STRATEGY PAPER 16

Need for Breeding Tomatoes Suitable for Processing

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI

August 2022

Need for Breeding Tomatoes Suitable for Processing

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI

August 2022

CONVENOR : Dr A.T. Sadashiva, Former Head, ICAR-Indian Institute of Horticultural Research, Bengaluru

EDITORS : Dr P.S. Birthal
Dr Malavika Dadlani

REVIEWERS : Dr Pritam Kalia, Emeritus Scientist, ICAR-IARI
Dr. R.T. Patil, Former Director, CIPHET, Ludhiana

CITATION : NAAS 2022. Need for Breeding Tomatoes Suitable for Processing. Strategy No. 16, National Academy of Agricultural Sciences, New Delhi, pp 20

Published by Dr Sanjeev Saxena, Executive Director on behalf of
NATIONAL ACADEMY OF AGRICULTURAL SCIENCES
NASC, Dev Prakash Shastry Marg, New Delhi - 110 012
Tel: (011) 25846051-52; Fax: (011) 25846054
Email: naas-mail@naas.org.in; Website: www.naas.org.in

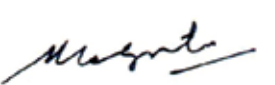
Preface

India, with more than 20 million tonnes of annual production from an estimated area of 0.81 million hectares, is one of the world's leading producers of tomatoes. With a population of over 1.38 billion, it is also the second largest consumer country. Tomato being an essential ingredient in Indian cuisine, nearly 99% of the tomatoes are consumed as fresh, with only about 150,000 tons (less than 1%) of tomatoes being processed annually. While other major tomato producing countries like the USA, and Italy process over 70 per cent of their produce, earning billions through the export of processed tomato products, India imported processed tomato products (canned tomato, sauce and paste) worth 20.64 Million US Dollars in 2019, raising the total imports by 146 % over previous years. The total value of tomato paste (HS200290) imports in India, during the marketing year 2019-20 reached US $ 19 million with a CAGR of 160% of which nearly 72% was from China, followed by the USA, Spain, Italy and Chile.

Ironically, in the peak season (rabi) when average yields in high tomato producing states like Andhra Pradesh are around 44.5 tonnes per hectare, due to lack of adequate processing facilities, and drastic drop in procurement prices, 40 to 50 per cent of the fresh produce is wasted every year. This glut in the fresh tomato market presents an opportunity to gainfully utilise 70 to 80 per cent of the harvest in the processing industry, provided the quality parameters needed for processing are met. The current varieties/hybrids, which cover over 90% of the area, are not specifically bred for processing qualities. Hence, there is a need to breed and promote tomato hybrids also suitable for processing, which are not only high yielding and firm but have high Brix (>5.5%), high lycopene levels (> 14 mg/100g FW), low acidity (0.35 to 0.40)%, and high viscosity (12-14 Botswick cm/30 sec). Moreover, with the scarce and uneconomical labour situation in the country, it will be desirable to breed 'once-over harvest' type hybrids. Besides quality traits, varieties need strong disease resistance and heat tolerance traits, to suit a prolonged sowing season from October to February, and harvesting from February to May. This will not only help reduce the use of pesticides but also ensure engaging the processing plants at least for five continuous months. To meet such specifications, targeted breeding programs need to be taken up by the public research institutions or through public/private CONSORTIA.

Assured procurement by the industry to encourage farmers to cultivate varieties for processing and support to such industry through enabling policies and incentives are also desired. Considering the farmers' and consumers' problems due to glut and scarcity in the fresh market and problems and potential of the tomato processing in India, the National Academy of Agricultural Sciences (NAAS) organized a Brain Storming Session (BSS) on "Need for Breeding Tomatoes Suitable for Processing" on November 24, 2020, in a virtual mode with Dr A.T. Sadashiva as the Convener, under the Co-Chairmanship of Dr D.P. Ray, Former Vice-Chancellor, OU&AT. The BSS was attended by many eminent scientists and experts from the relevant disciplines as well as processors from India and abroad. The deliberations, enriched by in-depth interactions, identified the focus areas of research and made specific recommendations, which, I believe, would be useful in preparing an action plan for processing tomatoes.

On behalf of the Academy, I compliment Dr A.T. Sadashiva, Convener, eminent resource persons, panellists and fellows of the Academy who participated in the deliberations and provided valuable inputs and information on processing tomatoes. I also thank the reviewers and editors Dr P.S. Birthal and Dr Malavika Dadlani for their support. I am hopeful that this document will be useful to all Fellowship, policy makers and other stakeholders.



(Trilochan Mohapatra)
President
National Academy of Agricultural Sciences

August 2022
New Delhi

Need for Breeding Tomatoes Suitable for Processing

1. INTRODUCTION

Tomatoes are essential component of the Indian cooking, and diets across the world. They are consumed fresh as salad, used in various culinary preparations, and processed for puree, sauce, ketchup, and powder. India is the second largest producer of tomatoes —17% of the global acreage and 11% of the production. In 2019-20, the country produced 20.57 million tons of tomatoes grown on 0.81 million hectares of land with per capita consumption at approx 15 kg. Most of the tomatoes produced are consumed fresh as salad and used in culinary preparations and hence surplus available for processing is less. Only a small proportion of the produce is used for processing into value-added products and remaining requirement of puree is met through imports. The available information suggests that hardly 1% of the tomatoes produced in India are processed into value-added products on a commercial scale (Subramanian, 2016) as compared to 85% in the developed countries like the US. However, this situation in USA is mainly due to high production, low population and large surplus which needs compulsory processing. The low-level of processing in India is because of low surplus due to large population and higher level of fresh consumption due to our culinary habits.

However, now due to a growing middle class and increase in consumption of value added tomato products, there is need to increase indigenous processing to reduce bulk imports of processed tomato which is mainly from China, USA and Italy. To meet the increased demand of tomato processing industry in the country, we need to grow more of processable varieties. Lack of suitable tomato varieties/F_1 hybrids available for commercial cultivation, acts as a disincentive for private sector to invest in processing infrastructure and value chains. On the other hand, driven by sustained increase in per capita income, growing urbanization, changing lifestyles, improvements in logistics and transportation, the demand for high-value food products, including the tomatoes and their value-added products, has been rising continuously. As a result, India imports huge quantities of primary processed forms or finished products of tomatoes. In 2019, India imported finished tomato products worth US $20.64 million. Nearly 72% of the imports were from China, followed by US, Spain, Italy and Chile. Therefore, the need for the development of high yielding tomato varieties / hybrids having resistance against major biotic and abiotic stresses, that are suitable for processing, and can be grown round the year, cannot be undermined.

In India, tomato is grown in two seasons in most part of the country, from June to September (Kharif/monsoon season) and from October to February (Rabi/spring season). In some regions, tomatoes can be cultivated throughout the year. The Southern states comprising of Andhra Pradesh, Karnataka and Tamil Nadu and the Central states of Madhya Pradesh, Maharashtra, Gujarat and Bihar contribute maximum to the total tomato production in the country.

Due to its perishable nature, post-harvest losses are high (12.4%) in fresh tomatoes. Hence, these need to be processed to reduce their bulk, moisture content and hence, the loss percentage. One of the main reasons of huge post-harvest losses of the harvested tomatoes occur due to inadequate storage facilities, which brings substantial loss to the growers and affects the national economy (Subramanian, 2016).

The preservation of tomatoes in a semi-processed state not only takes care of the marketable surplus, but also ensures the supply of raw materials for finished products like sauce, ketchup, drink and other processed items. Presently, in the absence of suitable processing varieties, Indian processors tend to import bulk tomato paste mostly from China and simultaneously process fresh market tomato F_1 hybrids during the glut period i.e., when the prices go below Rs.2 per kg. One of the main reasons as to why the Indian tomato processing industry is yet to successfully develop is because processors have not managed to obtain a reliable and consistent processable source for raw materials at the required cost and quality.

2. CURRENT STATUS OF TOMATO PRODUCTION

2.1 Attributes of Tomatoes for Processing

Tomato is one of the most important vegetable crops grown in India. Its cultivation is more remunerative during the off-season, hence farmers prefer growing high-yielding F_1 hybrids but mostly suitable for table purpose. Nonetheless, due to the non-availability of commercial varieties or hybrids suitable for processing the F_1 hybrids are procured and processed during the glut season, when the prices are ruling low. This situation is not desirable for the farmers as well as processors. Hence, to achieve the required processing traits in the final product, the processing industry needs more raw ingredient to convert it into the basic value-added products as puree or paste. Such a conversion requires more energy for traditional varieties, and results into higher cost of production making it essential to grow varieties specific for processing.

A typical processing genotype should possess high TSS (>5^{0}Brix), minimum sugar acid ratio (15:1), lycopene (>10mg/100g FW) with a high colour value of (>2) and low pH (<4.3) that improve quality of the valued-added products, and reduce energy consumption and cost of processing. Besides the quality attributes, plant habit of a typical processing genotypes should be determinate with a good foliar cover. Fruits are borne in clusters with concentrated fruit maturity and vine storability. Jointless pedicel is an important attribute of processing varieties. This facilitates machine harvesting. On the other hand, for fresh market tomatoes the plant habit can be a determinate/ semi-determinate/indeterminate, with fruit quality attributes of moderate TSS (3-4.5^{0}Brix), acidity (0.4-0.5%) and colour (<2).

The initial tomato breeding programmes in India led to the development of several OP varieties in the 1980s that were also suitable for processing. These included: Roma (NBPGR, New Delhi), Punjab Chhuhara (PAU, Ludhiana), Arka Ashish and Arka Ahuti (IIHR, Bengaluru) and Pusa Gaurav (IARI, New Delhi). But, none of these varieties are in commercial cultivation at present due to low yield and susceptibility to many diseases. Hence, there is a strong need for the development of high-yielding tomato varieties or F_1 hybrids suitable for processing and resistant to important diseases.

2.2 Status of Tomato Production

Tomatoes are cultivated in the tropical and sub-tropical regions of the world. Major tomato-growing countries are China, India, US, Turkey, Egypt, Italy, Iran, Spain, Brazil, Chile, Uzbekistan, Ukraine, Portugal and Tunisia, covering about 5.052 million hectares of land, producing 186.82 million tons with an average yield of 36.98 t/ha (Table 1). High productivity are recorded in the US (110.72 t/ha), Portugal (93.03 t/ha), Spain (77.75 t/ha) Turkey (72.6 t/ha), Brazil (72.24 t/ha), Chile (69.48 t/ha),

Italy (62.62 t/ha), Tunisia (56.89 t/ha), Iran (41.84t/ha) and Egypt (39.4 t/ha) (Table 1). China ranks first in area (1.111 million ha) as well as production (64.87 million t). India ranks next with an area of 0.812 million ha and production of 20.57 million t, though with extremely low yields (25.34 t/ha).

Table 1. Top 14 tomato producing countries (area in million ha; production in million t, and yield in t/ha

	2016			2017			2018			2019			2020		
Country	**Area**	**Production**	**Yield**	**Area**	**Production**	**Yield**	**Area**	**Production**	**Yield**	**Area**	**Production**	**Yield**	**Area**	**Production**	**Yield**
China	**1.02**	**56.42**	**56.2**	**1.03**	**59.6**	**57.9**	**1.04**	**61.63**	**59.25**	**1.091**	**62.97**	**57.72**	**1.111**	**64.87**	**58.36**
India	**0.76**	**18.4**	**24.2**	**0.8**	**20.71**	**26.0**	**0.79**	**19.38**	**24.6**	**0.781**	**19.01**	**24.34**	**0.812**	**20.57**	**25.34**
USA	0.14	12.88	91.1	0.13	11.14	88.7	0.13	12.6	96.8	0.111	12.16	109.80	0.110	12.23	110.72
Turkey	0.19	12.6	66.2	0.19	12.75	67.7	0.17	12.15	68.9	0.180	12.84	71.18	0.182	13.20	72.60
Egypt	0.2	7.94	39.8	0.2	6.73	40.5	0.16	6.6	41	0.175	6.81	39.00	0.171	6.73	39.40
Iran	0.15	5.83	39.1	0.15	6.23	40.2	0.16	6.58	41.4	0.122	5.46	44.57	0.129	5.79	44.84
Italy	0.1	6.44	61.9	0.09	6.02	60.3	0.09	5.79	59.7	0.099	5.78	58.35	0.100	6.25	62.62
Spain	0.06	5.23	83.4	0.06	5.16	84.8	0.06	4.77	85	0.057	5.00	87.82	0.055	4.31	77.75
Brazil	0.06	4.17	65.1	0.06	4.22	68.8	0.06	4.11	71.9	0.055	3.92	71.83	0.052	3.75	72.24
Ukraine	0.07	2.23	30	0.07	2.27	30.5	0.07	2.32	31.8	0.073	2.22	30.51	0.075	2.25	30.04
Uzbekistan	0.06	2.8	43.6	0.06	2.45	40.6	0.06	2.28	37.8	0.059	2.12	36.01	0.058	1.93	33.40
Tunisia	0.02	1.33	60.1	0.02	1.3	59.6	0.02	1.36	56.1	0.027	1.53	56.08	0.025	1.42	56.89
Portugal	0.02	1.69	81.2	0.02	1.75	83.7	0.01	1.33	84	0.016	1.53	96.29	0.015	1.40	93.03
Chile	0.01	0.91	63.7	0.02	0.99	62.7	0.02	0.95	62.7	0.015	1.04	68.70	0.011	0.78	69.48
World	**5.01**	**178.16**	**35.5**	**4.85**	**180.94**	**37.3**	**4.76**	**182.25**	**38.2**	**4.99**	**183.01**	**36.61**	**5.052**	**186.82**	**36.98**

Source: FAOSTAT (http://faostat3.fao.org/home/E). Accessed on 26th January, 2022.

2.3 State-wise Production of Tomatoes in India

As mentioned above, the major tomato-growing states are Andhra Pradesh, Madhya Pradesh, Karnataka, Gujarat, Odisha, West Bengal, Telengana, Chhattisgarh, Maharashtra and Bihar top ten tomato producers (Table 2). There is considerable inter-state variation in yield, with Andhra Pradesh (44.5 t/ha), Himachal Pradesh (42.9t/ha), Uttar Pradesh (39.6 t/ha), Karnataka (32.4 t/ha), Tripura (31 t/ha), Tamil Nadu (30.5 t/ha), Gujarat (29.1t/ha) and Madhya Pradesh (28.6) harvesting more than the national average.

Table 2. State-wise area, production and yield of tomato in India

S. N.	State	2015-16		2016-17		2017-18		Yield (MT/ ha)
		Area (in 000 hectares)	Production (in 000 MT)	Area (in 000 hectares)	Production (in 000 MT)	Area (in 000 hectares)	Production (in 000 MT)	
1	Andhra Pradesh	59.08	2236.56	49.79	4481.01	61.67	2744.32	44.5
2	Madhya Pradesh	73.7	2285.9	95.4	2719.57	84.53	2419.28	28.62
3	Karnataka	60.98	2046.14	60.45	1916.86	64.25	2081.59	32.39
4	Gujarat	46.4	1319.11	48.76	1411.85	46.61	1357.52	29.12
5	Odisha	90.91	1290.99	90.99	1311.21	91.01	1312.07	14.41
6	West Bengal	57.17	1204.43	57.35	1233.03	57.46	1265.25	22.01
7	Telangana	57.97	1475	37.97	520.47	41.48	1171.5	28.24
8	Chhattisgarh	54.91	908.98	62.33	1082.34	63.29	1087.33	17.18
9	Maharashtra	44.24	976.58	50.71	1124.89	45.5	1086.56	23.88
10	Bihar	45.81	1001.01	46.21	1009.6	45.01	941.56	20.91
11	Tamil Nadu	29.8	645.7	26.34	629.16	29.08	887.08	30.5
12	Uttar Pradesh	20.75	819.37	20.99	831.51	21.24	841.61	39.62
13	Haryana	29.03	675.38	31.82	643.59	34.99	753.72	21.54
14	Himachal Pradesh	11.04	485.54	11.06	473.28	11.24	481.94	42.87
15	Assam	17.66	445.02	18.18	393.6	18.28	396.24	21.67
16	Jharkhand	18.16	230.19	19.75	231.46	20.11	265.26	13.19
17	Punjab	7.69	191.18	8.07	200.38	9.01	224.26	24.89
18	Uttarakhand	8.55	93.22	8.63	94.01	9.2	103.85	11.28
19	Rajasthan	20.51	83.29	20.37	90.52	18.12	88.73	4.89
20	Tripura	1.81	53.81	1.83	57.33	1.82	56.5	31.04
21	Jammu & Kashmir	3.58	88.09	3.56	92.55	2.28	52.96	23.22
22	Meghalaya	2.15	34.02	2.16	34.5	2.2	35.51	16.14
23	Manipur	3.06	31.61	17.64	65.76	3.15	33.72	10.7
24	Nagaland	2.87	20.1	3.1	22.16	3.12	22.47	7.2
25	Others	1.08	14.2	1.1	15.28	1.19	13.84	11.63
26	Kerala	3.12	58.8	0.27	3.49	0.64	12.61	19.7
27	Mizoram	1.09	10.2	1.29	12.85	1.47	11.87	8.07
28	Sikkim	0.55	4.25	0.53	4.08	0.98	8.03	8.19
29	Arunachal Pradesh	0.23	3.32	0.23	2.11	0.25	2.15	8.6
	Total	**773.88**	**18732**	**796.86**	**20708.4**	**789.15**	**19759.32**	**25.03**

Source: Government of India (2018)

2.4 Market Prices

Prices of agricultural commodities are determined by the dynamics of their supply and demand which fluctuate depending on the seasonality in production and perishability. Horticultural commodities have a higher degree of seasonality as well as perishability, and in the absence of adequate storage and processing infrastructure their prices fluctuate significantly. Figure 1 shows the trend in monthly wholesale prices of tomatoes. At all India level, the monthly wholesale price for the period 2013 to 2018 has been estimated at Rs 20.49/ kg. The price is normally low (Rs 12.38-15.88) for the crop harvested during January-May. This is due to more arrival of tomatoes in the market. The price shows an upward trend during June - December, ranging from Rs 20.61 to Rs 31.08/kg because of the short supply during these months.

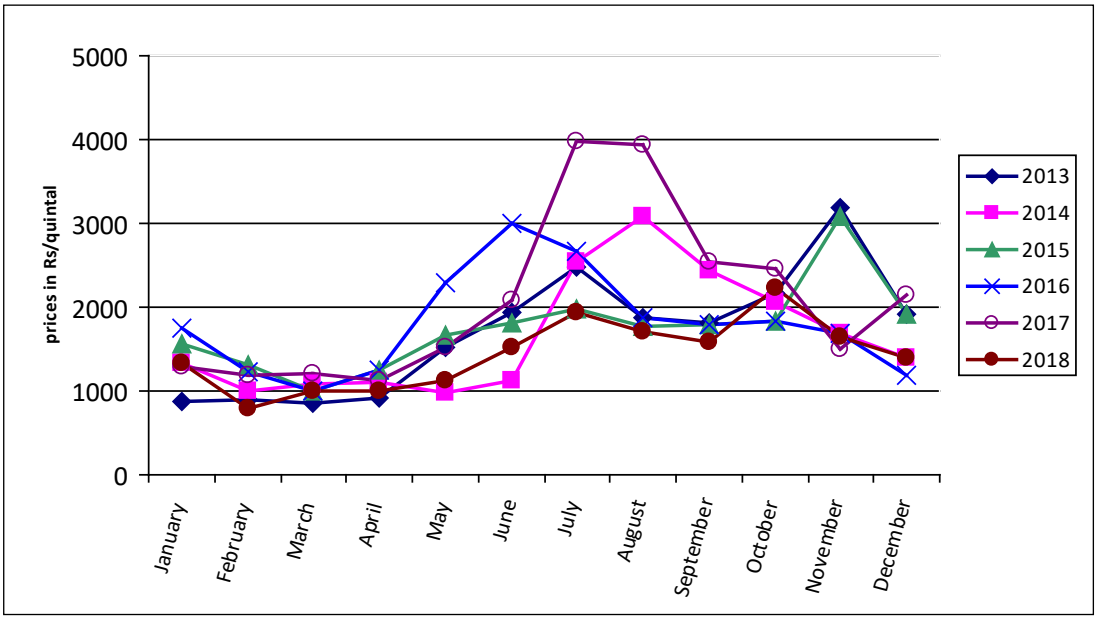
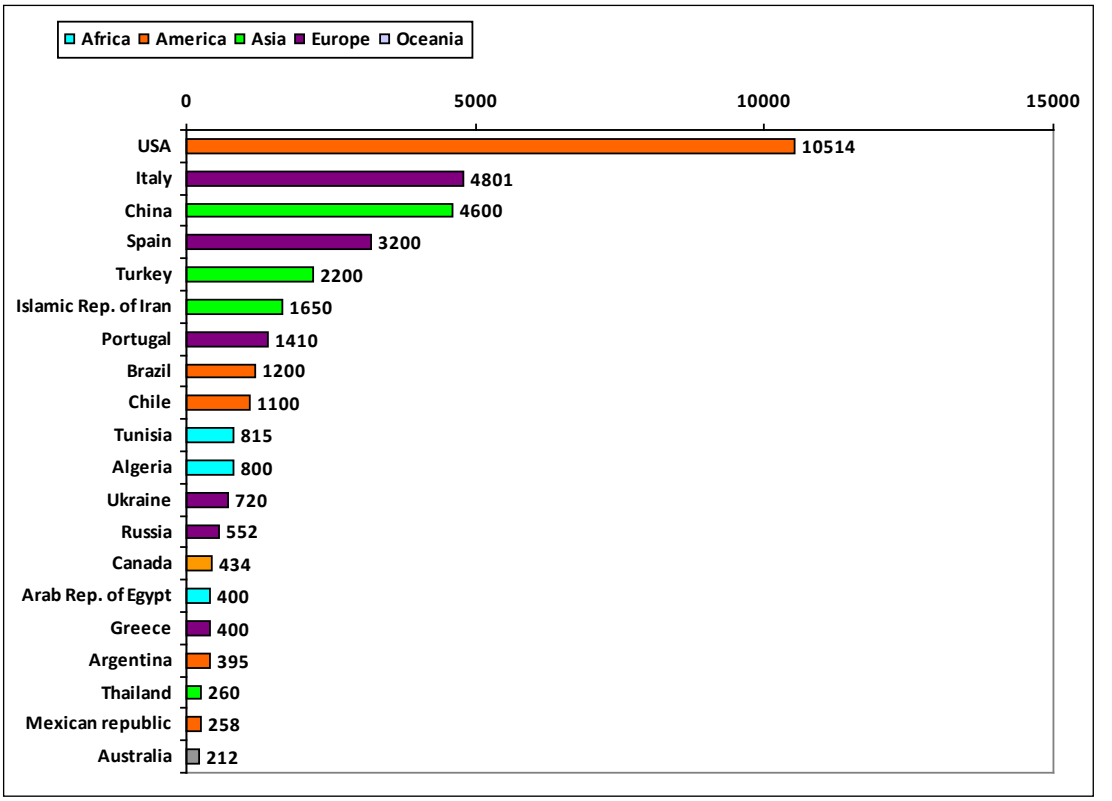


Fig 1: All India monthly average wholesale of Tomatoes

3. GLOBAL STATUS OF PROCESSING TOMATOES

3.1 Top 20 Countries for Tomato Processing

According to the World Processing Tomato Council (WPTC) the top 20 countries for tomato processing are: USA, Italy, China, Spain, Turkey, Islamic Republic, Portugal, Brazil, Chile, Tunisia, Algeria, Ukraine, Russia, Canada, Arab Republic, Greece, Argentina, Thailand, Iran Republic and Australia (Figure 2). The US with processed tomatoes of 10.51 million tons ranks first, followed by Italy (4.8 million t), China (4.6 million t) and Spain (3.2 million t) (WPTC, 2019).



Source: WPTC (2019).

Fig. 2 Top 20 tomato processing countries in the world in 2019

Eleven of the top 20 processing countries, *viz;* USA, Italy, China, Spain, Turkey, Iran, Portugal, Brazil, Chile, Tunisia and Ukraine account for 83% of the global processed tomatoes (Table 3). With a share of 27% USA (California) ranks first, and is followed by Italy (13%) and China (12%) (Table 4).

Table 3. Tomatoes processed by top 11 countries in the world from 2010 to2019 (000 t)

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
California, USA	11155	11067	11464	11020	12707	13018	11470	9492	11137	10144
Italy	5080	4950	4500	4080	4914	5393	5180	5200	4650	4801
China	7500	6792	3230	2850	6300	5600	5150	6200	3800	4600
Spain	2350	1985	1935	1650	2700	3028	2950	3350	2800	3200
Turkey	1280	1940	1750	2150	1800	2700	2100	1900	1300	2200
Iran	1400	1850	1750	1900	2200	1350	1150	980	750	1650
Portugal	1280	1065	1190	997	1197	1660	1507	1554	1198	1410

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Brazil	1796	1590	1294	1670	1400	1300	1450	1450	1400	1200
Chile	864	794	668	682	810	850	800	1080	1211	1100
Tunisia	850	868	840	618	720	920	650	643	618	815
Ukraine	280	440	385	330	470	550	550	650	735	720
Total Top 10	33555	32901	28621	28617	34748	35819	32407	31856	28981	31120
Share in the global market (%)	87%	87%	86%	86%	87%	87%	85%	84%	83%	83%
Others	5192	4733	4798	4580	5148	5555	5665	5941	5834	6263
Share of others	13%	13%	14%	14%	13%	13%	15%	16%	17%	17%
Global processing	38747	37634	33419	33197	39896	41374	38072	37797	34815	37383

Source: WPTC(2019)

Table 4. Percentage of total production of tomatoes processed by top 11 countries in the world during 2010-2019

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
USA (California)	29	29	34	33	32	31	30	25	32	27
Italy	13	13	13	12	12	13	14	14	13	13
China	19	18	10	9	16	14	14	16	11	12
Spain	6	5	6	5	7	7	8	9	8	9
Turkey	3	5	5	6	5	7	6	5	4	6
Iran	4	5	5	6	6	3	3	3	2	4
Portugal	3	3	4	3	3	4	4	4	3	4
Brazil	5	4	4	5	4	3	4	4	4	3
Chile	2	2	2	2	2	2	2	3	3	3
Tunisia	2	2	3	2	2	2	2	2	2	2
Ukraine	1	1	1	1	1	1	1	2	2	2
India	-	-	-	-	-	0.31	-	-	0.37	-

Source: WPTC(2019)

3.2 Country-wise Tomatoes Produced and Quantity Processed

As per the trend in the quantities of tomatoes produced and processed during 2014 to 2018, the USA (California) produced 13.41 million tons of tomatoes of which 11.57 million tons were processed. In other words, over 86% of the tomato production was used for some form of processing. Italy ranks second, where over 85% of the tomato produced is turned into value-added products. China although is the largest producer of tomatoes, processes only 9.4% of its produce. India is the second-largest producer of tomatoes with only an estimated one percent of its produce being utilized for processing.

Overall, over one-fifth of the global output of tomatoes is transformed into value-added products (in primary or finished form), but most of their processing remains concentrated in the developed countries due to high surplus available in those countries. In the developing countries the consumer preference seems to be more for fresh tomatoes to be consumed fresh as salad or used in culinary preparations.

Table 5. Tomatoes produced, and processed (million t) in top 9 countries in processing

Country	Particulars	2014	2015	2016	2017	2018	Average
USA (California)	Production	15.87	14.58	12.88	11.14	12.6	13.41
	Processed	12.71	13.02	11.47	9.49	11.14	11.57
	% processed	80	89	89	85	88	86.20
	% in world	32	31	30	25	32	30.00
Italy	Production	5.62	6.41	6.44	6.02	5.79	6.06
	Processed	4.91	5.39	5.18	5.20	4.65	5.07
	% processed	87	84	80	86	80	83.40
	% in world	12	13	14	14	13	13.20
China	Production	52.8	55.8	56.42	59.6	61.63	57.25
	Processed	6.30	5.60	5.15	6.20	3.80	5.41
	% processed	12	10	9	10	6	9.40
	% in world	16	14	14	16	11	14.20
Spain	Production	4.89	4.83	5.23	5.16	4.77	4.98
	Processed	2.70	3.03	2.95	3.35	2.80	2.97
	% processed	55	63	56	65	59	59.60
	% in world	7	7	8	9	8	7.80
Turkey	Production	11.85	12.61	12.6	12.75	12.15	12.39
	Processed	1.80	2.70	2.10	1.90	1.30	1.96
	% processed	15	21	17	15	11	15.80
	% in world	5	7	6	5	4	5.40
Iran	Production	6.36	6.01	5.83	6.23	6.58	6.20
	Processed	2.20	1.35	1.15	0.98	0.75	1.29
	% processed	35	22	20	16	11	20.80
	% in world	6	3	3	3	2	3.40
Portugal	Production	1.4	1.93	1.69	1.75	1.33	1.62
	Processed	1.20	1.66	1.51	1.55	1.20	1.42
	% processed	86	86	89	89	90	88.00
	% in world	3	4	4	4	3	3.60

Country	Particulars	2014	2015	2016	2017	2018	Average
Brazil	Production	4.3	4.19	4.17	4.22	4.11	4.20
	Processed	1.40	1.30	1.45	1.45	1.40	1.40
	% processed	33	31	35	34	34	33.40
	% in world	4	3	4	4	4	3.80
Tunisia	Production	1.25	1.35	1.33	1.3	1.36	1.32
	Processed	0.72	0.92	0.65	0.64	0.62	0.71
	% processed	58	68	49	49	45	53.80
	% in world	2	2	2	2	2	2.00
India	Production	18.74	16.38	18.40	20.71	19.38	18.72
	Processed		0.13			0.13	0.13
	% processed		0.80			0.70	0.75
	% in world		0.31			0.37	0.34
World	Production	174.78	176.82	178.16	180.94	182.25	178.59
	Processed	39.90	41.37	38.07	37.80	34.82	38.39
	% processed	23	23	21	21	19	21.40

Source: WPTC(2019)

3.3 Top Tomato Processing Groups in the World (2018)

According to WPTC (2019), of the 40 tomato processing groups ranked at the top 12 are based in the USA, eight in Italy, six each in China and Spain, two in Turkey and one each in Portugal, Japan, Ukraine, Algeria, Greece, Chile, Hungary and Tunisia (Table 6; Figure 3). Morning Star, which has 3 factories in California, has the highest processing capacity of 59000 tons per day. It processed 5.7 million tons of tomatoes in 2018.

Table 6. Top 40 world tomato processing groups during 2018 WPTC (2019)

2018 TOP WORLD TOMATO PROCESSING GROUPS								
RANK (by dally capacity)	COMPANY	COUNTRY	NUMBER OF FACTORIES	PROCESSING REGIONS	PROCESSING CAPACITY		2017 PROD (MT)	2016 PROD (MT)
					DAILY (MT)	YEAR (MT)		
1	Morning star	USA	3	CALIFORNIA.	59,000	57,00,000	30,00,000	36,00,000
2	TUNHE (“)	CHINA	16	CHINA	48,000	25,00,000	26,00,000	23,00,000
3	CHALKIS (“)	CHINA	17	CHINA	40,000	20,00,000	15,00,000	12,00,000
4	SUGALGROUP	PORTUGAL	5	PORTUGAL,SPAIN, CHILE	29,000	24,65,000	18,78,000	n.a
5	KAGOME GLOBAL (1)	JAPAN	5	CALIFORNIA, PORTUGAL, AUSTRALIA, JAPAN	27,900	23,80,000	18,86,000	19,82,000
6	CONESA (2)	SPAIN	8	SPAIN. PORTUGAL CHINA,CALIFORNIA	27,100	15,00,000	13,31,000	8,70,000
7	OLAM	USA	3	CALIFORNIA	22,000	15,75,000	8,00,000	10,50,000
8	JG BOSWELL	USA	2	CALIFORNIA	16,000	13,50,000	9,00,000	11,14,000
9	AGROFUSION	UKRAINE	3	UKRAINE	12,500	7,50,000	5,41,347	4,54,866
10	GUANNONG (“)	CHINA	1	CHINA	12,000	6,00,000	4,80,000	2,70,000
11	STANISLAUS (“)	USA	1	CALIFORNIA	11,500	7,50,000	n.a	n.a
12	HAOHAN GROUP (“)	CHINA	6	CHINA	11,000	11,25,000	6,50,000	6,00,000
13	CONSERVE ITALIA (“)	ITALY	6	ITALY, FRANCE	11,000	5,00,000	n.a	n.a
14	TAT KONSERVE (3)	TURKEY	3	TURKEY	11,000	5,00,000	3,20,000	320 000
15	CASALASCO (4)	ITALY	3	ITALY	11,000	5,60,000	5,60,000	5,43,000
16	MUTTI (5)	ITALY	3	ITALY	11,000	6,50,000	5,60,000	3,20,000
17	TRANSA (6)	SPAIN	2	SPAIN,PORTUGAL	10,500	4,40,000	3,49,217	3,04,326
18	LOS GATOS	USA	1	CALIFORNIA	10,000	10,00,000	n.a	n.a
19	CAMPBELL(“)	USA	2	CALIFORNIA	10,000	,000	n.a	n.a
20	TOMA-TEK (“)	USA	1	CALIFORNIA	8,000	7,50,000	n.a	n.a
21	T. DEL GUADIANA	SPAIN	1	SPAIN	8,000	4,40,000	3,72,578	3,22,596
22	ITALTOM (7) (“)	ITALY	1	NORTH ITALY	8,000	5,00,000	3,50,000	n.a
23	CONS. BENAMOR (“)	ALGERIA	4	ALGERIA	7,600	5,00,000	n.a	n.a
24	LA DORIA	ITALY	5	ITALY	7,500	3,60,000	2,78,000	2,41,000
25	NOMIKOS (8)	GREECE	3	GREECE,TURKEY	7,400	3,80,000	2,90,000	4,00,000

2018 TOP WORLD TOMATO PROCESSING GROUPS								
RANK (by dally capacity)	COMPANY	COUNTRY	NUMBER OF FACTORIES	PROCESSING REGIONS	PROCESSING CAPACITY		2017 PROD (MT)	2016 PROD (MT)
					DAILY (MT)	YEAR (MT)		
26	FUYUAN (“)	CHINA	2	CHINA	7,200	3,60,000	1,50,000	45,000
27	CONAGRA (“)	USA	2	CALIFORNIA	7,000	6,50,000	n.a	n.a
28	AGROZZI	CHILE	1	CHILE	6,500	4,00,000	3,85,000	3,85,000
29	TOMALIA (“)	SPAIN	1	SPAIN	6,500	3,25,000	n.a	n.a
30	THAI SUN (“)	CHINA	1	CHINA	6,000	3,00,000	n.a	n.a
31	DEL MONTE (“)	USA	1	CALIFORNIA	5,700	5,13,000	n.a	n.a
32	PCP(“)	USA	1	CALIFORNIA	5,500	5,00,000	n.a	n.a
33	PRONAT	SPAIN	1	SPAIN	5,400	3,80,000	2,44,669	1,88,776
34	RODOLFI (9) (“)	ITALY	3	NORTH ITALY	5,300	2,65,000	2,50,000	n.a
35	PRINCESIND.ALIM. (“)	ITALY	1	ITALY	5,000	3,00,000	2,50,000	n.a
36	ASSAN FOODS (“)	TURKEY	1	TURKEY	4,500	2,70,000	n.a	n.a
37	UNIVER	HUNGARY	1	HUNGARY	4,300	1,50,500	79,200	49,500
38	ALSAT	SPAIN	1	SPAIN	4,000	2,00,000	1,58,000	1,25,000
39	ESCALON (“)	USA	1	CALIFORNIA	3,500	3,18,000	n.a	n.a
40	MIZKAN	USA	1	CALIFORNIA	3,500	3,25,000	n.a	n.a
41	SOLANA	ITALY	1	NORTH ITALY	3,500	2,00,000	1,62,000	1,72,000
42	SICAMI”I	TUNISIA	1	TUNISIA	3,000	1,80,000	n.a	n.a

RANK (by daily capacity)	COMPANY	COUNTRY	NUMBER OF FACTORIES	PROCESSING REGIONS	PROCESSING CAPACITY		2017 PROD (MT)	2016 PROD (MT)
					DAILY (MT)	YEAR (MT)		

(1) Kagome Group: Ingamar Partners California,2 factories in Portugal-Italagro + FIT- , 1in Japan, 1 in Australia

(2) Conesa + Sopragol + Tomatagro + Tom1x + since 2016 Agraz & Agroex (Spain),X1angfeng&Huizetomato (China),Agusa (USA),+ Algosur since 2017

(3) Karacabey & Mustafakemalpa & Torball (Turkey)

(4) includes ARP since 2015

(5) Mutt1 + Pomodoro 43044 (ex Copador)

(6) Transa + Tomatagro

(7) Ferrara Foods.Steriltom & Emlllana Conserve

(8) D.Nomlkos + Copals + Merko

(9) Rodolfl Ozzano Taro & Castelguelfo + Von Felten

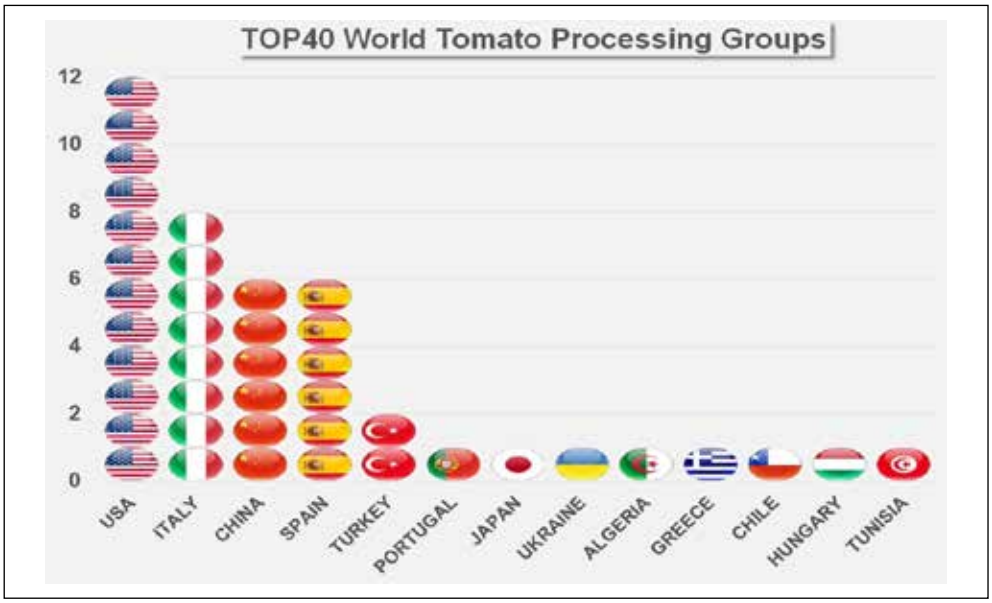


Fig 3. Top 40 world tomato processing groups WPTC(2019)

3.4 Certification of Processing Tomatoes

Processing Tomato Advisory Board (PTAB) which was established in 1987 at Davis, California, issues certificates regarding processing quality to the processors. The sample should be free from worm, should have minimum fungi percentage (<2 filament of Mold) in the analyzed sample, less green fruits, least materials other than tomato (MOT), good colour values, less limited use (LU), high solids, pH less than 4.3 and total solids (TSS) range from 4.63 to 5.71^{0}Brix. Scenario is same in all the countries which produce processing tomatoes in the world

Global Gap Fruits & Vegetables Certification Standard (https://www.globalgap.org/uk_en/for-producers/globalg.a.p./)

GLOBALG.A.P. is the internationally recognized standard for farm production. Their core product is the result of years of intensive research and collaboration with industry experts, producers and retailers around the globe. The goal of this organization is safe and sustainable agricultural production to benefit farmers, retailers and consumers throughout the world.

GLOBALG.A.P. Certification covers:

- Food safety and traceability
- Environment (including biodiversity)
- Workers' health, safety and welfare
- Animal welfare
- Includes Integrated Crop Management (ICM). Integrated Pest Control (IPC), Quality Management System (QMS), and Hazard Analysis

Its standard demands, among other things, greater efficiency in production. It improves business performance and reduces waste of vital resources. It also requires a general approach to farming that builds in best practices for generations to come.

4. PROCESSING TOMATOES – INDIAN SCENARIO

Though India, the world's second-largest tomato producer, processes less than 1% of its total production, with the introduction of several ready-to-eat meals, curries and snacking products, the demand for processed tomato products has grown in India at an annual rate of about 30% (Sasidharan and Colvine, 2020.) As a result, many new and modern tomato processing facilities are being established by both the existing and new entrants into the industry. Recognizing the major constraint of tomato paste supply chain, several units are taking steps to either establish local paste production units or partnering with paste production intermediaries to enhance and sustain local supplies. The critical challenge for these processors is the availability of sufficient volumes of fresh tomatoes meeting the quality standards on a consistent basis and at a price that makes processing viable, as there is no tomato variety or hybrid available for commercial cultivation which are suitable for processing purpose.

4.1 Need for Processing Tomatoes in India

In India, due to lack of adequate processing facilities, and drastic drop in procurement prices, 40 to 50 per cent of the fresh produce is wasted every year in the glut season (rabi), when average yields in high tomato producing states like Andhra Pradesh are around 44.5 tonnes per hectare. This wastage during the glut in fresh tomato market presents an opportunity to gainfully utilise 70 to 80 per cent of the harvest in the processing industry, if it meets the quality parameters needed for processing. The current varieties/hybrids, which cover over 90% of area, are not specifically bred for processing qualities. Hence, the market price during glut will be too low (Rs 0.50 to Rs. 2 a kg) and sometimes do not even meet the cost of production. Hence, farmers are forced to sell their produce at the prevailing low price or leave them on the plant without harvesting as the prevailing market price will not even meet harvesting and transport expenses. This tricky situation can be overcome in India by the development of processing varieties / hybrids and their adoption during rabi /glut season coupled with establishment of processing industries in major tomato growing areas. Further, the development of multiple stress resistant processing tomatoes will also ensure prolonged supply of processing tomatoes to the industries which can run the processing units for considerably a longer period. This will help in effective utilization of processing units and provide year round employment opportunity. Production costs are currently estimated at between Rs 2 to 2.50 per kg on average (assuming yields of 50 tonnes/ha and operating expenses of between Rs 40,000 – Rs 45,000). Processors consulted seek tomato at or under Rs 4.50 per kg to maintain commercially viable operations (though some indicated a willingness to go beyond Rs 5 per kg, particularly during the off-season). Mandi prices typically range between Rs 6 to 10 per kg though they may skew to Rs 2 per kg in glut market conditions and Rs 40 during the off-season. The challenge is to establish a price arbitrage equilibrium that supports both the farmer and processor – this can best be achieved through improved crop yields coupled with reduced production costs by the farmer and effective as well as sustainable contract farming mechanisms offered by the processor. Processors indicate that sourcing locally had several barriers including a lack of tomato quality consistency; a lack of availability of produce in the volumes required and price volatility (Subramaniam, 2016). In view of the above facts, there is a strong need to develop high yielding

variety / F_1 hybrid suitable for processing. Adoption of such processing varieties / F_1 hybrids during rabi will help the farmers to address price crash, as processors fix assured procurement price on contract basis. The total manpower requirement for tomato cultivation is 250-300 mandays per hectare (Kanika Dhamija, 2020). An additional employment opportunity to 10-15 workers per day can be ensured by processing industry. Further, post harvest losses (12.4 %) can also be minimized by adoption of tomatoes suitable for processing & value addition.

4.2 Processing Tomatoes-Breeding Efforts by the Public Institutions

'Pusa Ruby' was one of the earliest dual purpose tomato varieties released by IARI, New Delhi. Public bred processing varieties *viz;* Punjab Chhuhara (PAU, Ludhiana) , Roma (NBPGR, New Delhi), Pusa Gaurav (IARI, New Delhi), Arka Ashish and Arka Ahuti (IIHR, Bengaluru) were cultivated on a limited area, but gradually fresh market hybrids have been adopted by farmers because of their high yield potential.

In the absence of typical processing tomatoes in India, there is ample scope to breed dual-purpose tomatoes with processing quality attributes *viz.,* high pigment genes (Ogc, hp) for deep red colour, jointless pedicel and one time fruit maturity (also referred as Concentrated Fruit Maturity or CFM) for mechanical harvesting, on plant storability of fruits, TSS and acidity values suitable for processing purpose, resistance to bacterial wilt, early blight, and begomoviruses.

During the 1980s, a systematic programme for breeding processing tomatoes was initiated at ICAR-IIHR, Bengaluru by Dr S.K. Tikoo, a well known tomato breeder who exploited processing qualities such as jointless gene and CFM. In 2019, ICAR-IIHR released two high yielding F_1 hybrids, *viz,* **Arka Apeksha and Arka Vishesh** (Figure 4 & 5) that are suitable for processing and have a yield potential of 75-80 t/ha. Both the hybrids were assessed by four processing companies , *viz,* Sunsip Foods, Karnataka; Sahyadri Food Processing, Maharashtra; Jadli Foods, Tamil Nadu; and Cremica Foods, Punjab and were found suitable for processing purpose. In addition to high yield and processing qualities both the hybrids, have jointless pedicel and are suitable for once over machine harvesting. However, there is no indigenous processing variety / F_1 hybrid with TSS more than 5.5^0 Brix. So there is a need for high yielding F_1 hybrids with 5.5^0 Brix, and 6 to 8 mmoles of titratable acidity with better viscosity.

Figure 4. Arka Apeksha

Figure 5. Arka Vishesh

Processing of tomato depends largely on the international prices, mostly governed by the supply from China. Since there is no full-fledged processing unit exclusively for tomatoes, companies start processing tomatoes only when there is a glut in the fresh market. It is therefore, necessary to take the currently available appropriate hybrids from the public and private sectors for commercial cultivation through pre-sowing contracts with the processors, growers and seed providers. It is possible to sow the available hybrids in the southern and western regions of the country during October to December, and harvest during February and March. With availability of more heat-tolerant hybrids, the sowing window can get extended up to February, ensuring a five month long harvesting schedule for processors.

Table 7. Plant habit, fruit quality and processing qualities required by tomato processors

Parameters	Parameter in the existing commercial tomatoes	Parameters desired by processors
Plant habit	Determinate / Semi-determinate	Determinate
Fruit weight	90-100 g	60-70g
Fruit shape	Oblate / Oblong/ round/Square round /Oval	Round/oval/pear
Fruit firmness	Soft/medium/Firm/ very firm	Firm
Fruit colour	Light red to deep red	Deep red
Pedicel	Jointed / Jointless	Jointless
Fruit shoulder	Uniform green/ green	Uniform green
Fruit maturity	Gradual	Concentrated fruit maturity
Vine storability	For limited period	Prolonged vine storability
TSS (degree brix)	4-4.7	5.5 or higher
Colour value	1.98-2.12	> 1.95
Acidity (%)	0.34-0.38	<0.40
Titratable acidity	5-6 mmoles	6-8 mmoles
pH	4.21-4.41	< 4.40
Texture/ firmness (kg/cm^2)	6-8	>8
Lycopene (mg/100g FW)	8-10	>12
Lycopene in tomato paste , 27-28 degree brix (mg/100g FW)	12-14	>14
Viscosity (Botswick, cms/30 sec)	10-12	12-14
Disease resistance	Resistant to ToLCD	Resistant to major diseases for the year round production
Yield (t/ha)	75-80	➢ 75-80

4.3 Processing Tomatoes- Efforts of the World Vegetable Center (WVC), Taiwan

The World Vegetable Center (WVC) is actively involved in breeding tomatoes for high yield, quality and resistance to major diseases like begomoviruses, bacterial wilt, root knot nematodes, late blight and fusarium wilt. Breeding efforts of Dr Peter Hanson, (Global Plant Breeding Lead Scientist, WVC, Taiwan) have resulted in the development of several multiple disease resistant breeding lines that have been commercially exploited by Indian tomato breeders from both public institutions and private seed sector. Two dual-purpose (fresh market and processing) lines, *viz, AVTO 1706 & AVTO 1707* (Figure 6 & 7) suitable for non-staked cultivation with required fruit quality and yield under open field conditions have been developed by the WVC. Field trials during Rabi 2019-20 in Andhra Pradesh and Karnataka showed that the production cost could be reduced by 20-30% following non-staked cultivation with no yield penalty.

Figure 6. AVTO 1706

Figure 7. AVTO 1707

4.4 Tomato Processing Units in India

Compared to the top processing countries in the world, very few tomato processing units are located in India. The processing capacity of these units (30-600 tons/ day), is less than 1% of those in the USA (59,000 tons per day) (Table 8). Unlike the tomato processing units in other countries, Indian units are seasonal processing other fruits and vegetables. At present, tomatoes are processed to produce only tomato crush, tomato paste, tomato puree and tomato ketchup.

Table 8. List of tomato processing industries in India

SN	Name of the company	Main product & processing capacity	Location	brand
1	Hindustan Unilever	(40,000 tons per year). Ketch up and sauce now most of the requirement is fulfilled by Varun Agro industries	Nashik, Maharastra	Kissan

SN	Name of the company	Main product & processing capacity	Location	brand
2	Field Fresh Foods / Del Monte	Products: ketchup and sauces	Krishnagiri, Tamil Nadu	Del Monte
3	Nestle India	Ketchup	Bicholim, Goa	Maggi
4	Global Green	Ketchup, pasta sauce, tomato blend and pizza sauce (20,000 tons per year)	Srini Food Park in Chitoor, Andhra Pradesh	Tify
5	Indira Foods	Ketchup (30 tons per day)	Bengaluru	Indira's, Splitz, 2 Minutes, Pingani
6	Cremica Group	Tomato paste and puree (700 tonnes per day)	Una, Himachal Pradesh	Cremica squeasy, Tombo
7	Dabur India	Tomato paste and puree	Siliguri (West Bengal)	Dabur Hommade
8	Capricorn Food Products	Tomato paste and puree. (100 tons per day)	Paste making in Nashik (Maharashtra) and puree production in Koyna (Maharashtra), Krishnagiri (Tamil Nadu), Chitoor (Andhra Pradesh)	Supplies paste and puree to leading processors and private labels
9	Nijjer Agro Foods	Tomato paste and puree	Amritsar (Punjab)	Supplies to Nestle, Del Monte and other processed food makers in the northern Indian region.
10	GD Foods	Tomato paste and Ketchup (42,000 ton per year)	Tarn Taran (Punjab)	Tops
11	Mother Dairy	Tomato paste and ketchup (23,000 tons per year)	Bengaluru (Karnataka)	Safal
12	Godrej Beverages and Foods	Tomato paste, puree and sauce	Mumbai (Maharashtra)	Smart Cook Tomato puree
13	GRG Foods	Ketchup & tomato-based powders and mixes	Bengaluru	Spego brand of tomato ketchup and Revathi brand of tomato-based powders and mixes for the Southern India market.

SN	Name of the company	Main product & processing capacity	Location	brand
14	Griffith Laboratories	Manufacturers of Indian paste and powder mixes	Bengaluru	Supply to food services institutional clients including hotels and restaurant chains in India and overseas.
15	Chordia Food Products	Ketchup (2.5 tons per day)	Shirwal close to Pune (Maharashtra) and Chennai and Dharwad (Karnataka)	Navin, Toofan
16	Sun-Sip Foods	Tomato crush, puree, paste and ketchup (600 tons per day (Kolar))	Sunsip Agro Processors, Kolar Karnataka & Madanapalle, Chittor Dist, AP.	Sun SIP Tomato Crush
17	Sahyadri Farms	Tomato puree and ketchup (55 000 tons per year)	Factory : Dindori, Nashik	Sahyadri Farms Tomato Ketchup

India imported nearly 72% (21835 metric tonnes) of finished products (canned Tomato, sauce & paste) from China followed by USA, Spain, Italy and Chile. The total value was estimated to be 20.64 million US dollars during 2019 (Sasidharan and Colvine, 2020). The large imports can be cut down by processing locally produced tomatoes through establishment of processing industries in major tomato growing areas in the country. It also creates considerable employment opportunity in the country

5. RECOMMENDATIONS

- There is a need to develop high-yielding multiple disease and pest resistant dual-purpose or processing tomato varieties and F_1 hybrids with Concentrated Fruit Maturity (CFM) and jointless pedicel suitable for machine harvesting (MH). Emphasis should be on enhancement of productivity, lycopene and brix suitable for processing tomato using modern tools and technologies.
- Breeding processable tomato varieties suitable for polyhouse cultivation, particularly during off season (summer and kharif) is another area that needs to be addressed on priority.
- Employing CRISPR/Cas-9 based approaches to tweak some crucial genes that determine plant architecture and processing qualities may help in development of the desired cultivars in a shorter time frame. One such example is editing of GABA gene in tomato variety, Sicilian Rouge by Sanatech Seed company, Japan.
- There is an urgent need for the Indian tomato processing sector to look at value-added products, including those for the pharmaceutical and nutraceutical use to minimize losses

in the tomato industry. The sector should also look at the potential of other products like sun dried tomatoes, use of peel and seed - a by product from processing, and many such innovative uses based on a market analysis to identify the type of products best suited to replace fresh consumption.

- Priority should be given to securing tomato supply for processors at a fixed price through contract growing with the help of professional organizations, which are trusted both by the farmers and processors. For this, some government support may be provided. International collaborations should be encouraged for capacity building and collaborative research.
- Incentives for the development of indigenous and innovative processing technologies and establishment of processing industries in major tomato growing regions are recommended to facilitate tomato growers and processors. One district and one product module can be adopted. Incentives for mechanized harvesting, subsidizing transportation costs and support to small-scale processing industries in marketing the processed products through public distribution system are needed

REFERENCES

Annual Report World Processing Tomato Council (WPTC). Available at: http://www.tomatonews.com.

FAOSTAT: http://faostat3.fao.org/home/E). Accessed on 14th September, 2020.

Government of India. 2016. Horticultural Statistics at a Glance 2018. Horticulture Statistics Division, Department of Agriculture, Cooperation & Farmers; Welfare, Ministry of Agriculture & Farmers' Welfare, New Delhi.

Kanika Dhamija, 2020. Decoding the economics of growing tomatoes for amazing profit. KJ Krishi Jagran (Updated on 11th August, 2020)

Subramanian R. 2016. India processing tomato segment: Current status, trends and opportunities for engagement. World Vegetable Center, Taiwan.

Sasidharan S. and S. Colvine, 2020. India: The sleeping tiger? - Part 1_2_1213 http://www.tomatonews.com (published on 14th December, 2020).

Sasidharan S. and S. Colvine, 2020. India: The sleeping tiger? - Part 2 http://www.tomatonews.com (published on 21st December, 2020)

LIST OF PARTICIPANTS

1. Dr Trilochan Mohapatra, President NAAS, New Delhi
2. Dr D.P. Rey, Former Vice-Chancellor, OUA & T, Bhubaneswar, Odisha
3. Dr A.K. Singh, Secretary, NAAS, New Delhi
4. Dr A.T. Sadashiva, FNAAS, Director (R & D), Nethra Crop Sciences Pvt. Ltd., Bengaluru (Convener)
5. Dr Peter Hanson, Global Plant Breeding Lead Scientist, World Vegetable Center (WVC), Taiwan
6. Dr Ramakrishna Nair, Regional Director, South & Central Asia, WVC, Hyderabad
7. Dr Mans Lanting, ETC consultants India Pvt. Ltd., London
8. Mrs Sophie Colvine, General Secretary, World Processing Tomato Council (WPTC), France
9. Dr B.N.S. Murthy, Horticulture Commissioner, GoI, New Delhi
10. Dr M.R. Dinesh, Director, ICAR-IIHR, Bengaluru
11. Dr Surinder K Tikoo, Co Founder & Director, Tierra Seed Sciences Pvt. Ltd., Hyderabad
12. Dr Harinder Singh Oberoi, Head, PHT, ICAR-IIHR, Bengaluru
13. Dr H.C. Prasanna, PS, Division of Vegetable Crops, ICAR-IIHR, Bengaluru
14. Dr K. Madhavi Reddy, PS & I/C Division of Vegetable Crops, ICAR-IIHR, Bengaluru
15. Dr Zakir Hussain, PS, Dept of Vegetable Science, ICAR-IARI, New Delhi
16. Dr Y. S. Reddy, PS, Crop Improvement, ICAR-IIVR, Varanasi
17. Mrs Shruti Sasidharan, Consultant, Tomato News SAS, France
18. Dr B.K. Tripathi, Orbi seeds pvt. Ltd., Bengaluru
19. Dr Sanjay Dwivedi, Orbi seeds pvt. Ltd., Bengaluru
20. Dr Prasanna, Head Breeding, Bayers, Bengaluru
21. Dr B.C. Narasimha Prasad, Head of Biotechnology, Nuziveedu Seeds, Hyderabad
22. Mr M.V. Balaram, Lead Breeder, Nunhems India Pvt. Ltd., Bengaluru
23. Mr Nateshan, Tomato Breeder, Namdhari Seeds, Bengaluru
24. Dr Sandhikar, CEO, United Genetics, Bengaluru
25. Dr Arun Talwar, GM, Cremica Foods, Ludhiana
26. Mr Vilas Shinde, MD, Sahyadri Farms, Nashik
27. Mr Sathish Kumar, Deputy Chief of Bureau, Hindu News paper, Bengaluru
28. Dr Senthil Kumar, Senior Scientist, ICAR-IIHR, Bengaluru

Note: The designations and affiliations of the participants are as on date of BSS

65.	Climate Resilient Agriculture in India	2014
66.	Role of Millets in Nutritional Security of India	2014
67.	Urban and Peri-urban Agriculture	2014
68.	Efficient Utilization of Phosphorus	2014
69.	Carbon Economy in Indian Agriculture	2014
70.	MOOC for Capacity Building in Indian Agriculture: Opportunities and Challenges	2014
71.	Role of Root Endophytes in Agricultural Productivity	2014
72.	Bioinformatics in Agriculture: Way Forward	2014
73.	Monitoring and Evaluation of Agricultural Research, Education and Extension for Development (AREE4D)	2014
74.	Biodrainage: An Eco-friendly Tool for Combating Waterlogging	2015
75.	Linking Farmers with Markets for Inclusive Growth in Indian Agriculture	2015
76.	Bio-fuels to Power Indian Agriculture	2015
77.	Aquaculture Certification in India: Criteria and Implementation Plan	2015
78.	Reservoir Fisheries Development in India: Management and Policy Options	2016
79.	Integration of Medicinal and Aromatic Crop Cultivation and value Chain Management for Small Farmers	2016
80.	Augmenting forage Resources in Rural India: Policy Issues and Strategies	2016
81.	Climate Resilient Livestock Production	2016
82.	Breeding Policy for Cattle and Buffalo in India	2016
83.	Issues and Challenges in Shifting Cultivation and its Relevance in the Present Context	2016
84.	Practical and Affordable Approaches for Precision in Farm Equipment and Machinery	2016
85.	Hydroponic Fodder Production in India	2017
86.	Mismatch between Policies and Development Priorities in Agriculture	2017
87.	Abiotic Stress Management with Focus on Drought, Food and Hailstorm	2017
88.	Mitigation Land Degradation due to Water Erosion	2017
89.	Vertical Farming	2019
90.	Zero Budget Natural Farming – Myth or Reality	2019
91.	Loan Waiving versus Income Support Schemes: Challenges and Way Forward	2019
92.	Tropical Wilt Race-4 Affecting Banana Cultivation	2019
93.	Enhancing Science Culture in Agricultural Research Institutions	2020
94.	Payment for Ecosystem Services in Agriculture	2020
95.	Food-borne Zoonotic Diseases	2020
96.	Livestock Improvement through Artificial Insemination	2020
97.	Potential of Non-Bovine Milk	2021
98.	Agriculture and Food Policy for the Five Trillion Dollar Economy	2021
99.	New Agricultural Policy for Reshaping India	2021
100.	Strategies for Enhancing Soil Organic Carbon for Food Security and Climate Action	2021
101.	Big Data Analytics in Agriculture	2021
102.	WTO and Indian Agriculture: Concern and Possible Solutions	2022
103.	Antimicrobial Resistance	2022
104.	One World, One Health	2022
105.	Sugarcane-based Ethanol Production for Sustainable Fuel Ethanol Blending Programme	2022
106.	Utilization of Wastewaters in Urban and Peri-urban Agriculture	2022
107.	Certification of Quality Planting Material of Clonally Propagated Fruit Crops for Promoting Agricultural Diversification	2022
108.	Agri-startups in India: Opportunities, Challenges and Way Forward	2022

Status /Strategy Papers

1.	Role of Social Scientists in National Agricultural Research System (NARS)	2015
2.	Towards Pulses Self-sufficiency in India	2016
3.	Strategy for Transformation of Indian Agriculture for Improving Farmers Welfare	2016
4.	Sustaining Soybean Productivity and Production in India	2017
5.	Strengthening Agricultural Extension Research and Education – The Way Forward	2017
6.	Strategy on Utilization of Glauconite Mineral as Source of Potassium	2017
7.	Vegetable Oil Economy and Production Problems in India	2017
8.	Conservation Policies for Hilsa and Mahseer	2018
9.	Accelerating Seed Delivery Systems for Priming Indian Farm Productivity Enhancement: A Strategic View Point	2018
10.	Renewable Energy: A New Paradism for Growth in Agriculture	2018
11.	Rumen Microbiome an Amelloration of Methane Production	2019
12.	Harnessing Full Potential of A1 and A2 Milk in India: An Update	2019
13.	Development and Adoption of Novel Fertilizer Materials	2019
14.	Innovations in Potato Seed Production	2021
15.	Potential of Transgenic Poultry for Biopharming	2022

Policy Briefs

1.	To Accelerate Utilization of GE Technology for Food and Nutrition Security and Improving Farmers' Income	2016
2.	Innovative Viable Solution to Rice Residue Burning in Rice-Wheat Cropping System through Concurrent Use of Super Straw Management System-fitted Combines and Turbo Happy Seeder	2017
3.	Soil Health: New Policy Initiative for Farmers Welfare	2018
4.	Uniform Policy for Fish Disease Diagnosis and Quarantine	2019
5.	Saving the Harvest: Reducing the Food Loss and Waste	2019
6.	Better Management of Pesticides in India : Policy Perspective	2019
7.	Regulatory Framework for Genome Edited Plants: Accelerating the Pace and Precision of Plant Breeding	2020
8.	Covid-19 Pandemic: Impact and New Normal in Agriculture	2020
9.	Direct Benefit Transfer of Fertilizer Subsidy: Policy Perspective	2020
10.	Harmonization of Seed Regulations for Sustainable Food Security of India	2020
11.	Towards Revision of Biological Diversity Act 2002	2021

NAAS DOCUMENTS ON POLICY ISSUES

1	Agricultural Scientists' Perceptions on National Water Policy	1995
2	Fertilizer Policy Issues (2000-2025)	1997
3	Harnessing and Management of Water Resources for Enhancing Agricultural Production in the Eastern Region	1998
4	Conservation, Management and use of Agrobiodiversity	1998
5	Sustainable Agricultural Export	1999
6	Reorienting Land Grant System of Agricultural Education in India	1999
7	Diversification of Agriculture for Human Nutrition	2001
8	Sustainable Fisheries and Aquaculture for Nutritional Security	2001
9	Strategies for Agricultural Research in the North-East	2001
10	Globalization of Agriculture: R & D in India	2001
11	Empowerment of Women in Agriculture	2001
12	Sanitary and Phytosanitary Agreement of the World Trade Organization–Advantage India	2001
13	Hi-Tech Horticulture in India	2001
14	Conservation and Management of Genetic Resources of Livestock	2001
15	Prioritization of Agricultural Research	2001
16	Agriculture-Industry Interface: Value Added Farm Products	2002
17	Scientists' Views on Good Governance of An Agricultural Research Organization	2002
18	Agricultural Policy: Redesigning R & D to Achieve It's Objectives	2002
19	Intellectual Property Rights in Agriculture	2003
20	Dichotomy Between Grain Surplus and Widespread Endemic Hunger	2003
21	Priorities of Research and Human Resource Development in Fisheries Biotechnology	2003
22	Seaweed Cultivation and Utilization	2003
23	Export Potential of Dairy Products	2003
24	Biosafety of Transgenic Rice	2003
25	Stakeholders' Perceptions On Employment Oriented Agricultural Education	2004
26	Peri-Urban Vegetable Cultivation in the NCR Delhi	2004
27	Disaster Management in Agriculture	2004
28	Impact of Inter River Basin Linkages on Fisheries	2004
29	Transgenic Crops and Biosafety Issues Related to Their Commercialization In India	2004
30	Organic Farming: Approaches and Possibilities in the Context of Indian Agriculture	2005
31	Redefining Agricultural Education and Extension System in Changed Scenario	2005
32	Emerging Issues in Water Management – The Question of Ownership	2005
33	Policy Options for Efficient Nitrogen Use	2005
34	Guidelines for Improving the Quality of Indian Journals & Professional Societies in Agriculture and Allied Sciences	2006
35	Low and Declining Crop Response to Fertilizers	2006
36	Belowground Biodiversity in Relation to Cropping Systems	2006
37	Employment Opportunities in Farm and Non-Farm Sectors Through Technological Interventions with Emphasis on Primary Value Addition	2006
38	WTO and Indian Agriculture: Implications for Policy and R&D	2006
39.	Innovations in Rural Institutions: Driver for Agricultural Prosperity	2007
40.	High Value Agriculture in India: Prospects and Policies	2008
41.	Sustainable Energy for Rural India	2008
42.	Crop Response and Nutrient Ratio	2009
43.	Antibiotics in Manure and Soil – A Grave Threat to Human and Animal Health	2010
44.	Plant Quarantine including Internal Quarantine Strategies in View of Onslaught of Diseases and Insect Pests	2010
45.	Agrichemicals Management: Issues and Strategies	2010
46.	Veterinary Vaccines and Diagnostics	2010
47.	Protected Agriculture in North-West Himalayas	2010
48.	Exploring Untapped Potential of Acid Soils of India	2010
49.	Agricultural Waste Management	2010
50.	Drought Preparedness and Mitigation	2011
51.	Carrying Capacity of Indian Agriculture	2011
52.	Biosafety Assurance for GM Food Crops in India	2011
53.	Ecolabelling and Certification in Capture Fisheries and Aquaculture	2012
54.	Integration of Millets in Fortified Foods	2012
55.	Fighting Child Malnutrition	2012
56.	Sustaining Agricultural Productivity through Integrated Soil Management	2012
57.	Value Added Fertilizers and Site Specific Nutrient Management (SSNM)	2012
58.	Management of Crop Residues in the Context of Conservation Agriculture	2012
59.	Livestock Infertility and its Management	2013
60.	Water Use Potential of Flood-Affected and Drought-prone Areas of Eastern India	2013
61.	Mastitis Management in Dairy Animals	2013
62.	Biopesticides – Quality Assurance	2014
63.	Nanotechnology in Agriculture: Scope and Current Relevance	2014
64.	Improving Productivity of Rice Fallows	2014

For detail visit web site: http://naas.org.in

Continued on inside cover