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Tomato breeding for processing in India: Current status and prospects

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Abstract

Tomato is an important vegetable crop in the world for both fresh consumption and making processing products such as ketchup, sauce, paste etc. Tomato is rich source of nutrients and possesses health beneficial compounds.India is the second largest producer of tomato (20.57 mt) after China. In our country, most of tomatoes are consumed as fresh for vegetable purpose, and hardly <1% is only processed for making processed products compared to the developed countries like Italy (64.02%), Spain (39.41%) and USA (10.34%). Hence, there is a need of suitable varieties for processing purpose for year round cultivation to sustain the processing industries in the country with suitable growing regions.A large number of cultivated and wild tomato species are available in the world genebank, which have processing attributes. Although, previous efforts have generated a few varieties (e.g. Pusa Ruby, Roma, Punjab Chhuhara) for processing purpose but currently these old varieties do not meet the demand of modern processing industries. Hence, in this mini-review we summarise current status and prospects of breeding for processing varieties in India.

Keywords: Breeding, processing, tomato cultivars,

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the important vegetable crops for both fresh consumption as vegetable and making processed products such as juice, sauce, ketchup, paste, puree, canned fruits etc. Owing to health benefits and economic importance, tomato is consumed worldwide as either fresh or processed. Tomato is a rich source of vitamins-A and -C, minerals and antioxidants mainly lycopene and beta-carotene, and other compounds like flavonoids, hydroxycinnamic acid derivatives. Lycopene is a very powerful antioxidant which prevents cancer. It has been proven that cooked tomatoes and tomato products are the best source of lycopene, since the lycopene is released more after cooking and increases bioavailability. Where, raw tomato contains only about 20% of lycopene than in cooked tomato. Overall, tomato is considered as functional and protective food for human.

In 2022, world tomato production reached to nearly 186.82 million tonnes from total area of 5 million hectare with an average productivity of 36.97 t/ha (FAOSTAT 2022, Table 1).

China (64.86 mt) is the top producer of tomato sharing nearly 34.72% followed by India (20.57 mt, 11.01%). In India, tomato is maximum produced in Andhra Pradesh (19.75 mt) with highest productivity (44.50 t/ha) followed by Madhya Pradesh (24.19 mt) (Table 2).

Tomato processing is one of the major economically important sectors at world level. In 2020, processed tomatoes were the world's 479th most traded product, with a total trade of $4.94 billion (Citation). Between 2019 and 2020 the exports of processed tomatoes grew by 8.82%, from $4.54 billion to $4.94 billion. Trade in processed tomatoes represent 0.029% of total world trade (APEDA 2021-22). In 2020, in terms of values the top exporters of processed tomatoes were

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Table 1: Major tomato producing countries in the world

Country	Area (ha)	Production (tonnes)	Productivity (t/ha)	% of world production	% processed (of country production)
China	1111480	64865807	58.35	34.72%	9.05%
India	812000	20573000	25.33	11.01%	0.93%
Turkey	181879	13204015	72.59	7.06%	9.76%
USA	110439	12227402	110.71	6.54%	10.34%
Egypt	170862	6731220a	39.39	3.60%	0.99%
Italy	99780	6247910	68.27	3.34%	64.02%
Iran	129058	5787094	44.84	3.09%	13.64%
Spain	55470	4312900	77.75	2.30%	39.41%
Mexico	84926	4137342	48.71	2.21%	4.76%
Brazil	51960	3753595	72.24	2.00%	1.31%
World Total	5051983	186821216	36.97	100%	10.83%

Source: FAOSTAT (2022)

Table 2: Major tomato producing states in India

State	**Area ('000 ha)**	**Production ('000 tonne)**	**Productivity (t/ha)**
Andhra Pradesh	61.67	2744.32	44.50
Madhya Pradesh	84.53	2419.28	28.62
Karnataka	64.25	2081.59	32.39
Gujarat	46.61	1357.52	29.12
Odisha	91.01	1312.07	14.41
West Bengal	57.46	1265.25	22.01
Chhattisgarh	63.29	1087.33	17.18
Maharashtra	45.50	1086.56	23.88
Telangana	41.48	1171.50	28.24
Uttar Pradesh	21.24	841.61	39.62
Taamil Nadu	29.08	887.08	30.50
Total	**789.15**	**19759.32**	**25.03**

Source: NHB (2017-18)

Italy ($2.14 billion), China ($667 million) and Spain ($500 million); whereas top importers were Germany ($586 million), United Kingdom ($517 million) and France ($280 million). On the other hand, tomato processing in India is very low i.e. 0.93% of total tomato production of the country, as compared to the developed countries like USA (10.34%), China (9.05%), Turkey (9.76%) and world total (10.83%) (Table 1, Figure1)

Hence, there is an urgent need to develop tomato varieties suitable for processed products (NAAS 2022).Also, it is important to develop processing varieties for year round cultivation to sustain processing industries in the country and to meet the climate change scenario and biotic as well as abiotic stress specially heat and drought stress. This article highlights current status, prospects and challenges in breeding tomato for processing purpose.Arrange all Tables and Figures in last i.e. after reference.

Breeding objectives

Tomato fruits are consumed mainly as raw or fresh and cooked vegetables. Whereas, processing tomatoesare used for making juice, soup, sauce, ketchup & other processed products. Although yield and biotic/abiotic stresses are common objectives of both fresh and processing tomatoes, it is important to keep these while breeding all kinds of varieties. Processing tomato parameters are mentioned in Table 3.

Exotic Tomato Lines for Processing Traits

Exotic tomato accessions are available at the Tomato Genetics Resource Centre (TGRC), University of California, Davis, USA and mutants have been developed for different traits including processing parameters (Table 4).

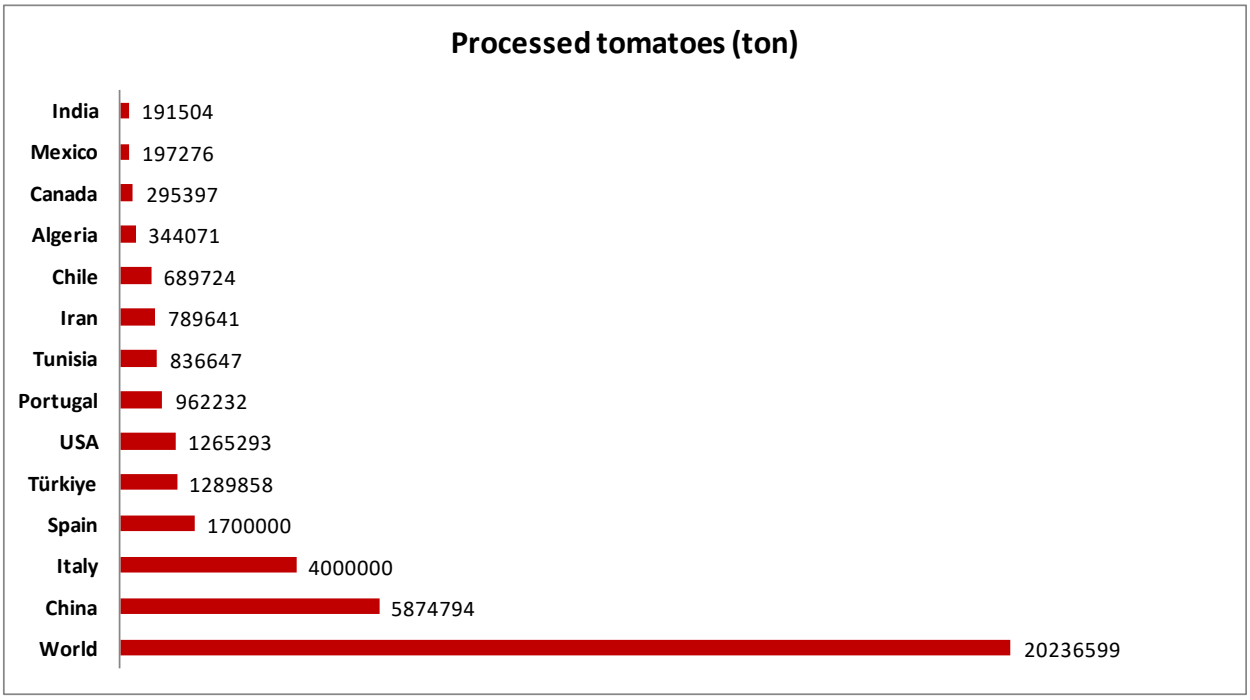

Figure 1: Major tomato processing countries

Table 3: Processing parameters of tomato

Parameters	Processing	
Plant type	• Determinate growth • Concentrated flowering • Jointless pedicel (easy to detach/harvest) • Mechanical harvesting	
Fruit traits	Processing traits	Standard values required by processing industries
	Total soluble solid (TSS)	> 5.5°Brix
	Colour value crushed tomato juice (a/b, Hunter Lab scale)	> 1.95
	Acidity	< 0.40%
	pH	< 4.40
	Texture/Firmness	> 4.00
	Lycopene	> 8.5 mg/100 g
	Lycopene in tomato paste/ puree (27-28^0 Brix)	> 15.00
	Viscosity (Botswick, cm/30 sec)	12-14
	Yield (t/ha)	> 50
	Vitamin C	> 25 mg/100 g
	Pericarp thickness	> 0.4 cm
	Fruit weight	> 80 g
	Juice yield	> 70%
	No. of locules	2-4
	• Uniform fruit set and ripening • Intense red colour • Thick pericarp • Firm flesh • Small locule area • No cracking • Elongated shape • Smooth surface • Free from wrinkles	

	• Small core • High viscosity (consistency) • High alcohol-insoluble solids
Yield	• High fruit yield
Biotic and abiotic stress	• Resistant to biotic stresses (diseases e.g. TYLCV, BW, FB and EB, and pests) and tolerant to abiotic stress like heat and drought stress

Source: Standard processing values were taken from 'Consortium Research Platform on Hybrid Technology (CRP-HT-Tomato-3024), ICAR-IIVR, Varanasi (UP).

Table 4: List of potential tomato lines for processing and other desirable traits available at international gene-banks

S. No.	Accession No.	Category	Features
World Vegetable Centre, Taiwan			
1.	AVTO2149	Dual Purpose Tomato (for fresh or processing use)	Determinate line with high lycopene, featuring bacterial wilt, fusarium wilt and TYLCD resistance. Medium fruit size with round to blocky shape.
2.	AVTO2151	Dual Purpose Tomato (for fresh or processing use)	Determinate line with high fruit lycopene content, featuring bacterial wilt, TYLCD and root-knot nematode resistances. Medium fruit size with blocky to oblong shape.
3.	AVTO1909	Dual Purpose Tomato (for fresh or processing use)	Determinate line with bacterial wilt, TYLCD and root-knot nematode resistance. Medium fruit size with blocky shape. Heat tolerant.
4.	AVTO1914	Dual Purpose Tomato (for fresh or processing use)	Semi-determinate line with high lycopene, featuring bacterial wilt, TYLCD, late blight and root-knot nematode resistance. Medium fruit size with oblong to plum shape. Heat tolerant.
5.	AVTO1915	Dual Purpose Tomato (for fresh or processing use)	Semi-determinate line with high lycopene, featuring bacterial wilt, TYLCD, late blight and root-knot nematode resistance. Medium fruit size with oblong to plum shape. Heat tolerant.
6.	AVTO1906	Dual Purpose Tomato (for fresh or processing use)	Determinate line with bacterial wilt, TYLCD, fusarium wilt and root-knot nematode resistance. Medium fruit size with blocky shape. Heat tolerant.
7.	AVTO1907	Dual Purpose Tomato (for fresh or processing use)	Semi-determinate line with high lycopene, featuring bacterial wilt, TYLCD and root-knot nematode resistance. Medium fruit size with blocky shape. Heat tolerant.
8.	AVTO1707	Dual Purpose Tomato (for fresh or processing use)	Determinate line with high lycopene, featuring bacterial wilt and TYLCD resistance. Medium fruit size with blocky to oblong shape. Heat tolerant.
9.	AVTO1706	Dual Purpose Tomato (for fresh or processing use)	Determinate line with high lycopene and beta-carotene, featuring bacterial wilt and TYLCD resistance. Medium fruit size with blocky to oblong shape. Heat tolerant.
10.	AVTO0102	Cherry tomato category (Fresh Market Tomato)	High beta-carotene variety for hot wet season production.
11.	AVTO1174	Cherry tomato category (Orange fruit)	Indeterminate line with TMV and TYLCD resistance. Small orange fruit with oblong shape. Heat tolerant.
12.	AVTO1349	Cherry tomato	Indeterminate line with TMV and TYLCD resistance. Oblong fruit shape with good heat tolerance.
13.	AVTO2036	Cherry tomato	Indeterminate line with late blight, TMV, TYLCD and fusarium wilt resistance. Globe fruit shape with good heat tolerance.
14.	AVTO2037	Cherry tomato (pink fruit)	Indeterminate line with late blight, TYLCD and fusarium wilt resistance. Small pink fruit with oblong shape.
15.	AVTO9706	Cherry tomato category (Orange fruit)	Indeterminate line with TMV resistance. Small orange fruit with globe shape. Heat tolerant.
16.	AVTO9805	Cherry tomato category (Orange fruit)	Indeterminate line with TMV resistance. Small orange fruit with oblong shape. Heat tolerant.
17.	AVTO9801	Fresh Market Tomato	Determinate line with TMV resistance. Small fruit size with plum shape and red color.
18.	AVTO9802	Fresh Market Tomato	Good dual-purpose variety for fresh market/ processing.
19.	AVTO1424	Fresh Market Tomato	Semi-determinate line with bacterial wilt and TYLCD resistance. Medium to large fruit size with oblong shape. Deep red internal color due to crimson gene (*ogc*) which increases lycopene content, *Ty3* and *Mi-1*genes in coupling phase linkage.
20.	AVTO2017	Fresh Market Tomato	Semi-determinate line with bacterial wilt and excellent TYLCD resistance. Medium fruit size with oblong shape. Heat tolerant.
21.	AVTO2101	Fresh Market Tomato	Determinate line featuring TYLCD and strong bacterial wilt resistance. Medium-large, round fruit and good fruit set. Heat tolerant.
22.	AVTO1219	Fresh Market Tomato	Semi-determinate line featuring Ph-2, Ph-3 late blight and Ty-1/Ty-3, Ty-2

			TYLCD resistance. Medium fruit size with blocky to heart shape.
Tomato Genetics Resource Centre (TGRC), University of California, Davis, USA			
23.	LA0089	cv. Principe Borghese *(S. lycopersicum)*Autogamous-SC	Heat tolerance. Donated as 'Prince Borghese'. Variety popular in southern Italy. Extremely compound clusters, probably s gene. Fruits oval with strong nipple tip. Locules very puffy. Sets fruit well under high temperatures. Categories: Cultivar; Stress tolerant
24.	LA0315	*S. lycopersicum* Autogamous-SC	New jointless mutant from *S. cheesmaniae* LA0166. Very long pedicels and peduncles, long irregular sepals, inflorescence very compound, with leafy tendencies. Allele test to j: F1 plants with joint, but abscission imperfect.
25.	LA1017	*S. lycopersicum* Autogamous-SC	Derived from *S. cheesmaniae* LA0435 and LA0422 (probably widespread). Pachypericarp (Ppc) = thick-walled fruit, and protruberant (ptb)
26.	LA1019	*S. lycopersicum* Autogamous-SC	Traits: Pachypericarp fruit. Derived from *S. cheesmaniae* LA0434 (Rambek jointed). Stock carries following characters, none showing monogenic segregation except ppc; Pachypericarp (ppc) =thick-walled fruit; also thick calyx, and firm fruit.
27.	LA1028	*S. chmielewskii* Facultative-SC	Source of high solids and high pigment. Tolerant to PSTVd
28.	LA1162	*cv.* Cuba Plum *S. lycopersicum* Autogamous-SC	Small, 1.5 cm diameter, red plum, very prolific and very acid. Skin = y. Typical of original Cuba Plum
29.	LA1222	cv. VF-145 78-79 *S. lycopersicum* Autogamous-SC	Introduced by Hanna in 1961, first mechanically harvested variety. Plant small, determinate. Fruit small, round and firm. 78-79 is one of various sublines selected (also 22-8, 21-4).
30.	LA1500	*S. lycopersicum* Autogamous-SC	Traits: High solids, intense pigment Relatively uniform for high solids (7.5-7.8%). Fruit size variable. Segregates for uniform ripening (u/+) and male sterility. Homozygous for the dark unripe color (Ip). Bred from *S. chmielewskii*.
31.	LA1501	*S. lycopersicum* Autogamous-SC	Traits: High solids. Comments: Relatively uniform for high solids (7.5%). Fruits large, set variable. Segregates for uniform ripening (u/+) and male-sterility. Bred from *S. chmielewskii*.
32.	LA1502	*S. lycopersicum* Autogamous-SC	Traits: High solids, Comments: Relatively uniform for high solids (ca. 7.9%). Good set and fruit size. Segregates for the dark unripe trait (Ip/+) and probably for uniform ripening (u/+).
33.	LA1503	Background VF145-22-8 *S. lycopersicum* Autogamous-SC	Traits: High solids, Comments: Segregates for solids level (ca. 7.5%). Carries the dark unripe trait (Ip), segregates for uniform ripening (u/+), fruit size, and strong attachment. Bred from S. chmielewskii.
34.	LA1563	*S. lycopersicum* Autogamous-SC	Traits: High solids, Comments: High soluble solids bred from *S. chmielewskii*. Fruits larger than VF145. Ripe fruit darker, sweet.
35.	LA1994	*S. lycopersicum var. cerasiforme* Autogamous-SC	Small yellow fruit, extremely sweet (high soluble solids), sets under high temperatures
36.	LA1996	S. lycopersicum var. cerasiforme Autogamous-SC	Comments: Mutant Af "Anthocyanin fruit" in Vigoroz? Georgiev (Sofia, Bulgaria): Anthocyanin on green fruit. Produces early large fruits with many locules. From cross with *S. chilense* LA0458.
37.	LA2019	*S. lycopersicum* Autogamous-SC	Virescent tangerine mimic. Homozygous for phenotype exactly like t^v. Jointless, very firm fruit, determinate canning type vine, vigorous.
38.	LA2086	*S. lycopersicum* Autogamous-SC	High sugar derivative
39.	LA2093	*S. pimpinellifolium* Autogamous-SC	Traits: Resistant to some isolates of late blight, high soluble solids.
40.	LA2375	cv. San Marzano S. lycopersicum Autogamous-SC	It is a special selection of San Marzano, carrying strong resistance to heat sterility
41.	LA2661	cv. Nagcarlang *S. lycopersicum* Autogamous-SC	Traits: Heat tolerance, Comments: Sets fruit under high temperature / high humidity.
42.	LA2662	cv. Saladette S. lycopersicum Autogamous-SC	Traits: Heat tolerance, Comments: Fruit 40-60g, plum to globe shaped, firm 2-3 locules... Sets under high temperatures / high humidity." Categories: Cultivar; Stress tolerant
43.	LA2711	cv. Edkawi S. lycopersicum Autogamous-SC	Traits: Salt tolerance, Categories: Cultivar; Stress tolerant
44.	LA3006	*S. lycopersicum* Autogamous-SC	Lycopene is 20% higher than hp-1 lines

45.	LA3120	cv. Malintka 101 *S. lycopersicum* Autogamous-SC	Traits: Heat tolerance, Categories: Cultivar; Stress tolerant
46.	LA3320	cv. Hotset *S. lycopersicum* Autogamous-SC	Traits: Heat tolerance, Categories: Cultivar; Stress tolerant
47.	LA3847	cv. NC HS-1 *S. lycopersicum* Autogamous-SC	Traits: Heat tolerance, Categories: Cultivar; Disease resistant; Stress tolerant
48.	LA3897	*S. lycopersicum* Autogamous-SC	Traits: High beta-carotene from *S. galapagense*
49.	LA3898	*S. lycopersicum* Autogamous-SC	Traits: High beta-carotene from *S. galapagense*
50.	LA3899	*S. lycopersicum* Autogamous-SC	Traits: High beta-carotene from *S. galapagense*
51.	LA3911	cv. Micro-Tom *S. lycopersicum* Autogamous-SC	May contain the gene mnt (miniature)
52.	LA4082	*S. lycopersicum* Autogamous-SC	High soluble solids content.
53.	LA4104	*S. lycopersicum* Autogamous-SC	Traits: High fruit sucrose from S. chmielewskii Comments: Fruit accumulate sucrose due to low levels of vacuolar invertase; introgressed from S. chmielewskii LA1028.
54.	LA4345	cv. Heinz 1706-BG *S. lycopersicum* Autogamous-SC	This line was used for the tomato reference genome sequencing project. See variety description in TGC 54: 26. Fruit oval to pear shaped. Foliage light green, long inflorescences.
55.	LA4347	cv. B-L-35 *S. lycopersicum* Autogamous-SC	Long storage, hanging type tomato; from the Balearic Islands; fruit are pear shaped and ripen to a dull pinkish yellow color, keep for several months in storage without deterioration.
56.	LA4410	*cv.* Meek *S. lycopersicum* Autogamous-SC	Cultivar name translated from the Ukrainian. 8/2021: fruit are blocky and elongate (processing type?).
57.	LA4453	*S. lycopersicum* Mating System: Unknown	Breeding lines selected for fruit sucrose accumulation. Fruit size ca. 40 g. In a processing tomato background.
58.	LA4454	*S. lycopersicum* Mating System: Unknown	Breeding lines selected for fruit sucrose accumulation. Fruit size ca. 45 g. In a processing tomato background.
59.	LA2093	*S. pimpinellifolium* Autogamous-SC	Resistant to some isolates of late blight, high soluble solids
60.	LA1028	*S. chmielewskii* Facultative-SC	Source of high solids and high pigment. Tolerant to PSTVd
61.	LA1579	*S. pimpinellifolium* Facultative-SC	Traits: Drought tolerance, Comments: Salt and/or alkali tolerant.
62.	LA1421	*S. lycopersicum var. cerasiforme* Autogamous-SC	Traits: Flooding tolerance, Categories: Latin American cultivar; Stress tolerant
63.	LA1310	*S. lycopersicum var. cerasiforme* Autogamous-SC	Traits: Salt tolerance, Categories: Stress tolerant; Wild species
64.	LA4133	*S. lycopersicum var. cerasiforme* Autogamous-SC	Traits: Salt tolerance, Categories: Stress tolerant; Wild species

Improved breeding lines have also been developed by the World Vegetable Centre, Taiwan for breeding application. Besides, several indigenous varieties have been developed by the national institutes but there is need to strengthen breeding research on processing tomatoes to meet the current industry requirements.

Indigenous Tomato Varieties for Processing or Dual Purpose

Several tomato processing or dual purpose varieties were developed by research institutes and a few of the varieties are summarised below (Table 5, Figure 2).

Table 5: Old tomato varieties suitable for processing in India

Varieties	Fruit wt(g)	Juice Yield(%)	TSS (^{0}Brix)	pH	Acidity (%)	Ascorbic acid(mg/100g)	Lycopene (mg/100g)	Puree Yield(%)
Pusa Ruby	41	67	4.8	4.2	0.59	10.9	4.3	29
Roma	60	69	5.4	4.3	0.57	2.7	4.6	32
Punjab Chhuhara	43	69	5.0	4.3	0.49	8.6	5.1	29
ArkaAhuti	56	65	5.2	4.3	0.55	5.2	5.2	30
Arka Ashish	56	71	5.6	4.3	0.52	6.7	7.0	30
Pusa Gaurav	60	63	5.6	4.4	0.44	7.9	6.0	28

Source: Sadashiva (2021), ICAR-IIHR, Bengaluru-personal communication (by Dr. N. Rai)

Table 6: New tomato varieties developed for dual (fresh and processing) purpose by ICAR-IIHR, Bengaluru

S.No.	Parameters	ArkaApeksha (H-385)	ArkaVishesh (H-391)	Parameters desired by Processing Industry
1.	TSS (^{0}Brix)	4-4.7	4-4.6	> 5.5
2.	Colour value*	1.96-2.09	1.98-2.12	> 1.95
3.	Acidity of crushed juice (%)	0.34-0.38	0.32-0.36	0.35-0.40
4.	pH	4.12-4.40	4.21-4.41	< 4.40
5.	Texture/ Firmness	4.05-4.30	4.09-5.41	> 4.00
6.	Lycopene (mg/100g FW)	11.12-11.42	8.5-10.5	>8.5
7.	Lycopene in tomato paste , 27-28^0 brix (mg/100g fresh weight)	14.15	14.14	>15
8.	Viscosity (Botswick, cm/30 sec)	12-12.50	14-14.20	12-14
9.	Avg. fruit weight (g)	75-80	70-75	> 80
10.	Yield (t/ha)	80-90	75-80	> 50
11.	Special traits	Suitable for processing into puree, paste, ketchup, sauce, tomato crush		

*Colour value of crushed tomato juice (a/b, Hunter Lab scale)
Source: Sadashiva (2021), ICAR-IIHR, Bengaluru-personal communication by Dr. N. Rai

Figure 2: Old tomato processing varieties

However, none of these varieties are now fit for processing, because they do not possess today's market requirements except cv. ArkaApeksha and ArkaVishesh recently developed by IIHR, Bengaluru (Figure 3).

ArkaAhuti: It is pure line selection of variety Otwa-60 and released from IIHR Bangalore. Plants are indeterminate in growth habit. Fruits are oval in shape, pulpy, tough skin and uniform ripening.

Arka Ashish: Open pollinated variety bred for processing, fruits oval, very firm, thick fleshed with 2 locules, excellent fruit colour (lycopene 10mg/100g), TSS 4.8 °Brix, tolerant to powdery mildew and fruit cracking, yield potential 38 t/ha in 130 days

Figure 3: New tomato processing varieties developed by ICAR-IIHR, Bengaluru

Source: Sadashiva (2021), ICAR-IIHR, Bengaluru-personal communication

ArkaSaurbh: It is an improvement over breeding line V-685 from Canada and released from IIHR, Bangalore. Plants are semi- determinate. Fruits are firm, fleshy, deep red and weighing about 70 g. This is a dual purpose variety suitable for both fresh market and processing purposes. It is resistant to fruit cracking.

ArkaRakshak: High yielding F1 hybrid with triple disease resistance (ToLCV, BW and early blight), fruits square round, large (90-100g), deep red colored, firm, suitable for fresh market and processing, yield potential 75-80 t/ha in 140 days.

ArkaShreshtha: It is developed and released from IIHR, Bangalore. Plants are semi- determinate. Fruits are round having light green shoulder and 75 g an average fruit weight. Fruits can be stored for 17 days (from breaker to softening stage) at room temperature. It is resistance to bacterial wilt and suitable for both fresh marketing and processing purposes.

Kashi Chayan: This is a high yielder variety against national checks in different states, at ICAR-IIVR, Varanasi and at farmer's field. This variety is resistant to ToLCV carrying 'Ty3' gene and tolerant to high temperature (up to 30 °C, night). Contains TSS (4.2-5 °Brix) and lycopene (5.4 mg/ 100g) and firm (>6). This variety can be used for cultivation in climatic zone IV, VI, VII and VIII and could also be utilized in breeding programs for developing new resistant / tolerant variety for biotic and abiotic problems.

Kashi Aman: Plant of this variety is determinate in growth. Fruits are round with high pericarp thickness. An average fruit weight ranges from 80-100 g with 4 locules. TSS content is 4.6 °Brix at fruits ripe stage. This variety is recommended for cultivation in Punjab, Bihar & Jharkhand. An average yield is 50-60 t/ ha.

Kashi Abhimaan: This is derived by VRT-04/010 x VRT-04/011. Plants are determinate in growth. Fruits are deep red in colour. Pericarp thickness is 0.6 cm and suitable for long transportation. Average fruit weight ranges from 75-95 g. TSS content is 4.2-4.6 °Brix. This is tolerant to tomato leaf curl virus disease as it carries Ty2 gene.

Punjab Chhuhara: It is derivative of the cross Punjab Tropic x EC55055, released in 1975 from PAU, Ludhiana. It is suitable for summer season. Plants are dwarf (60 cm), bushy and determinate growth habit. Fruits are pear shaped, thick pericarp, and well protected under foliage. It has good keeping quality and sets fruits under high temperature conditions. It is good for processing purposes. It is tolerant to root knot nematode and susceptible to early and late blight.

Pusa Ruby: It is a derivative of Improved Meeruti x Sioux. This is early maturing very old and wider adoptable variety having indeterminate growth habit. Fruits are flattened, grooved, firm and medium size. It is suitable for rainy season for all over the country.

Pusa Gaurav: It was developed from the exotic segregating generation of a cross between Galmour and 'Watch' and released by the IARI, New Delhi. Plants are dwarf, bushy with moderate foliage cover. The fruits are smooth, elliptical (egg shaped) and borne in clusters. The unripe fruits are firm with thick flesh (0.6 cm) and two well-filled locules that facilitate easy transportation over long distances. Whole fruit is suitable for processing and canning because it is without neck constriction and has

higher TSS (6 °Brix) and better keeping quality at room temperature.

Roma: It is an introduction form USA. Plants are semi-dwarf in growth. Fruits are pear shaped with thick pericarp, red in colour on ripening, free from green shoulder, bilocular, small seed cavity and less seeded. This variety possesses good keeping quality and good for processing.

Prospects and Challenges in Processing Tomatoes

Tomato is an important vegetablein the world for fresh market and processing products. India accounts for 16% in area and 11% of tomato production in the world. Worldwide major tomato is consumed as fresh or raw vegetable (89%) and only a small fraction (~11%) is processed. Surprisingly, in India utilization as processed tomatoes is very low i.e. < 1%. Moreover, per capita consumption of processed tomato is very small amount (200 g) in India. Hence, there is a huge scope to use tomato in the form of processedproducts such as tomato crush, pulp, paste, puree, ketchup, canned products etc. Moreover, this is important to avoid glut in main (winter) season, and so suitable processing varieties should be developed which can be grown throughout the year particularly under summer and rainy seasons. Major Indian companies involved in tomato processing are M/s Hindustan Unilever Ltd. (Kissan), M/s FieldFresh FoodsPvt. Ltd. (Del Monte), M/s Nestle India (Maggi), M/s Global Green Company Pvt. Ltd., M/s IndiraFoods, M/s Cremica Group, M/s Dabur India (Hommade), M/s GD Foods Mfg. (India) Pvt. Ltd. (Tops), M/s Mother Dairy (Safal), M/s Capricorn Food Products India Ltd., M/s NijjerAgro Foods Ltd., M/s Godrej Beverages and Foods, M/s GRG Fine FoodsPvt. Ltd., National Agricultural Cooperative Marketing Federation of India Ltd.(NAFED), M/s ITC Group (Farmland), M/s SunsipAgro Processors, M/s Sahyadri Farms etc. These companies are located in various parts of the country such as Andhra Pradesh (Chittoor), Delhi (Noida), Maharashtra (Nasik, Pune), Punjab (Amritsar, Ludhiana), Tamil Nadu (Krishnagiri, Vellore, Chennai), Goa and Karnataka (Bengaluru, Dharwad). In our country, processing capacity is very less (30-600 tons per day) and it is seasonal also, compared to the developed country like USA (59000 tons per day, California). There are several researchableand operational issues associated with development of processing varieties and successful establishment of processing industries on business model which need to be resolved to strengthen processing tomato in India.

Strategies of Processing Tomatoes in India

There is a need of multi-dimensional approach to augment processing industry in India (Figure 4).

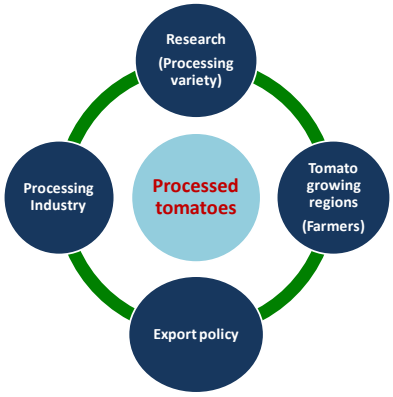

Figure 4: Schematic layout of strategies for processing tomato in India

For which several issues need to be taken care of. Research, operational and export policy related to industry and farmers should be taken together for full fledged processing business in the country.

Researchable issues:

- Strengthening of research on tomato processing varieties in public and private partnership (PPP) mode.
- Large scale evaluation of available processing tomato varieties /hybrids.
- Breeding for high yielding tomato processing varieties suitable for year round cultivation.
- Import of improved breeding lines and germplasm from international genebanks.
- Lack of commercial processing varieties/F1 hybrids.
- Development of tomato processing varieties database in India.
- Development of region-specific package of practices for cultivation of processing tomatoes.
- Need to develop varieties for year round cultivation to sustain processing industries.
- Presently, fresh market tomatoes are being processed which faces seasonal glut issues.
- International research collaborations for processing such as mechanical harvesting.
- Operational and industry related issues:

- Certification of processed varieties and products by authorised agencies/institutions.
- Need to establishmore processing industries in the country exclusively on tomato with focus on major tomato growing areas.
- Establishment of collection centers in major tomato growing areas.
- Determining minimum support price for processing tomatoes.
- Ensure income to farmers and bridge the gap between farmers and industry.
- Public distribution of processed products at subsidized prices to increase demand.
- Establish export policy and encourage regular export of processed products.

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सारांश

टमाटर दुनिया में एक महत्वपूर्ण सब्जी की फसल है जिसका उपयोग ताजा खपत और केचप, सॉस, पेस्ट आदि जैसे प्रसंस्करण उत्पादों को बनाने के लिए किया जाता है। टमाटर पोषक तत्वों का एक समृद्ध स्रोत है और यह स्वास्थ्य के लिए लाभकारी होते हैं। चीन के बाद भारत टमाटर (20.57 मिलियन टन) का दूसरा सबसे बड़ा उत्पादक देश है। देश में, अधिकांश टमाटर सब्जी के उद्देश्य के लिए ताजा के रूप में उपयोग किए जाते हैं। विकसित देशों जैसे इटली (64.02%), स्पेन (39.41%) और संयुक्त राज्य अमेरिका (10.34%) की तुलना में, हमारे देश में 1% से कम टमाटर का उपयोग प्रसंस्कृत उत्पाद बनाने के लिए किया जाता है। देश में किस्मों के अभाव के कारण प्रंसस्करण उद्योग को बढावा नहीं मिल पाया है। इसलिए, सालों भर प्रसंस्करण उद्योगों को जारी रखने के लिए उपयुक्त टमाटर के किस्मों की आवश्यकता है। जैसा की विदित है कि दुनियाभर जीन बैंक मे बड़ी संख्या में टमाटर के सामान्य और जंगली प्रजातियाँ उपलब्ध हैं, जिनमें प्रसंस्करण के गुण मौजूद हैं। हालांकि, पिछले प्रयासों से प्रसंस्करण उद्देश्य के लिए उपयुक्त कुछ किस्मों जैसे पूसा रूबी, रोमा, पंजाब छुहारा इत्यादि को विकसित किया गया है, लेकिन वे वर्तमान के प्रसंस्करण उद्योगों की मांग को पूरा करने में सक्षम नहीं हैं। इसलिए, इस लघु–समीक्षा में भारत में प्रसंस्करण किस्मों को विकसित करने हेतु वर्तमान कि स्थिति और संभावनाओं का सारांश प्रस्तुत करते हैं।

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