedure as described by Ranganna (1986)[2]. The data obtained were subjected to statistical analysis as per the procedure outlined by Panse and Sukhatne (1967) [3].

Results and Discussion

The data regarding the chemical composition of tomato ketchup are presented in Table 1 and Table 2.

Titrable Acidity of the ketchup was recorded significantly highest in the parent LE-65 (2.36 %) followed by parent LE-67 (2.17 %), LE-62 (2.13 %) and EC -165749 (2.10 %). Among the hybrids LE-65 × Punjab Chhuhara (2.34 %) recorded significantly highest titrable acidity followed by EC-165749 × Pant T - 3 (2.05 %), LE-65 × Pant T-3 (1.95 %), LE-67 × Pusa Gaurav (1.96 %), EC-165749 × Pusa Gaurav (1.89 %) and LE-65 × Pusa Gaurav (1.89 %), while the lowest titrable acidity was recorded with LE-56 × Pusa Gaurav (1.37 %). The checks Lakshmi, US -618 and Arka Vikas recorded 1.56, 1.60 and 1.49 % titrable acidity, respectively. It might be due to one of them as their parent recorded the highest acidity and also be due to its higher acidity content in the juice. Similar results were reported by Gowda *et al*. (1993) [4] and Jawaharlal *et al*. (1999) [5].

Considering the reducing sugars, the parent Punjab Chhuhara (14.74 %) recorded the highest in ketchup which was on par with the parent LE-64 (14.54 %), EC-165749 (14.00 %) and LE-67 (13.98 %). The hybrid LE-62 × Punjab Chhuhara (18.64 %) recorded significantly highest reducing sugars followed by LE-62 × Pant T-3 (16.43 %), EC-165749 × Pusa Gaurav (16.25 %), LE-56 × Punjab Chhuhara (15.76 %) and LE-64 × Punjab Chhuhara (15.50 %), while the lowest reducing sugars was recorded with EC-165749 × Pant T-3 (9.23 %). The checks Lakshmi, US -618 and Arka Vikas recorded 11.58, 10.80 and 10.98 % reducing sugars, respectively. The significantly highest total sugars of ketchup was recorded by the parent EC-165749 (17.23%) followed by Punjab Chhuhara (16.40 %), LE-67 (15.92 %) and LE-64 (15.32 %). The hybrids LE-62 × Punjab chhuhara (20.70 %) recorded the significantly highest total sugars in the ketchup followed by EC-165749 × Pusa Gaurav (18.67 %), LE-62 × Pant T-3 (17.94 %), LE-56 × Punjab Chhuhara (17.27 %) and LE-64 × Punjab Chhuhara (16.76%), while the lowest total sugars was recorded with EC-165749 × Pant T-3 (11.12 %). The checks Lakshmi, US -618 and Arka Vikas recorded 13.90, 13.05 and 13.45 % total sugars, respectively. It might be due to one of them as their parent recorded the highest sugar content and also be due to its higher sugar content and TSS in the juice.

Ascorbic acid content of the ketchup was recorded significantly highest (Fig. 10) in the parent LE-56 (62.26 mg/100 g) which was on par with Punjab Chhuhara (59.83 mg/100 g). Among the hybrids LE-64 × Punjab Chhuhara (78.25 mg/100 g) recorded significantly highest ascorbic acid followed by LE-56 × Pusa Gaurav (74.03 mg/100 g), LE-56 × Pant T-3 (72.42 mg/100 g), LE-56 × Punjab Chhuhara (70.98 mg/100 g) and LE-67 × Pusa Gaurav (68.76 mg/100 g), while the lowest ascorbic acid content was recorded with LE-62 × Pant T-3 (31.20 mg/100 g). The checks Lakshmi, US -618 and Arka Vikas recorded 48.40, 49.50 and 51.24 mg/100 g ascorbic acid, respectively. It might be due to one of them as their parent recorded the highest ascorbic acid content and also be due to its higher ascorbic acid content in the juice. Similar findings were reported by Gowda *et al*. (1993) [4] and Jawaharlal *et al*. (1999) [5].

Considering the total carotenoid content, the parent LE-64 recorded the highest in ketchup (21.24 mg/100 g) which was on par with LE-65 (20.18 mg/100 g) and theses are followed by the parent Punjab Chhuhara (18.79 mg/100 g) and LE-67 (18.68 mg/100 g). The hybrid LE-56 × Punjab Chhuhara (24.83 mg/100 g) recorded significantly highest total carotenoid content followed by LE-64 × Pusa Gaurav (23.12 mg 100 g), LE-56 × Pusa Gaurav (21.85 mg/100 g), LE-64 × Punjab Chhuhara (21.60 mg/100 g) and LE-65 × Pusa Gaurav (21.10 mg/100 g), while the lowest total carotenoid content was recorded with LE-65 × Punjab Chhuhara (9.81 mg/100 g). The checks Lakshmi, US -618 and Arka Vikas recorded 15.75, 14.65 and 17.65 mg/100 g total carotenoid content, respectively.The significantly highest lycopene content of ketchup was recorded by the parent LE-64 (19.80 mg/100 g) which was on par with LE-65 (18.50 mg/100 g) and theses are followed by the parent Punjab Chhuhara (17.90 mg/100 g) and Pant T-3 (17.78 mg/100 g). The hybrid LE-56 × Punjab Chhuhara (22.47 mg/100 g) recorded significantly highest lycopene content which was on par with LE-64 × Pusa Gaurav (21.20 mg/100 g) and these are followed by LE-64 × Punjab chhuhara (20.62 mg/100 g), LE-65 × Pusa Gaurav (20.30 mg/100 g) and LE-56 × Pusa Gaurav (19.92 mg/100 g), while the lowest lycopene content was recorded with LE-65 × Punjab Chhuhara (8.47 mg/100 g). The checks Lakshmi, US -618 and Arka Vikas recorded 15.11, 13.40 and 16.80 mg/100 g lycopene content, respectively. It might be due to one of them as their parent recorded the highest lycopene content and total carotenoid content and it might also be due to its higher sugar content and TSS in the juice. These findings are in line with those reported by Gowda *et al*. (1993) [4] and Jawaharlal *et al*. (1999) [5].

Organoleptic score of the ketchup was recorded highest in the parent LE-53 (4.53) followed by LE-64 (4.47) and Punjab Chhuhara (4.47). Among the hybrids LE-56 × Punjab Chhuhara (4.73) recorded highest organoleptic score followed by LE-64 × Punjab Chhuhara (4.63), LE-62 × Punjab Chhuhara (4.60) and LE-56 × Pusa Gaurav (4.57), while the lowest organoleptic score was recorded with LE-62 × Pusa Gaurav (3.70). The checks Lakshmi, US -618 and Arka Vikas recorded 4.07, 4.00 and 4.30 organoleptic score, respectively. The hybrids LE-56 × Punjab Chhuhara, LE-64 × Punjab Chhuhara LE-62 × Punjab Chhuhara and LE-56 × Pusa Gaurav are best suited for processing having moderate acidity and high lycopene content and these hybrids scored maximum for overall acceptability of the products. Results are in agreement with the findings of Gowda *et al*. (1993) [4], Khandekar *et al*. (1994) [6], Ereifej *et al*. (1997) [7] and Bengal *et al*. (2005) [8].

Table 1: Chemical constituents of freshly prepared ketchup

S. No	Characters	Titrable Acidity (%)	Reducing sugars (%)	Total sugars (%)
1	EC -165749 x Punjab Chhuhara	1.77	9.86	11.65
2	EC -165749 x Pant T-3	2.05	9.23	11.12
3	EC -165749 x Pusa Gaurav	1.89	16.25	18.67
4	LE-56 x Punjab Chhuhara	1.52	15.76	17.27
5	LE-56 x Pant T-3	1.39	13.60	15.90
6	LE-56 x Pusa Gaurav	1.37	13.30	15.54
7	LE-62 x Punjab Chhuhara	1.65	18.64	20.70
8	LE-62 x Pant T-3	1.60	16.43	17.94
9	LE-62 x Pusa Gaurav	1.68	12.20	14.63
10	LE-64 x Punjab Chhuhara	1.44	15.50	16.76
11	LE-64 x Pant T-3	1.68	10.40	12.93
12	LE-64 x Pusa Gaurav	1.60	13.09	14.62
13	LE-65 x Punjab chhuhara	2.34	12.84	14.59
14	LE-65 x Pant T-3	1.95	12.63	14.93
15	LE-65 x Pusa Gaurav	1.89	12.34	14.74
16	LE-67 x Punjab Chhuhara	1.81	10.62	12.45
17	LE-67 x Pant T-3	1.60	12.56	14.68
18	LE-67 x Pusa Gaurav	1.96	10.20	11.40
19	EC -165749	2.10	14.00	17.23
20	LE-56	1.68	10.39	11.94
21	LE-62	2.13	10.28	11.83
22	LE-64	2.05	14.54	15.32
23	LE-65	2.36	12.02	14.56
24	LE-67	2.17	13.98	15.92
25	Punjab Chhuhara	1.72	14.74	16.40
26	Pant T-3	1.65	12.94	15.28
27	Pusa Gaurav	1.80	9.75	11.26
28	Lakshmi	1.56	11.58	13.90
29	US-618	1.60	10.80	13.05
30	Arka Vikas	1.49	10.98	13.45
	CD @ 5%	0.16	0.98	0.82
	SE(m) ±	0.06	0.35	0.29

Table 2: Chemical constituents of freshly prepared ketchup

S. No	Characters	Ascorbic acid content (mg/100 g)	Total carotenoid content (mg/100 g)	Lycopene content (mg/100 g)	Overall acceptability
1	EC -165749 x Punjab Chhuhara	45.14	17.29	16.20	4.33
2	EC -165749 x Pant T-3	34.76	16.74	15.38	4.27
3	EC -165749 x Pusa Gaurav	39.00	13.81	12.68	4.23
4	LE-56 x Punjab Chhuhara	70.98	24.83	22.47	4.73
5	LE-56 x Pant T-3	72.42	15.78	14.12	4.07
6	LE-56 x Pusa Gaurav	74.03	21.85	19.92	4.57
7	LE-62 x Punjab Chhuhara	47.58	21.60	20.62	4.60
8	LE-62 x Pant T-3	31.20	18.03	16.56	4.37
9	LE-62 x Pusa Gaurav	54.90	11.52	9.25	3.70
10	LE-64 x Punjab Chhuhara	78.25	23.12	21.20	4.63
11	LE-64 x Pant T-3	64.32	10.59	8.98	3.93
12	LE-64 x Pusa Gaurav	43.26	19.75	18.98	4.47
13	LE-65 x Punjab Chhuhara	31.74	9.81	8.47	3.90
14	LE-65 x Pant T-3	43.00	16.80	15.25	4.33
15	LE-65 x Pusa Gaurav	35.38	21.10	20.30	4.50
16	LE-67 x Punjab Chhuhara	42.70	14.92	13.74	4.13
17	LE-67 x Pant T-3	38.45	11.57	9.58	4.00
18	LE-67 x Pusa Gaurav	68.76	16.37	14.86	4.23
19	EC -165749	53.68	12.36	10.26	3.80
20	LE-56	62.26	14.20	12.52	4.00
21	LE-62	39.92	16.34	14.60	4.20
22	LE-64	32.94	21.24	19.80	4.53
23	LE-65	56.73	20.18	18.50	4.47
24	LE-67	50.00	18.68	17.64	4.37
25	Punjab Chhuhara	59.83	18.79	17.90	4.47
26	Pant T-3	41.48	18.50	17.78	4.40
27	Pusa Gaurav	46.35	14.53	13.04	4.10
28	Lakshmi	48.40	15.75	15.11	4.07
29	US-618	49.50	14.65	13.40	4.00

30	Arka Vikas	51.24	17.65	16.80	4.30
	CD @ 5%	4.18	1.26	1.51	0.15
	SE(m) ±	1.47	0.44	0.53	0.05

Conclusion

In an evaluation of nine parents, eighteen hybrids and three checks of tomato for quality of ketchup, the parent LE-64 was found to be the best for making ketchup followed by LE-56 and Punjab Chhuhara. The hybrids involving LE-64, LE-56 and Punjab Chhuhara were found to be better for their qualities such as lycopene content, total carotenoid content, ascorbic acid content and sugars.The hybrids LE-56 × Punjab Chhuhara, LE-64 × Punjab Chhuhara, LE-62 × Punjab Chhuhara and LE-56 × Pusa Gaurav are best suited for processing having moderate acidity and high lycopene content and these hybrids scored maximum for overall acceptability of the products.

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