

Green Innovation Centre in the
Agri-Food Sector (GIAE) - India



INDIA PROCESSING TOMATO SEGMENT

CURRENT STATUS, TRENDS AND OPPORTUNITIES FOR ENGAGEMENT

PREPARED BY THE WORLD VEGETABLE CENTER FOR DEUTSCHE
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EXECUTIVE SUMMARY

Tomatoes are an important crop for both the farmer and the consumer in India. With 11% share of global production, India produces more tomatoes than any other country, except China. Despite this, less than 1% of India's tomato production is processed, way below the average of 26% for the world's top 10 tomato producing countries.

Tomato-based processed food consumption in India is growing at an annual rate of over 30% creating massive demand for existing processors like Hindustan Unilever and Nestle, ushering in the entry of new market players like Kagome and creating new prospects for product imports. Many of these processors are pursuing efforts to build up improved supply chain mechanisms to increase the share of locally-processed paste and other inputs for production in the wake of a stiff 30% customs duty now levied on imports. Specialized paste, pulp and juice processors like Capricorn Foods, Nijjar Agro Foods and Varun Agro are also raising production capacities by expanding their farmer cluster base and working with farmers to improve supply throughput by adopting better production practices. Seed companies like United Genetics India are working on producing a range of specialized seed inputs suited for the Indian processing tomato market

Much of India's tomatoes are grown by a large number of smallholder farmers (estimated at near to half of India's farming community) with holdings of between 1-3 acres of land. The southern and central states constitute much of India's production including the states of Andhra Pradesh, Telangana, Karnataka and Maharashtra. Farmers typically sell to a local aggregator or to a trader in a regional *mandi*. The processing industry however seeks the agglomeration of a large number of farmers in closely-knit clusters to enable both a sustained supply of larger volumes of tomato to the processing unit and the maintenance of tomato product quality. Current production methods adopted are focused on reducing crop risk through an excessive use of pesticides which, along with low yields, contributes towards increasing the price point at which farmers can sell to processors.

June 2016 figures from the World Processing Tomato Council (WPTC) indicate a likely 8% drop in global production in processing tomato amongst major producers due to adverse climate conditions as well as other macro-economic factors. This suggests a possible reduction in the availability of processed raw material like tomato paste as well as an upward trend in prices which will impact Indian processors that depend on imported inputs for some or all of their requirements.

A series of measures to enhance the production of processing tomato in India and improved coordination across the value chain can assist in increasing supply access to processors and enhance production viability as well as creating more consistent returns to tomato growers. These strategies would include the availability of improved cultivars suitable for production more consistent with processing parameters, reduction in the cost of production, enabling sustainable tomato production through the two main seasons to maximize the use of processing capacity and facilitating more farmer clusters producing processing tomatoes thus raising aggregate production volumes and enabling the application of production practices that can have a wider impact on cost or production and quality including the possible use of mechanized harvesting.

The importance of cooperation between tomato growers and processors to plan and organize production and adopt technologies and methods that enhance the value chain for all stakeholders is critical to achieving sustained change that can benefit all. In view of its engagement with supply chain aspects in key producing states, the German Government-supported "Green Innovation Centre in the Agri-Food Sector" program is uniquely placed in facilitating progress towards understanding and addressing key production constraints that inhibit the expansion of the processing tomato market.

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INTRODUCTION

BACKGROUND

Tomatoes are amongst the most widely grown crop in India. The largest production centers are in southern and central India – principally the states of Andhra Pradesh, Telangana, Karnataka, Madhya Pradesh and Maharashtra. Tomatoes are produced and processed during the two main seasons across much of India – August to October (*kharif*) and December to April (*rabi*). Where conditions suit, tomatoes are also grown during the off-season (May to July) including under protected cultivation though given the low volumes of production, prices are often the highest during this period.

India is the world's second largest tomato producer but processes less than 1% of its production. This impacts farmers by way of high postharvest losses and low returns during periods of market glut. Indian tomato-based product manufacturers import significant quantities of tomato pulp and paste at high prices which also entails an import duty of 30%. Existing Indian paste and pulp makers are unable to operate their units at optimum capacities due to a lack of fresh tomato at the required volumes at the right price. Further, the types of tomatoes currently grown in India are generally less suitable for processing due to their low quality parameters for paste and pulp production. The overall result of these constraints is a loss of value to all stakeholders involved with tomato production and processing and its wider impact on local and regional economic development.

On the other hand, the demand in India for processed tomato products has been growing at an annual rate of about 30% over the past 3 years. Further, the range of processed tomato foods is also expanding with the introduction and demand for several ready-to-eat meals, curries and snack products finding favor with the Indian consumer. As a result, new tomato processing facilities are being established by both existing and new entrants into the industry. Recognizing the tomato and paste supply chain constraints, several are taking steps to either establish local paste production themselves or partner 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 processing quality standards on a consistent basis and at a price point which makes processing viable.

The German Government's "Green Innovation Centre in the Agri-Food Sector" (GIAE) which focusses on improving the India tomato value chain with a focus on two states, Maharashtra and Karnataka provides a platform to examine, test and scale-up value-chain improvements to particularly address supply chain constraints which could benefit both farmers and processors.

SCOPE OF THE STUDY

This study seeks to assess current status and trends in tomato production and processing in India with a focus on the states of Maharashtra and Karnataka, an examination of issues hindering enrichment and expansion of the tomato processing value chain and to highlight areas which could be considered for further examination and possible engagement under GIAE. The pilot areas of Kadur in Karnataka and Narayangaon in Maharashtra identified for this project are tomato production centers with potential for expansion and are close to major tomato processing centers in the region. This study limits its focus on the production and supply chain aspects related to the processed tomato value chain.

No significant studies, reports or validated data are currently available which have examined the Indian processed tomato market and supply chain constraints. As such, this study is a preliminary investigation of this sub-sector and aims to capture broad market trends and issues raised through consultations with

industry representatives. Further investigations may thus be required over a longer time-frame to examine these aspects more thoroughly in a more comprehensive study.

METHODOLOGY

Little published literature exists on the processing tomato segment in India. Thus, much of the data has been gathered through interviews with tomato processing companies and value-added product manufacturers during the period April to June 2016. Much of the information was gathered through visits to processors located in Bengaluru, Delhi, Gurgaon, Hyderabad and Ludhiana as well as through telephone interviews where face-to-face meetings were not possible. A list of processors and individuals contacted is listed at the end of this report. Processors showed immense interest in the conduct of the study and while they were reticent regarding sharing data that might be commercial-in-confidence all were keen to contribute towards this study and keen to access its findings.

Published resources of the World Processing Tomato Council (WPTC) have been drawn upon to assess global trends in relation to developments in the Indian tomato processing market.

Key industry representatives contacted included Bangalore-based processors like Global Green Company and GRG Fine Foods, Hindustan Unilever and Nashik-based paste maker Varun Agro, as well as leading tomato product makers like the Cremica Group and FieldFresh Foods (Del Monte). In addition, we consulted with United Genetics India, a leading producer of tomato hybrid seed products including specialized seeds for the processing tomato segment. Expert advice was sought from specialists at the Indian Institute of Horticulture Research (IIHR) and independent consultants. The team also conducted discussions with civil society agency, APMAS on developments with respect to tomato production and the processing sector in Andhra Pradesh. Dr. Peter Hanson, the World Vegetable Center's tomato breeder has also contributed to this study.

This study complements another study undertaken on the tomato seedling industry in the focal areas identified for the GIAE. The seedlings and nursery management study assesses the capacity and potential of the local seedling small-businesses in supporting the expansion of tomato production and the introduction of improved planting materials in Maharashtra and Karnataka which would have a direct impact on prospects for the processing tomato sector.

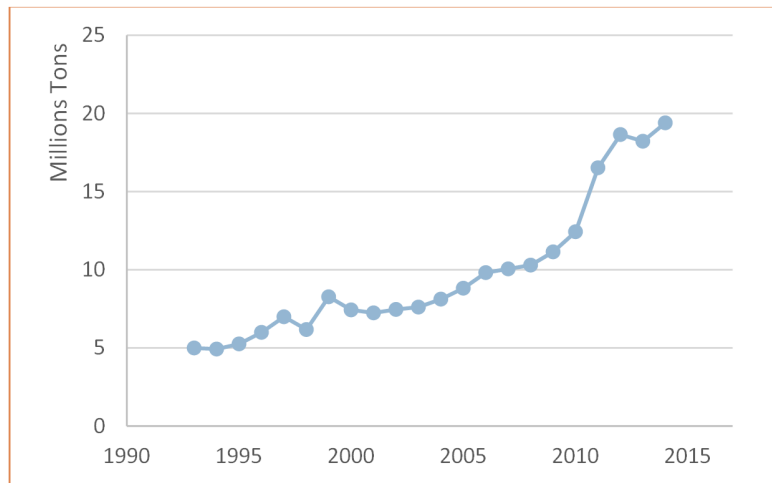
THE INDIAN CONTEXT

TOMATO PRODUCTION

Tomato (*Solanum lycopersicum*) is one of the important crops used as a fresh vegetable as well as in a variety of processed products such as ketchup, sauce, juice, puree, pasta sauce, salsa, tomato-based powders, sun-dried tomatoes, curries and ready-to-eat products. On a global scale, more than 163 million tonnes (MT) of tomatoes were produced in 2014, or about 15% of total global vegetable production. In 2012, tomato production had a net value of US\$59 billion, the eighth most valuable agricultural product worldwide¹. Global fresh tomatoes exports totaled US\$8.4 billion in 2015.

Global tomato production has increased by nearly 40% since 2002. FAO statistics show that the increase has been distributed evenly across the top 10 producing countries. While China is the leading producer with a share of 31%, India has consistently produced more tomatoes than third-ranked USA since 2008 with global share of 11% of production. Thus, tomatoes are an important crop for both the farmer and the consumer in India. Amongst vegetable crops, tomato ranks third in priority after potato and onion in India as reflected in the tonnage produced. With an estimated production of 19.4 MT, India ranks second behind China in tomato production as well as in the area planted to the crop. Trends in tomato production in India (Figure 1) show a strong expansion of production since 2010 largely due to an expansion in the area under cultivation in view of increasing market demand and a differential higher rate of return for farmers as compared with other crops.

FIGURE 1: TRENDS IN INDIA'S TOMATO PRODUCTION



Source: FAOSTAT 2016

¹ FAOSTAT

However, while India’s market share in tomato production has increased, a consistent challenge has been the consistently low crop yields of India’s tomato farmers. Productivity levels of Indian tomato farmers are the lowest amongst the world’s 10 largest tomato producers as reflected in Figure 2 below. This is despite a considerable increase in production and the area under tomato cultivation (Figure 3). These low yields can be attributed to a number of factors. Much of India’s tomato production comes from smallholder farmers who do not undertake intensive crop cultivation and do not practice good agricultural practices. The economies of scale through producing tomatoes in large-sized land-holdings, use of intensive cultivation and improved production practices that other producing countries have adopted have yet to be widely adopted in India.

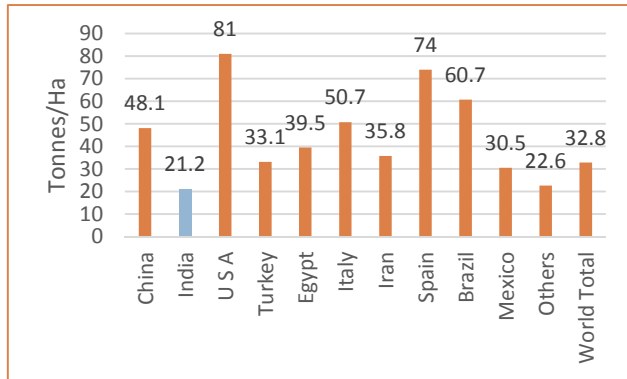


FIGURE 2: AVERAGE YIELDS OF TOP 10 PRODUCERS

India’s leading tomato producing states are Andhra Pradesh, Karnataka, Madhya Pradesh and Telangana as indicated in Table 1 below. Andhra Pradesh produces 18% of India’s tomatoes while Karnataka and Maharashtra’s share of national tomato output is 11% and 6.4% respectively. Also, tomato productivity levels in Karnataka, Madhya Pradesh, Gujarat and Maharashtra are significantly better than the national average.

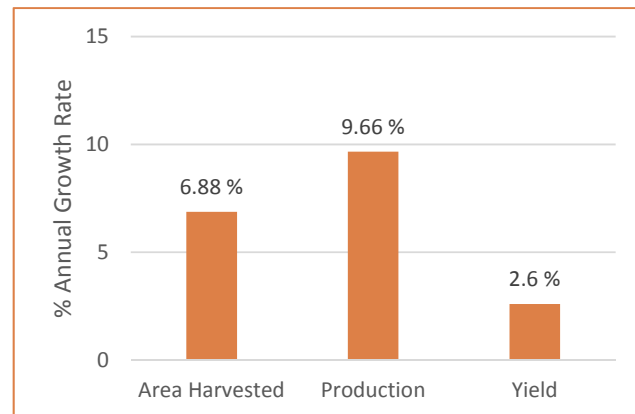


FIGURE 3: INDIAN TOMATOES - GROWTH IN COVERAGE, PRODUCTION AND YIELD

TABLE 1: KEY TOMATO PRODUCING STATES IN INDIA - 2014

States	Area Under Cultivation (000 Ha)	Production ('000 T)	Yield Tonnes/Ha
ANDHRA PRADESH	168	3,355	20
KARNATAKA	61	2,068	33.9
MADHYA PRADESH	66	1,937	29.5
TELANGANA	74	1,484	20
ODISHA	97	1,386	14.3
GUJARAT	45	1,259	28.2
MAHARASHTRA	50	1,200	24
INDIA TOTAL	882	19,402	21.2

Source: NHB Database 2014

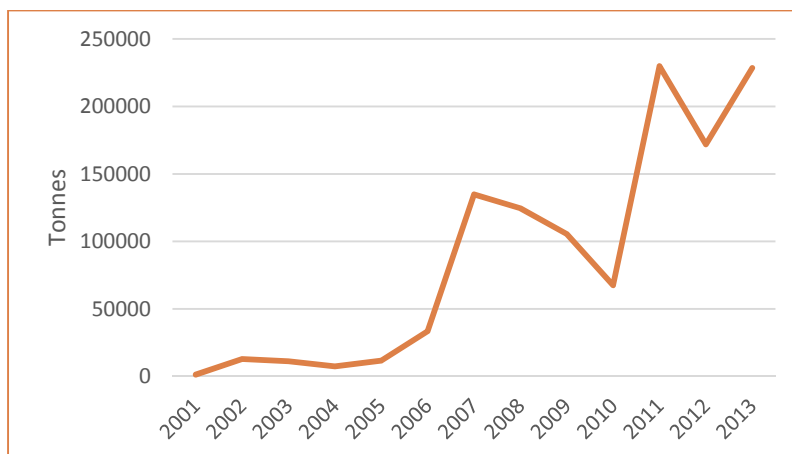
A list of the top tomato producing districts in India are listed in Table 2 below. The majority of these districts lie in Andhra Pradesh and Telangana states with Kurnool and Chittoor districts in the Madanapalle production belt producing the most tomatoes.

TABLE 2: TOP 10 TOMATO GROWING DISTRICTS IN INDIA - 2013

	District	State	Production (Tonnes)
1	Kurnool	Andhra Pradesh	599,040
2	Kolar	Karnataka	547,753
3	Chittoor	Andhra Pradesh	491,760
4	Medak	Telangana	455,740
5	Rangareddy	Telangana	370,800
6	Shadol	Madhya Pradesh	315,000
7	Nalgonda	Telangana	314,400
8	Anantapur	Andhra Pradesh	293,800
9	Mahbubnaga	Telangana	292,840
10	Nasik	Maharashtra	296,311

Over 1% of India’s fresh tomatoes also are exported to markets in the Middle East and the South Asian region. According to the FAO, the volume of fresh tomato exports have annually increased by more than 25% over the past three years with a 38% increase in value during 2014 as compared with the previous year (Figure 4). In 2015, India’s global tomato exports were valued at US\$67 million; small in comparison to the global trade in fresh tomatoes at US\$8.4 billion (or 0.8% of world share).²

FIGURE 4: INDIAN TOMATOES EXPORT TRENDS

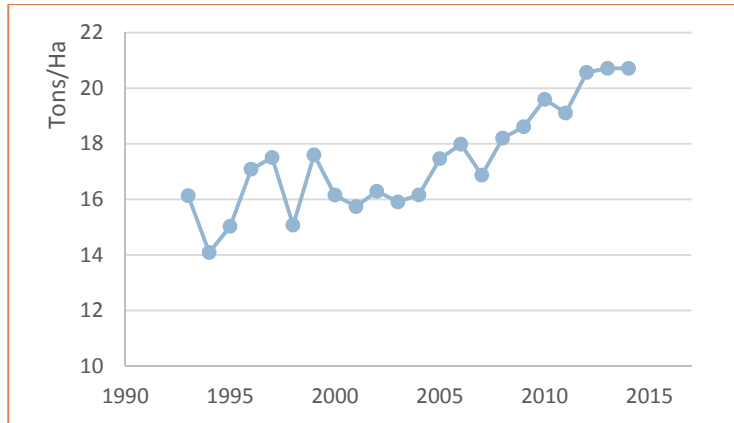


India grows tomatoes through millions of smallholdings across the country who lack access to inputs like quality seeds and fertilizer, and technical expertise. They use cultivation methods that have been consistently suboptimal resulting in fields that produce only moderate harvests. As a result, farm yields over the past two decades have shown no significant gains (Figure 5), the exception being some states

² “World’s Top Exports”: June 2016

like Karnataka, Madhya Pradesh, and Gujarat where more intensive tomato cultivation has been undertaken in recent years.

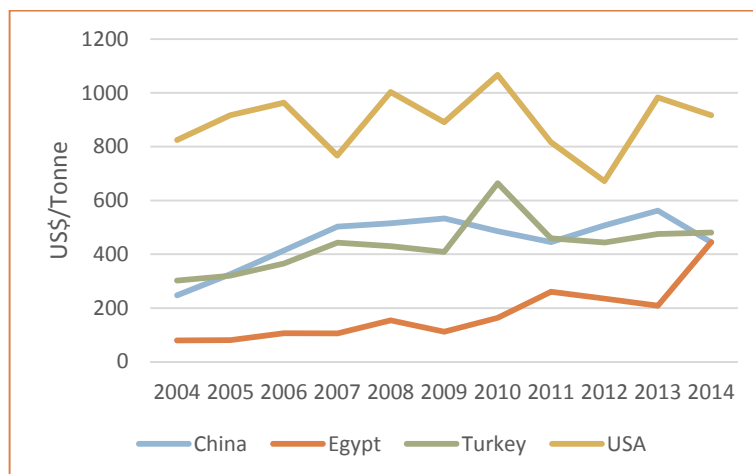
FIGURE 5: TOMATO FARM YIELD LEVELS IN INDIA



Source: FAOSTAT 2016

Figure 6 shows trends in the average annual tomato wholesale prices of the top tomato producing countries. While relevant data for India is not available it is useful to note that the average wholesale price in India for 2013-14 was about US\$310 per tonne (US\$145/tonne in 2001), well below prices in other major producing markets. Though this is attractive to customers and processors, low prices are a dis-incentive for farmers to produce more, particularly in the context of the consistently low yields achieved by Indian tomato farmers.

FIGURE 6: AVERAGE ANNUAL PRICES OF TOP TOMATO PRODUCING COUNTRIES



Source: FAOSTAT 2016

TOMATO PRODUCTION IN KARNATAKA

A summary of tomato production in Karnataka state is provided in Table 3 below. Karnataka is the second largest tomato producing state after Andhra Pradesh and accounts for 11.4% of total production. The State produced 2.07 MT of tomatoes from a cultivated area of about 61,000 ha. Karnataka's tomato productivity average is estimated at 34 tonnes/ha, the highest achieved amongst leading Indian tomato producing states. Kolar district produces some 28% of total state tomato production while Belgaum, Haveri and Mandya districts each have a share of between 8-10%. Irrigation remains a critical bottleneck for growers in several districts. Access to markets has also encouraged growers to cluster around the central and southern districts.

TABLE 3: DISTRICT-WISE TOMATO PRODUCTION IN KARNATAKA - 2013

District	Prod (Tonnes)	District	Prod (Tonnes)
Kolar	547,753	Gulbarga	28,774
Belgaum	192,430	Bellary	28,021
Haveri	184,413	Chitradurga	27,451
Mandya	174,771	Ramanagara	26,851
Tumkur	107,200	Bijapura	24,880
Chamarajanagara	91,680	Bagalkot	21,647
Chikkaballapura	71,507	Raichur	17,480
Davangere	68,966	Bangalore (Urban)	15,061
Hassan	67,410	Yadagiri	14,322
Koppal	62,834	Dharwad	12,003
Bangalore (Rural)	57,795	Gadag	5,997
Mysore	53,554	Shimoga	3,470
Chikmagalore	42,027	Kodagu	263
Bidar	36,153	U. Kannada	112

Source: National Horticulture Database 2014

TOMATO PRODUCTION IN MAHARASHTRA

A summary of tomato production across districts in Maharashtra state is provided in Table 4 below. Maharashtra contributes about 6% to the total production of tomato in the country with about 1.2 MT and a productivity of 24 tonnes/ha. Nasik produces some 35% of all tomatoes in the state while Pune, Beed, Solapur and Satara districts contribute between 7-10% each towards the state's total tomato output. About half of all tomatoes produced in the state get traded in the organized markets and in 2013-14 fetched an average price of Rs 13.42/kg (Price in 2012-13 was Rs 7.31 per kg)

TABLE 4: DISTRICT-WISE TOMATO PRODUCTION IN MAHARASHTRA - 2013

District	Prod (Tonnes)	District	Prod (Tonnes)
Nasik	296,311	Parbhani	9,652
Pune	87,799	Chandrapur	7,992
Beed	77,760	Buldhana	7,339
Solapur	73,410	Osmanabad	5,720
Satara	61,230	Jalna	5,000
Sangli	54,200	Washim	4,960
Nagpur	24,678	Gondia	4,719
Latur	22,345	Raigad	4,680
Aurangabad	17,960	Nandurbar	4,418
Thane	14,640	Yeotmal	4,080
Dhule	13,032	Jalgaon	3,945
Bhandara	12,012	Akola	2,308
Nanded	11,550	Gadchiloli	700
Wardha	10,600	Amravati	142

Source: National Horticulture Database 2014

TOMATO PRODUCTION IN ANDHRA PRADESH

A summary of tomato production across districts in Andhra Pradesh state as in 2013 is provided in Table 5 below. Andhra Pradesh produces 18% of tomatoes in the country with production of 3.4 MT from an area of 170,000 ha and a productivity of 20 tonnes/ha. Three of the four southern districts of Rayalseema (Anantapur, Chittoor and Kurnool) in addition to Guntur are the state's largest producers of tomato.

TABLE 5: DISTRICT-WISE TOMATO PRODUCTION IN ANDHRA PRADESH - 2013

District	Prod (Tonnes)	District	Prod (Tonnes)
Kurnool	599,040	West Godavari	166,680
Chittoor	491,760	Vizianagaram	119,580
Anantpur	293,800	Srikakulam	117,820
Kadapa	275,540	Visakhapatnam	55,000
Guntur	218,560	Prakasham	51,200
Krishna	203,140	East Godavari	50,340

Source: National Horticulture Database 2014

TOMATO VARIETIES POPULAR IN PROJECT STATES

A summary of tomato varieties commonly grown in the project areas of the states of Maharashtra and Karnataka is provided in Table 6 below with a summary of key characteristics of these varieties. This data was collected through interviews with tomato farmers and nursery owners in Kadur and Narayangaon.

TABLE 6: COMMERCIAL TOMATO HYBRID VARIETIES POPULAR WITH FARMERS IN KARNATAKA AND MAHARASHTRA

Seed Company	Variety	Fruit Characteristics
JK Seeds	811	Determinate. Oval shaped fruit, firm with thick skin suitable for distant transportation. Deep red color after ripening. Weight 90-100 gms. First harvesting starts 68-70 days after transplanting. Highly tolerant to TLCV. Best suited for summer season of Central & South India.
J K Seeds	Akshay	Determinate. Oval-square shaped fruit, firm with thick skin suitable for distant transportation. Deep red color after ripening. Weight 85-95 gms. First harvesting starts 65-68 days after transplanting. Tolerant to TLCV.
Nunhems	Lakshmi	Large determinate plants. Maturity of 55-60 days after transplanting. Flat round firm fruits of 80- 90 gms with sour taste. Good heat set and resistance to TLCV.
Raasi Seeds	Raina	Semi determinate plants with good foliage cover. First harvest 60-65 days after transplanting. Fruit is rectangular square oval red with 2-3 locules. Weight 90-100 gms. Fruits are firm and good for transportation. Intermediate resistance for BW and TLCV.
Seminis	Ayushman	Determinate. Fruit is square round and deep red. Weight 95 to 100 gms.
Syngenta	1057	Determinate, bushy, medium foliage cover. Fruit are firm, square oval, medium size. Weight 80-100 gms. Fruit harvesting starts 55-60 days after transplanting. Ripe fruits are uniform red and glossy. Farmers in Maharashtra encountered serious tospovirus attack with this variety during 2016.
Syngenta	2048 Meghdoot	Determinate. New rainy season variety. Vigorous with profuse branching. Fruit - firm, square, medium size. Weight 70-90 gms. Fruit harvesting starts 55-60 days after transplanting. Ripe fruits are red and glossy.
Syngenta	Abhinav	Semi-determinate. Plant with vigorous plant habit. Broad leaves with good foliage cover. Firm fruit with good keeping quality. Square shape and medium size; weight of 80 -100gms. Fruit harvesting starts 60-65 days after transplanting. Uniform fruit ripening with ripe fruits deep red & glossy.
US Agriseeds	US440	Determinate, 60-65 day maturity, Fruit size 80 – 100 gms, Shape is flat round with good firmness. TLCV and heat tolerant and high shelf life.
US Agriseeds	US3140	Determinate, 60-65 day maturity, Fruit size 80 – 100 gms, Shape is flat round. TLCV and heat tolerant.

In Narayangoan in Maharashtra, tomato seedling production is dominated by Syngenta’s Abhinav and 1057, while in Kadur in Karnataka JK Seed’s 811 and Syngenta’s 1057 were the top sellers. None of these varieties are optimal for processing use.

TOMATO PROCESSING INDUSTRY

According to the World Processing Tomato Council (WPTC), an estimated 41.37 million tonnes (MT) of tomato worldwide were processed into value-added products in 2015. This is about 26% of global production of fresh tomato. By comparison, less than 1% of India's tomato production currently gets processed into such products.

Globally, 33% of all tomato processing is undertaken in the US, mostly in California. An estimated 130,000 tonnes of tomato were processed in India in 2015, which is 0.3% of the global tomato processing market. Table 7 below provides a list of top tomato processing countries.

TABLE 7: TOP 10 PROCESSING TOMATO COUNTRIES 2015

Rank	Processing Country	Quantity ('000 tonnes)	% of Total
1	USA, including California	13,375	33%
2	China	5,600	14%
3	Italy	5,393	13%
4	Spain	3,028	7%
5	Turkey	2,700	7%
6	Portugal	1,660	4%
7	Iran	1,350	3%
8	Brazil	1,300	3%
9	Tunisia	935	2%
10	Ukraine	550	1%
	India	130	0.30%
	Total	41,374	

PROCESSED PRODUCTS AND PROCESS

For the industrial market, tomato paste is an important product because it is used as the base for a wide range of other products. A wide range of value-added products are produced from tomatoes including tomato juice, paste, diced/peeled tomatoes, strained tomato pulp, ketchup, pasta, pickles and pizza sauces, salsa, gravies, ready-to-eat (RTE) curries and tomato-based powder products. Processed tomato products have wide applications in the household, food processing industry, snacks foods, hotels, restaurants and fast food retail chains.

The process involves washing and grading tomatoes and then boiling them in steam jacked kettles before pulping in a continuous pulper where skin and seeds are separated from the pulp. The filtered extracted pulp is the basic material from which other products are made. The recovery of pulp varies from 40% to 50% depending upon the quality of tomatoes. To make juice, fresh tomatoes are crushed directly instead of boiling them prior to processing in stainless steel kettles.

THE INDIAN PROCESSED TOMATO MARKET AND TOMATO SUPPLY CHAIN

India's demand for processed tomato products is expanding at an estimated 30% annually driven by massive consumer demand for established products like pasta sauce and ketchup as well as new ready-to-eat products, gravies and bulk supplies to food retail chains including fast-food restaurants, hotel chains. There is also a significant increase in exports of processed tomato-based food products fueled in part by a burgeoning Indian diaspora. The Indian market is also witnessing strong product diversification with expansion into curry gravies, ready-to-eat curries and dry powder mixes in addition to traditional products like ketchup, puree, juice and dried tomato.

A recent survey by Assocham (the Associated Chambers of Commerce of India) conducted in leading Indian cities indicates that the demand for tomato puree and ketchup has surged by 40% in just the month of June 2016 due to surging fresh tomato prices and a trend towards easier-to-cook meals. Retail price of tomatoes shot up to Rs 80-100 during the month in several metros due to tight supply from several southern states where the late off-season (May to July) harvest crop was damaged at the flowering stage by serious drought conditions.

India's annual ketchup consumption is estimated at 13,000 tonnes with a market valuation of Rs 1.8 billion (US\$ 28 million). Nestle's Maggi dominates the ketchup market with a 37% market share followed by Unilever's Kissan (29%) and Heinz (10%).

Tomato paste production appears to be commercially viable when processing facilities are based in and around key Indian tomato growing areas. The typical financial model for a 4,500 TPA (tonnes per annum) paste unit involving a capital cost of Rs 5 to 6 million (US\$800,000), projects an IRR (Internal Rate of Return) of about 42% based on an operations window of 150 days in a year (presuming raw material availability for 4 months only).

Though the market for processed tomato products is expanding, the processing industry is often confronted with the problem of limited supply of processing tomatoes. Quality parameters for processing include color, total soluble solids, sugar content and firmness for which existing Indian tomato varieties currently available in India are considered unsuitable. The most popular market type for the fresh market is acidic, and highly suitable for curries and other common dishes. Processors are required to neutralize this acidity with increased dosage of sugar resulting in higher production costs. Despite the high potential for growing tomatoes, low yields increase the cost and the risk of growing tomatoes resulting in depressed farmer incomes.

Key challenges for developing tomato varieties suitable for processing comprise; a) disease susceptibility, especially Tomato yellow leaf curl diseases caused by whitefly-transmitted begomoviruses; thrips-transmitted tospoviruses, bacterial wilt, and fungal diseases such as early and late blight; b) low fruit set mainly due to high temperatures and c) unmarketable fruit yields due to poor color development, softness, blossom end rot, cracking and other defects. Tomato varieties of compact plant habit, concentrated fruit set, and the jointless pedicel (fruit are easily detached from the plant) facilitate rapid hand harvesting or even mechanical fruit harvesting that lowers labor costs. Available processing varieties thus require significant breeding initiatives to enable them to adapt to local conditions.

Tomato quality depends on many factors such as cultivar, growing conditions and ripening on and off the vine. The physical and chemical characteristics of tomato also affect the quality of processed product. To facilitate farmer involvement in growing tomatoes for processing, high yield coupled with good processing qualities need to be combined in the varieties available to the farmer.

The desirable qualities for a processing tomato cultivar include high total soluble solids (5-6 Brix), acidity not less than 0.4%, pH less than 4.5, uniform red color with a/b color value of at least 2, smooth surface,

free from wrinkles, small core, firm flesh and uniform ripening. Other physical characteristics sought by processors are fruit weight be at least 50 g, to be spotless and disease free.

Processors seek reliable and consistent sourcing of tomatoes meeting quality standards at an acceptable price and in the volumes desired to enable optimum capacity utilization. Volatility in production levels and variations in harvest timing contribute to dramatic price swings and provide a challenge for processors to maintain sustained plant operations.

Indian tomato value-added manufacturers have found it difficult to procure the requisite volumes of paste concentrate and pulp from local suppliers. Paste producers are in turn unable to procure fresh tomatoes from farmers meeting the quality standards and in quantities that enable optimum plant utilization. As a result, most paste makers have diversified their operations, processing tomatoes during the peak seasons covering (December to April and August to October) and mango pulp or other fruits during the lean season (April to July). Thus, many paste and pulp producers in Karnataka, Maharashtra and Andhra Pradesh produce tomato paste during the two key seasons (December to April and August to October) when prices are relatively low and yields are high and operate their units to manufacture mango pulp during the period April to July, thus maintaining year-round operations.

Tomato price fluctuations can also severely impact procurement and processing. The All-India Coordinated Research Project on Postharvest Technology estimated total average postharvest losses of 13% for tomato though losses could be higher across the value chain. In Andhra Pradesh a large number of smaller tomato processing plants are reported to have suspended operations due to the unviability of processing in view of fluctuations in tomato prices and supply bottlenecks.

Despite the high differential prices, tomato processed product manufacturers depend on importing significant large quantities of tomato paste from California, China, Italy and Spain. A 30% customs duty levied on import of tomato paste, pulp and juice concentrate in 2014 has moved value-added producers to either develop their own local supply chains for paste processing or to contract supplies from local paste makers. Cremica, the Jalandhar-based ketchup and pasta maker blends imported and locally-procured paste to achieve an optimum quality-price mix that ensures processing viability without compromising on product quality.

Tomato processing specifications are laid out in the Indian Fruit Products Order, 1955 according to which compliance requires are as follows: a) Tomato Juice (5% total solids); b) Tomato Puree (9% total solids and Sodium Benzoate 250 ppm); Tomato Ketchup (25% total solids. Acidity: 1.0% Sodium Benzoate: 750 ppm).

LEADING INDIAN TOMATO PASTE MAKERS AND PRODUCT MANUFACTURERS

Hindustan Unilever: HUL's Kissan brand is India's second-most popular ketchup brand with a market share of 25%. HUL was one of the first processing firms to institutionalize farm-gate sourcing of tomatoes from smallholder farmers in Nasik district in 2011. Kissan partnered with smallholder farmers, a local tomato paste processor named Varun Agro and agri-input supply companies to establish a supply chain aimed at producing tomato paste locally that could be used as an input into its ketchup production process. Unilever sourced 40,000 tonnes of tomato from India in 2011, some 60% of its requirement for ketchup production. Working with growers it sought to mainstream sustainable agriculture practices including improving soil fertility, water management, and pest control. Further details can be found in Case Study 2.

Field Fresh Foods/Del Monte: India's third largest processed tomato products maker, Field Fresh manufactures ketchup, pasta and pizza sauce under the Del Monte brand at its factory in Krishnagiri

District, Tamil Nadu. It has established a 120 ha R&D farm at Ladhawal, near Ludhiana where it is undertaking tomato production trials including specialized cultivars for the processing industry and the application of mechanization for tomato cultivation and harvesting.

Nestle India: Nestle is India's leading ketchup maker with a market share of 37% through its Maggi brand. Nestle also produces tomato soup mixes competing against Knorr and other leading brands. Nestlé India collaborates with suppliers to source raw materials locally under its Supplier Development Program though it also uses its global supply chain to import raw material for ketchup production in India.

Global Green: This Bangalore-based processor and exporter commenced large scale contract farming of hybrid tomatoes in 2012 to meet the growing demand for tomato paste and tomato paste based sauces in India. It has promoted the use of processing hybrid varieties from United Genetics USA like UG-37, UG-157, UG-52, amongst farmers which have a high lycopene content. It established farmer groups and small cooperatives to enable production volumes for its processing needs and to improve quality compliance through a cluster-based approach. Global Green sources tomatoes over the two peak seasons annually from farmers in the Madanapalle area in Andhra Pradesh as well as from Kolar and adjoining areas of Karnataka which are processed at the facilities of Srinivasa Food Park in Chittoor, Andhra Pradesh. Global Green processes over 20,000 tonnes of fresh tomato each year. Using paste produced at the Srinivasa Food Park, it produces value-added tomato based products under the *Tify* brand including ketchup, pasta sauce, tomato blend and pizza sauce.

Indira Foods: Established in 2008, Indira Foods produces tomato ketchup for the retail and institutional segments with a focus on the southern Indian market. With capacity to process 30 tonnes/day it has a 70% market share of sales to hotels, restaurants and airlines in Karnataka but also supplies to Global Green and Namdhari Group. The company procures tomatoes from Kolar district in Karnataka.

Cremita Group: produces tomato ketchup, puree, pasta sauce, dips and Indian gravies at its production facilities in Ludhiana (Punjab) and NOIDA, near Delhi. Apart from its retail products, the company supplies to food chains like McDonald's, Barista, Café Coffee Day, Pizza Hut, Domino's and Papa John's as well as to institutional partners and private labels like Big Bazaar, Spencer's, Taj Group, ITC, Jet Airways and Air India.

Dabur India: Is a leading producer of tomato puree, tomato juice, soups and chutneys under its Homemade retail brand and for the institutional market. Tomato processing operations commenced in 2011 at its processing plant in Siliguri (West Bengal) while juices are produced at its factory in Nepal.

Capricorn Food Products: Capricorn is one of India's largest independent tomato paste makers supplying paste and puree to leading processors and private labels including Hindustan Unilever, Nestle and FieldFresh. It has processing facilities for paste making in Nashik (Maharashtra) and puree production in Koyana (Maharashtra), Krishnagiri (Tamil Nadu), Chittoor (Andhra Pradesh). In 2013, Capricorn established a plant in Nashik, Maharashtra with the capacity to produce 100 MT of tomato paste every day. During the tomato offseason (particularly during April to July), Capricorn's paste making units' process mango pulp to maintain round-the-year operations.

Nijjer Agro Foods: An Amritsar-based tomato paste manufacturer which supplies to Nestle, Del Monte and other processed food makers in the northern Indian region.

GD Foods: Produces both tomato paste and processed products like ketchup under its Tops brand at its plant operations in Tarn Taran (Punjab). It currently operates plant facilities producing 42,000 tonnes per annum and supplements tomato processing with chili and apple products. For tomatoes, it undertakes contract farming over 400 ha with farmers in Punjab.

Mother Dairy: The company produces tomato paste and its Safal brand of tomato ketchup at its 23,000 tonnes per annum pulp and concentrate unit near Bengaluru in Karnataka. Mother Dairy partnered with Bayer CropScience to improve tomato production amongst farmers in Chickballapur and Tumkur districts of Karnataka for its processing needs. Bayer CropScience identified tomato varieties suitable for processing and scientifically raised seedlings of the shortlisted varieties. These were then provided to some 361 farmers for further cultivation on 280 hectares under its supervision and improved crop production practices including crop protection techniques were applied as well as the internalization of traceability processes. As a result, tomato yields of farmers are reported to have increased from 35 tonnes/ha to 45 tonnes/ha. The company also announced in February 2016 plans to develop a new puree production and processing unit in Ranchi in Eastern India. Mother Dairy also sells frozen tomatoes in the Delhi-National Capital Region which it processes at its facility in West Delhi.

Godrej Beverages and Foods: Godrej targets the home cooking segment with its Smart Cook tomato puree range of products.

GRG Foods: Bangalore-based food products company manufactures its Spego brand of tomato ketchup and Revathi brand of tomato-based powders and mixes for the Southern India market.

National Agriculture Co-operative Marketing Federation: NAFED operates a tomato paste and ketchup production facility in Vellore (Tamil Nadu).

ITC Group: ITC produces a range of ready-to-eat (RTE) products for the Indian and export market under its Kitchens of India brand. This includes curry pastes, sauces and chutneys which include tomato as an important ingredient.

Griffith Laboratories: Griffith is a US-based specialized condiments producer which manufactures Indian paste and powder mixes at its Bengaluru facility for food services institutional clients including hotels and restaurant chains in India and overseas.

Chordia Food Products: Chordia produces tomato ketchup, paste and mixes at its factories in Shirwal close to Pune (Maharashtra) and Chennai and Dharwad (Karnataka) for both the domestic retail market and supplies to institutional clients. With an installed capacity of 2.5 tonnes per day it previously supplied tomato paste to Nestle but now consumes most of its processed paste.

An assessment of processing capacities and operations amongst leading tomato processors in India shows some interesting trends. Most paste processors supply to a number of value-added product makers though some ketchup and snack manufacturers have annual processing contracts with maste makers. Processers use between 10-20% of their annual processing capacities for tomato paste production while the remainder is used for processing other vegetables and fruit, particularly mango pulp. Andhra Pradesh remains the leading center for processors, possibly due to the availability of large volumes of fresh produce including tomatoes, mangoes and other raw material supplies. Maharashtra, Karnataka, Tamil Nadu and Punjab are other key processing centers. Srini Food Park and Jain Foods in Andhra Pradesh, Devaraja Foods and Capricorn Foods in Tamil Nadu and Varun Foods in Maharashtra have amongst the largest production processing capacities. Key processors made significant increase in processing capacities during 2013-14, however utilization for processing tomatoes remains stagnant due to raw material availability and price constraints.

CURRENT TRENDS

New market entrants in India are seeking to develop integrated value chains to meet their processing priorities. Japanese paste maker, Kagome has acquired a majority stake in Tasty Bites, a sauce and snack

maker giving it considerable access to the India market. Kagome's earlier attempt to establish an Indian joint-venture to produce processed tomato products appears not to be progressing. However, the company is likely to pursue efforts to build up a base for processed tomato in India. As part of this effort, Kagome has acquired a stake in the hybrid seed company United Genetics India (UniGen India). This company is developing a range of tomato seed products for the Indian market including a specialized range of processing tomatoes (more details are provided in Case Study 3).

June 2016 figures from the World Processing Tomato Council (WPTC) indicate a likely 8% drop in production in processing tomato amongst major producers globally due to adverse climate conditions. This suggests a possible reduction in the availability of processed raw material like tomato paste as well as an upward trend in prices. This will likely also impact Indian processors who are partly or largely dependent on imported paste, pulp and juice as raw material input into their production processes.

Some major trends are clearly evident amongst large-scale tomato processors operating in India. One, an increasing emphasis on procuring and using paste and pulp sourced from domestic sources, either through a) the establishment of in-house paste production units; b) managing the supply chain management for raw material but hiring processing facilities based on seasonal needs as pursued by Global Green; and, c) sourcing paste from intermediaries through long-term supply contracts or spot purchases. Second, paste/pulp producers as well as value-added product processors are more vigorously developing networks with farmer groups and clusters and incentivizing the adoption of contract farming. There is an increased recognition that value enhancement along the supply chain can make the subsequent manufacturing process both more sustainable and commercially viable. Product manufacturers indicate a willingness to source paste from wherever it is available in India. For example, producers like Cremica and FieldFresh with production facilities in north India procure paste from Krishnagiri and Chittoor tomato paste firms when required.

Mega food parks like the India Food Park in Tumkur (Karnataka), the Srimi Food Park and the proposed Agripalli Food Park in Andhra Pradesh provide facilities for establishing regional processing facilities near to raw material production centers. Food parks provide access to common facilities for pulping and processing for limited periods – preferred by firms which may require short-term processing capacities without the need to invest in new production facilities. Further, pulping tomatoes often requires raw material storage facilities because pulping is seasonal and storage enables excess procurement during high supply periods or at low price points allowing deferred processing thus optimizing capacity utilization.

The network of collection centers, pack-houses and logistic facilities enhances reach and supply chain efficiency while maintaining quality. Thus integrated food processing facilities facilitate effective backward and forward linkages, storage and reduce waste caused mainly due to inadequate facilities or improper handling. To farmers in its catchment area it provides a much-needed alternative platform to sell their produce and facilitates the prospect for success of contract farming arrangements.

ISSUES RELATING TO TOMATO SUPPLY CHAIN

Inputs

- A key constraint to production is the lack of improved cultivars particularly those suited for processing. Tomato varieties in India have been bred mainly for the fresh market. The introduction of high-yielding varieties including open pollinated varieties suitable for processing is required to address this. The increased risk of pests such as leaf miners, whiteflies, fruitworm and the emerging *Tuta absoluta* threat; viral, fungal and bacterial diseases including tospoviruses, tomato yellow leaf curl disease; bacterial wilt, early blight/late blight, need to be addressed

through building resistance into seeds as well as through adoption of improved (Integrated Pest Management) IPM practices. India needs "tropical" processing tomato cultivars resistant to tomato yellow leaf curl diseases, bacterial wilt, early blight, be high yielding with good fruit quality. Processing plant characteristics should include a determinate plant habit, compact vine, uniform ripening and jointless pedicel for mechanical harvesting or to facilitate faster manual picking.

- Farmers also complain of poor quality seeds or seedlings with higher disease risk usually due to spurious seeds or unlicensed nurseries. A companion study conducted on seedling production in the project's pilot areas indicates significant opportunity to improve the quality of seedlings provided to farmers including reducing the risk of early viral infections by improving the skills and operations of nurseries producing tomato seedlings.

Production Practices

- Reductions in the cost of production would be necessary if more farmers are to profitably and sustainably produce tomatoes particularly for the processing industry. IPM interventions will reduce pesticide use (an estimated 15% of operations costs based on anecdotal data provided by tomato farmers) while the use of mulch and drip irrigation and fertigation can help reduce input and labor costs. Further field investigations on the cost: benefits of staking or trellising for processed tomato production may also offer additional cost reductions.
- High temperatures during April and May have affected tomato production adversely in key growing belts of Maharashtra. With temperatures exceeding 40°C, high flower and leaf drop has been experienced during this period. Severe drought in several areas of Maharashtra has also affected production in the region and highlights the need for effective use of water management techniques to address a serious risk for tomato farmers. Irrigated tomato production in dry areas/seasons allows for effective water management that can optimize fruit solids content and avoid losses from over-watering or under watering.
- Farmers experience serious problems in securing farm labor during the planting and harvest periods creating serious crop risk particularly given the multiple and frequent pickings required over a 2 to 3-month period. In addition, the high labor costs reduce margins for farmers and are a dis-incentive for farmers who may wish to get into tomato production.
- Most farmers have little exposure or training on good agricultural practices and typically adopt production methods that they see their peer farmers practicing in their neighborhood. Thus, many farmers implement improper crop management decisions particularly with respect to crop disease risk and management. The lack of horticulture extension services or the inability of the government extension system to respond effectively to farmers with advice and support is another factor contributing to poor crop production practices.
- The emergence of new virus challenges and the inability of older tomato cultivars to resist new disease strains is causing the majority of farmers to frequently spray their crop with pesticides and in increasingly higher dosages. This unscientific approach to combating crop risk, often without the evidence of symptoms also adds significantly to the cost of production.
- Tomato yields are extremely low through a combination of factors – small field-size, inferior inputs including seed quality and poor production practices.
- Lycopene is the main carotenoid in tomato fruit producing red color and its content is a critical quality parameter for the processing tomato industry. Lycopene synthesis is temperature sensitive, favored by average temperatures of 16-21 °C and inhibited above temperatures of 30 °C

(Zhang et al., 2008)³. However, Indian agro-climatic zones where tomatoes are generally grown are unlikely to suit these conditions. Day temperatures in the growing season in most of Karnataka and Maharashtra are usually in the 30-35° C range though summer temperatures are significantly higher. Varieties need to be developed that suit Indian heat stress conditions.

Market Access and Market Price

- Tomato farmers sell their produce usually through a local aggregator or via a trader at the local or regional *mandi*. Farmers realize an estimated 30-50% of total value through the supply chain with the remainder being distributed amongst a multiplicity of traders and commission agents. This low margin on total value makes production unviable during the glut periods when tomato prices can fall to between Rs 0.50 to Rs 2 a kg.
- Few farmers are organized into production clusters through formal or informal structures like registered organizations or Farmer Producer Organizations (FPOs) reducing their access to contract farming options as well as their bargaining capacity with processors. Four FPOs are believed to have been approved but there is little evidence that these have become operational. Case Study 1 provides some insight on the rationale for contract farming and strategies to support the interests of both producer and processor.
- Farmers and middlemen have a preference to sell to urban markets rather than to sell to processors. As a result, several paste makers have indicated a slippage of 10-20% in production which farmers seek to sell on the open market when market rates are more attractive than the contracted rates.
- 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.
- There is also a significant interstate trade in tomato driven largely by availability (varying harvest seasons and particularly off-season production), price variations and quality considerations. *Mandis* and traders play a primary role in moving produce around through extensive trading networks. This, in part helps create price equilibrium across regional markets but could also cause local shortfalls, a particular issue for the small processors who depend on local markets to secure raw tomato.

Issues for Processors

- 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.

³ Zhang, T., J. Shi, Y. Wang and S.J. Xue. 2008. Cultivar and agricultural management on lycopene and vitamin C contents in tomato fruits. Pp. 27-45. In: V.R. Preedy and R.R. Watson, eds.) Tomatoes and Tomato Products. Science Publishers, Enfield NH, USA.

- Most tomato varieties currently used by farmers for crop cultivation are unsuitable for the processing industry. Most tomatoes produced in India are acidic and the fruit have large locules and thin walls which are less suited for processing. Thus, more fruit is required to produce tomato paste; anecdotal evidence provided by local processors suggests that compared to global standards, twice as much tomato by weight may be required per unit of paste produced which also impacts on the procurement price offered to farmers.
- Product perishability is a significant quality factor for processors. Tomatoes are highly perishable and transportation and storage can result in physical losses of as high as 25-30%, and these also compromise processed paste quality.
- Additionally, processors seek consistent supplies of fresh tomatoes and a planned production scheduling synchronized with plant process requirements. Processors would need to negotiate staggered planting dates with farmers within clusters to ensure steady tomato supplies delivered to the factory at the right time. Tomatoes require cold storage systems to maintain them for longer periods than a few days and few processors seek to maintain a stockpile of tomatoes for subsequent processing requirements. The challenge for processors is that the contract price offered may not match farmer expectations for round-the-year supplies particularly given that off-season tomatoes fetch a huge premium in the table tomato segment. A constant supply of cheap tomatoes over the year is unrealistic as off-season tomato prices would be very high and not affordable by processors.

A summary of tomato production issues encountered in the project areas (Kadur/Chikamagalur and Narayangaon) and suggested responses are summarized in Table 9 below.

TABLE 8: TOMATO PRODUCTION ISSUES AND POSSIBLE RESPONSES

Problem	Consequences	Area	Possible Interventions
Over-production/ Gluts	Low prices	CH NG	<ul style="list-style-type: none"> • Processing • Crop diversification • Off-season production
Pests, diseases, abiotic stresses	<ul style="list-style-type: none"> ↑ Pesticides Use ↑ Production costs ↑ Risks 	CH NG	<ul style="list-style-type: none"> • Resistant cultivars • IPM, grafting • Protected (net) cultivation
Poor water management	Water shortage; Low water tables	CH	<ul style="list-style-type: none"> • Drip irrigation • Plastic mulches
Labor shortages	Labor expensive, unavailable	CH NG	<ul style="list-style-type: none"> • Long shelf life cultivars (fewer harvests) • Mechanization / Labor-saving technologies
Lack of technical information and diagnostics	Improper crop management decisions	CH NG	<ul style="list-style-type: none"> • Training and technical advice to public and private extension staff • Linkages with local agencies for sustained diagnostic and technical support

FINDINGS

A summary of key findings resulting from this study is provided below.

- India is the second largest producer of tomatoes with a 11% global share but processes less than 1% of its produce compared to 26% in other major producing countries, and this results in a loss of value to the farmer, consumer and the economy.
- An annual growth rate of over 12% in India's tomato production over the past 5 years indicates strong interest amongst farmers to grow tomato as a major commercial crop.
- The yields of Indian tomato producers are the lowest amongst major tomato producing countries, signaling inefficiencies in production, depressed farmer incomes and loss of value in the supply-side value chain.
- Andhra Pradesh, which produces more tomatoes than any other state with an 18% share also is one of the main hubs for tomato paste and pulp production in India.
- Key tomato growing districts in Karnataka are principally Kolar (28%) and Belgaum, Haveri and Mandya districts which each have a share of between 8-10%. In Maharashtra, production is largely centered around Nasik which generates some 35% of all tomato produced in the state.
- Wholesale prices of tomato in India are the lowest amongst key tomato producing countries, a disincentive for farmers to produce more, particularly given the low yields achieved by Indian tomato farmers.
- Of the estimated 41 million tonnes of tomato processed globally in 2015, only 130,000 tonnes were processed in India which comprises 0.3% of the global tomato processing market. As the world's second largest tomato producer India could potentially process much more of the crop.
- India's domestic demand for processed tomato products is expanding at an estimated 30% annually.
- Responding to this development, the Indian processing and processed tomato industry is in a state of dynamic change – with existing players increasing production capacities and expanding product lines as well as the entry of new processors.
- The imposition of a 30% customs duty tariff on imported tomato paste and other tomato value-added products has pushed processors to take steps towards sourcing locally.
- Several processors have reduced the use of imported paste through limited local sourcing as well as through blending imported and locally-produced paste to achieve the necessary input parameters.
- There are several barriers to sourcing locally including a lack of consistent quality, a lack of available produce and price volatility. Traditional fresh market tomato cultivars are unsuitable for processing as they do not meet the processing quality parameters of color, total soluble solids and sugar content as well as fruit firmness. Expanding supplies of seed of processing tomato varieties that suit Indian agro-climatic conditions is a necessary first step to raising local production. India needs "tropical" processing tomato cultivars resistant to key pest and viral risks that are high yielding and demonstrate good fruit quality. Indian seed companies have had little incentive to develop dual purpose cultivars, however this may change if demand from processors increases.
- The use of unsuited tomato varieties for processing has serious financial implications for processors as they have to use more fresh tomato per unit of paste produced. This impacts on processing production costs and lowers the procurement price offered by processors to farmers.
- Farmers indicate increasing problems in securing labor for cultivation and harvesting and the prevailing high cost of labor reducing their margins.

- The large number of fragmented small-holdings causes practical challenges for paste producers in securing the volumes required for processing.
- The current high cost of producing tomatoes in project areas is a disincentive for farmers to take up commercial cultivation for the processing industry. Key costs are pesticide use (sprays three times a week; Rs 20,000 per ha) due to disease risk. Staking also adds a capital cost of Rs 50,000 per ha. Techniques to reduce production costs are available and will have a positive impact on crop economics and incentives to grow the crop.
- Tomato cultivation appears commercially viable for farmers across both project areas except during the glut period. They also indicate that disease risk is one of their biggest fears that could impact on production and crop viability.
- A combination of improved crop yields and reduced cost of production can significantly increase the attractiveness of tomato cultivation by Indian farmers to support the processing tomato sector.
- Processors seek supplies of fresh tomatoes through much of the year and across all three seasons, provided the price point is right. Tomato, once a summer harvested crop, can now be grown across the year over three crop cycles across most states, due to advancements in seed science and breeding techniques.
- Processors are putting in place strategies to source locally through in-house supply chains or through processing contracts with intermediaries. This creates real opportunity to develop a strong supply chain backbone with farmers. To achieve this, farmers will first need to be convinced through the implementation of a successful demonstration model of a processing tomato supply chain that reflects better and sustainable returns for the farmer as well as the processor.
- Potential improvements in production practices as well as the use of processing tomato cultivars on the one hand and enhanced contract farming initiatives by processors can produce a feasible price equilibrium for long-term engagement between producers and processor to expand the processed tomato value chain.

RECOMMENDATIONS

- **Geographical Coverage:** Any initiative aimed at improving the tomato value chain with the intent of supporting the processed tomato sector could consider including Andhra Pradesh amongst the areas covered given the prospect of making a significant impact.
- **Varietal Development and Trials:** Seed companies need to be encouraged and facilitated to develop locally adapted varieties that meet the quality requirements of the processing industry in India. Dual purpose varieties could incorporate critical characteristics required for Indian tropical conditions including multiple disease resistance, heat tolerance, firm deep red fruit suitable for processing, and plant traits such as jointless pedicel and compact plant habit. These specialized processing tomato cultivars should also demonstrate improved yields in various agro-climatic conditions, supported by production methods suited for processing tomato cultivation. Varietal development also needs to address resistance to critical viral diseases and heat tolerance without adversely impacting on fruit quality characteristics. The project may facilitate the conduct of trials of suitable varieties or lines in farmer fields under controlled conditions in partnership with interested seed companies which offer such specialized seeds suited to Indian conditions.
- **Crop Production:** Improved yields and reduced product costs are achievable by using good agricultural practices, reducing pesticide application and the use of IPM practices amongst other strategies. Demonstration farms need to be established in key project clusters to showcase these techniques as success stories and to promote a network of champion farmers who could promote these approaches to their peers.
- **Field Pilots:** Amongst the processors interviewed, several showed interest in participating in a collaborative program to both demonstrate and deliver supply chain production improvements with farmers. Pilot areas could be identified within captive procurement clusters of a select number of interested processors to implement improvements. This could include development of innovative procurement terms and mechanisms that incentivize farmers and processors to collaborate for a common and sustainable outcome.
- **Production Clusters:** The promotion of farming clusters in the form of FPOs etc., in key growing areas linked through contract farming with the processing tomato industry supply chain would greatly support the expansion of the domestic tomato processing sector. To enhance on-site value-addition and attractiveness of this proposition to the farming community the prospect of intermediate paste production at the aggregation point could be examined. This could possibly be under joint-ownership of both farmers and processor but under the processor's supervision for quality and operational compliance.
- **Mechanization:** The project should seek to collaborate with processors keen on supply chain improvements to test the technical and financial feasibility of mechanizing production suited to smallholder farmers; particularly mechanical harvesting. Both UniGen India and FieldFresh could be potential partners in such trials. Its application for a large number of small farmers operating in clusters would be an appropriate case study to demonstrate true economies of scale and where labor shortages and high labor costs are constraints. This would be best done where new cultivars with good processing qualities are being trialed as they also need to demonstrate attributes suited to mechanization such as synchronous fruiting and jointless pedicels to allow fruit to be easily detached from the plant.

CASE STUDIES

CASE STUDY 1: CONTRACT FARMING FOR THE PROCESSING INDUSTRY

Contract farming in fruits and vegetables is being led by cooperatives, farmer groups, and private firms, both multinational and domestic. Punjab has been a pioneering state in introducing contract farming, with the entry of PepsiCo in tomato processing in 1989. This was followed by an Amritsar-based processor, Nijjer Agro Foods Limited in 1991. The Bharti Group's FieldFresh has also incorporated contract farming under its supply chain linkages for products like gherkins and tomatoes. Amongst other firms interviewed, Hindustan Unilever, Global Green, Nestle, Cremica and Mother Dairy have also adopted contract farming with a range of variations based on market, resource and management provisions.

Contractual agreements can be of three basic types a) contracts under which only sale and purchase conditions are specified; b) contracts under which a corporate firm supplies the farmer with agricultural inputs and the final produce is bought at a contracted price, and; c) arrangements where a corporate firm invests all capital and technical know-how in the field and the farmer provides land and labor. In the first two models, the pattern of risk sharing depends on the contract provisions and farmers may have to bear the risk of production or price shocks. In the third model all risks remain with the firm and farmers neither bear any risk nor is party to any profits.⁴

Past experiences reveal that in the advent of price volatility either farmers have refused to sell the produce to processors/retailers (when market price exceeded contracted price) or the latter have not procured produce (when the contracted price exceeded the market price). Also, in case of crop failure, farmers may have to bear the loss without any support from processors/retailers. There are also cases when poor quality produced by farmers has resulted in firms' refusal to procure produce. These issues need to be addressed in balanced, transparent, quasi-legal provisions in order to protect the interests of both growers and buyers.

The nature of contracting has been instrumental in removing grower risk through buyback guarantees and provisions for coping against production failure. FieldFresh links with farmers through production contracts and by encouraging state-of-the-art cultivation and handling practices. A 120-hectare model farm near Ludhiana in Punjab has facilities to promote modern farming practices and provides demonstration sessions to farmers, as well as advanced packhouse facilities. The contract also offered farmers extension services and seed, the cost of which was adjusted in the final transaction. Further, balanced contracts that benefit both parties in terms of assured markets, competitive price and guarantee against risk raise the potential for success in contract farming.

It will likely to be important for contract farming to move beyond a limited buyer-seller relationship and to gradually bring in the elements of backward linkage. This could be instrumental in providing the farmers much more than assured markets and fair prices, but also support in the form of risk mitigation, access to information on cultivation, postharvest technology, and markets, and access to credit and other inputs.

⁴ Toward Contract Farming in a Changing Agri-food System - Ashok Gulati, Kavery Ganguly, and Maurice R. Landes

CASE STUDY 2: HINDUSTAN UNILEVER – SOURCING LOCALLY FOR ITS PROCESSING NEEDS

Hindustan Unilever (HUL's) Kissan brand is India's second-most popular ketchup brand with a market share of 29%. It was one of the first processing firms to institutionalize farm-gate sourcing of sustainable tomatoes from smallholder farmers in Nasik district in 2011. Kissan successfully partnered with smallholder farmers, tomato paste processor, the Maharashtra government and the agri-input supply companies. The intention was to deliver a significant advantage over the competition, which were import dependent for their tomato paste needs.

In the past, HUL was dependent on imports for its tomato paste requirements because of the inconsistent quality and availability of the commodity from local producers. Volatile prices also affected production costs. In 2010, HUL identified the business benefits of sourcing more raw-materials locally and changed its procurement practices so as to reduce costs and improve sustainability. It decided to work with the farmers to source tomato paste for its range of Kissan tomato ketchup.

Varun Agro, a local tomato paste maker now works directly with around 2,500 smallholder farmers to meet HUL's quality and sustainability requirements. Varun Agro oversees the training and advice on good agricultural practices offered to farmers. Participating farmers have seen their yields increase from around 24 Mt per hectare to 65 Mt per hectare. Farmers previously cultivated Indian varieties like Pusa Ruby, Pusa Early Dwarf and Solan Gola. These had a yield of 5-6 tonnes per ha and were very juicy thus making transportation difficult over long distances. The quality of their crop has also increased and they benefit from the security of a guaranteed buyer. By 2015, around 3,000 smallholder farmers have been trained in sustainable practices. This includes innovations like teaching farmers about intercropping tomatoes with mangoes to increase yields and income.

Under the contractual arrangements with Varun Agro, farmers can sell 25% of their produce on the local market, giving them a secondary route to market which allows them to take advantage of higher prices if the opportunity arises.

HUL also collaborated with Bayer CropScience and Syngenta to further develop the tomato value chain. These specialist agronomy partners assisted in areas such as setting up tomato nurseries, providing training in pest management and plant protection, and using 'demonstration fields' to showcase best practice. Unilever sourced 40,000 metric tonnes of tomato from India in 2011, about 60% of its requirements. Now, all of HUL's requirements for tomato paste comes from Varun Agro, most of it from an area of 800 hectares in and around Nashik, Ahmednagar and Pune in Maharashtra.

Source: Hindustan Unilever: 2015

CASE STUDY 3: UNITED GENETICS – PRODUCING IMPROVED SEED PRODUCTS TO SUPPORT THE PROCESSING TOMATO INDUSTRY

United Genetics India is the Indian subsidiary of United Genetics Inc. headquartered in the USA. The company has been active in developing processing tomato hybrids suitable for Asian markets. In 2005, United Genetics India commenced operations in Bengaluru with a focus on developing tomato seed products for the Indian market including the initiation of work on processing tomato seeds better suited to the varied agro-climatic conditions experienced in India and can endure pest and disease loads encountered here. Much of the breeding work undertaken on tomato has sought to address tomato leaf curl virus (ToLCV) and bacterial wilt.

UniGen India has released a number of tomato hybrids in India which are considered suitable for the processing tomato sector. These have relatively higher brix and lycopene levels suitable for the Indian market with improved disease resistance particularly for ToLCV, bacterial wilt and late blight. UniGen India has been actively involved in multi-locational trials of several World Vegetable Center tomato lines in India that are considered to have improved Ty resistance.

Released varieties are reported to have brix contents of between 5.4 to 5.6, viscosity of 5.0 to 6.0 and fruit size of 80-100 g. Other characteristics include firm fruits suitable for transportation, thick walls, uniform maturity and enhanced adaptability to varying conditions including under high temperatures and humid conditions. Company management indicate relative success in achieving Ty-1, 2 & 3 VFFN resistance in trials currently underway.

UniGen India is conducting trials in several locations in Karnataka, Maharashtra, Gujarat and Punjab. Its seed production hubs are in Koppal in Karnataka and near Aurangabad in Maharashtra.

In 2014, the Japanese tomato processor Kagome acquired a 70% majority stake in United Genetics Inc. including its Indian subsidiary signaling its interest in developing tomato varieties suited for cultivation in India as well as to establish backward integration with its strategy to establish tomato processing operations in India.

UniGen India has also been conducting trials on the mechanization of tomato production particularly mechanized harvesting in Gujarat. A similar trial is underway in collaboration with FieldFresh in Ladowal, Punjab.

UniGen India is of the view that the use of high quality seeds specifically for processing tomato coupled with the adoption of good agricultural production practices and mechanization will radically enhance value in the Indian processing tomato market.

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