

Characterization of Determinate Tomato Hybrids: Search for Better Processing Qualities

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Abstract

Thirty-one determinate tomato hybrids developed by both public and private sectors in India over the years were characterized in order to select the most appropriate hybrids for processing purpose. The performance of each hybrid was evaluated using certain physical and chemical indices. Most quality indices showed significant differences between hybrids, although their values remained in the typical ranges for processing tomatoes. In our study, two pear shaped private bred hybrids (BSS-423; TH-1359) qualified all the physico-chemical characteristics required for processing. However, three round shaped public (BCTH-62 and BCTH-4) and private (Vijay Lakshmi) bred hybrids also showed great promise for requisite qualification. The promising hybrids also showed high yield potential (> 60.0 t/ha) which is the general acceptance criteria among the farmers. The correlation study indicates some significant positive relationship between polar diameter and pericarp thickness, equatorial diameter and locule number, titratable acidity and vitamin C content, and lycopene and total carotenoids content of the fruit. The data generated in this study is of equal significance for the growers as well as for the tomato processors in the long run.

Keywords: Tomato; Hybrid; Yield; Processing quality

Introduction

Tomato (*Solanum lycopersicum*) is one of the important crops used as fresh vegetable as well as a variety of processed products such as juice, ketchup, sauce, canned fruits, puree, paste, etc. Tomato and tomato products made its attention even in terms of value of micro-nutrients existing at low concentration. Apart from contributing nutritive elements, colour and flavour to the diet, tomatoes are also a valuable source of antioxidants, or chemo-protective compounds, and may thus be termed a “functional food” [1]. The antioxidant potential of tomato is derived from a mixture of antioxidant biomolecules, including lycopene, ascorbic acid, phenolics, flavonoids and vitamin E, and is especially high in cherry tomatoes [2]. Because of their importance to human health [3], antioxidants may be considered a valuable quality attribute of tomatoes and it is important to minimize losses of these compounds during the post-harvest period. Tomato ranks 11th as the possible sources of Vitamin A and 25th for Vitamin C among the vegetables grown in India [4]. A beneficial effect of tomato consumption in the prevention of some chronic diseases such as some type of cancer and cardiovascular diseases has been reported [5]. Apart from the nutritional and antioxidant vitamin contents, sugars and organic acids, which form a substantial fraction of tomato dry matter, are relevant more to taste attributes than to the nutritional value of tomato, with tomato antioxidants playing a major role in the latter aspect [6]. Quality and flavour of the processed products depend on chemical components like reducing sugar, acidity, ascorbic acid, lycopene, β -carotene, T.S.S. and total sugar which has been reported to vary greatly with variety [7]. The desirable qualities for a tomato cultivar to be used for processing includes high total soluble solids (4-8° Brix), acidity not less than 0.4%, pH less than 4.5, uniform red colour, smooth surface, free from wrinkles, small core, firm flesh and uniform ripening [8].

There is an extensive 60-year literature on the quality of processed tomato products and on breeding cultivars to suit processing needs. There has also been considerable research on tomato agronomy, yet there are clearly large gaps in the understanding of how the field environment and crop management influence each of the fruit properties measured

at harvest to estimate the quality of processed products. Tomato paste is the product of most interest since it is reformulated into many other products. The market of tomato processing products around the world are expanding whereas, in the tropics, the tomato processing industry often confronted with the problem of limited supply of processing tomatoes. Low yield increases the cost and the risk of growing tomatoes. Therefore, farmer's income is decreased. Scientists from the tropical regions have identified the reasons why tomato varieties grow in these areas are unadapted. The reasons fall into three main categories, i.e., susceptibility to diseases, low fruit setting ability and poor quality fruits. However, in the developing countries of wet and humid tropics, there are far more important steps that need to be taken. First is to improve the processing tomato varieties to adaptable varieties of the tropics, since the potential for tomatoes in tropics is great.

In most of the advanced countries, nearly 80% of the fresh tomatoes are processed into various products. Currently, only 2.2% of the total produce in India is processed and the rest marketed as fresh vegetables [9]. Tomato quality depends on many factors such as cultivar, growing condition and ripening on and off the vine. The physical and chemical characteristics of tomato also affect the quality of processed product. Therefore, good quality tomatoes should be processed for the best products. High yield coupled with good processing qualities are the pre-requisites for the general acceptance of the hybrid by the farmers. However, very little attempt has been made so far to assess the physical

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and chemical properties of tomato hybrids developed by both public and private sectors in recent times from the point of view of processing. The present study was, therefore, conducted to assess the processing qualities of determinate tomato hybrids which would be acceptable by the processing industries.

Materials and Methods

Thirty one determinate tomato hybrids developed by both public and private sectors were evaluated during autumn-winter season in the Research Farm of Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India, situated at 23.5° N latitude and 89° E longitude with a mean sea level of 9.75 m.

Seed beds were prepared in a sandy loam soil and were 20 cm tall and 1.0 m wide. Weathered cowdung manure @ 4 kg/m² was mixed into the beds. Beds were drenched with formaldehyde (4.0%) and covered with polythene sheet for 10 days to avoid damping off disease. Seeds, after treatment with Thiram (3 g/kg of seed), were sown during the 1st week of August, 2010 at shallow depth 5 cm apart and covered with finely sieved leaf mold. After sowing, beds were covered with straw until germination and hand watered regularly. Nursery beds were covered with 200 µm ultraviolet (UV)-stabilized polyethylene film supported by bamboo poles with open sides to protect seedlings from rain and direct sunlight. Seedlings were hardened by withholding water 4 days before transplanting. One-month seedlings, at least 15 cm in height with 3-4 leaves, were transplanted to the main field at a spacing of 60×45 cm apart in the plot size of 3.6 m×4.5 m during the 1st week of September, 2010. Management practices for cultivation were followed as per Chattopadhyay et al. [10]. The data on fruit yield (t/ha) of hybrids were calculated on plot yield basis.

Fresh red ripe fruits at an earlier stage of maturity of thirty one hybrids were collected from the field during December-January and brought to the laboratory of Post Harvest Technology of Horticultural Crops, Directorate of Research, Kalyani, West Bengal for determination of different physico-chemical parameters. There was a distinct pattern of higher quality in the latest-set (youngest) fruit in terms of total solids, °Brix (soluble solids), and titratable acidity as observed by Renquist and Reid [11]. After taking different morphological characters of fruits like fruit shape, colour (as per documented descriptors), weight, polar and equatorial diameter (by Digital slide calipers), pericarp thickness (Digital slide calipers), number of locules/fruit, ten random sampled fruits from each replication were used to estimate different biochemical constituents like total soluble solids (by digital hand refractometer), titratable acidity (in terms of citric acid) [12], pH (by digital pH meter), ascorbic acid (Indophenol method) as suggested by Ranganna [13], lycopene and total carotenoid contents [13] following standard methods.

The experiment was conducted by following Randomized Block Design with three replications. Data were subjected to ANOVA for a Randomized Block Design with three replications according to Gomez and Gomez [14] and simple correlations were worked out and tested for significance.

Results and Discussion

Nine out of thirty one tomato hybrids were pear shaped and rest of the hybrids were either round or flattish round in shape. Fruit weight of tomato plays an important role in consumer preference as well as in processing industry. The present study revealed that tomato had a wide and significant variation in fruit weight among the different hybrids. The mean weight of the fruit ranged from 42.00 g to 134.40 g and the

maximum being in Aruna, whereas the minimum was found in HTH-2-2 (Table 1). Six pear shaped and twelve round shaped red coloured hybrids were having fruit weight of more than 80 g (Table 2).

A wide range (3.18 cm to 6.48 cm) of variation was recorded among the different hybrids in respect of their mean polar diameter with the maximum in Crystal-448 (6.48 cm) followed by TH-1359 (5.96 cm) and BSS-423 (5.46 cm) and the minimum in HTH-2-2 (Table 1). Hybrids with high polar diameter and having pear shape are desired for processing purpose as the fruit contains more pulp as reported by Tiwari [15]. Like polar diameter, the maximum equatorial diameter was observed in HTH-2-2 (6.36 cm), whereas minimum in SHTH-1 (3.94 cm).

Number of locules in the fruit is an important trait for selection of hybrids for processing. There should be minimum number of locules (2-3) for proper shape of the fruit and at the same time favours high concentration of solids and ascorbic acid content [16]. Ascorbic acid is present in higher concentration in the locules than in the pericarp tissue. In the present study, a slight variation in locule number of different hybrids was observed with the minimum 2.0 in TH-1359 followed by Roopsi (2.2), BSS-423 (2.3), ARTH-1001 (2-4) and the maximum 4.40 in HTH-2-2 (Table 1). Usually pear/oblong shaped varieties (higher polar diameter) have lower number of locules [17,18]. This observation corroborates the present finding, where genotype (TH-1359, Roopsi, BSS-423, ARTH-1001) with minimum (2.0-2.4) number of locules registered higher polar diameter. On the other hand, round-fruited hybrids with higher equatorial diameter (HTH-2-2, VLTH-1, ARTH-3) had more number of locules (more than 4.0) which corroborated the findings earlier worker [19].

Thickness of the pericarp also bears an important quality attributes for processing purpose [20]. Tomatoes with thicker pericarp would stand long distance transport and keep well [21]. Thus, tomatoes for processing should have more than 0.50 cm of pericarp thickness which would keep the fruit firm and evaporation of water through surface would be less [15]. A significant variation was observed on pericarp thickness of the fruit (Table 1). Among the hybrids, JKTH-2040 had the maximum (1.02 cm) pericarp thickness while HTH-2-2 had the minimum (0.36cm) pericarp thickness. Shape and size also bears a strong relationship with pericarp thickness. It was observed in general that pear shaped hybrids (JKTH-2040, ARTH-1023, BSS-437, ARTH-1001) had higher pericarp thickness than the round shaped fruits. This result is in accordance with the findings of Thakur and Kaushal [17].

High total soluble solids (TSS) are the main quality component for nutritional and processing purposes [20]. Among the 31 hybrids, the maximum total soluble solids content (5.10 °Brix) was found in Vijay Lakshmi followed by Kundal- 90 (5.00 °Brix) and BSS-423 (4.96°Brix). Only two pear shaped and eight round shaped red coloured hybrids were having TSS of more than 4.5°Brix (Table 2).

Two important quality attributes of processing tomatoes are pH and titratable acidity [22]. Citric acid is the most abundant acid in tomatoes and the largest contributor to the total titratable acidity [23]. The acidity of the fruit is also important as a contributor to the flavour of the tomato products. Minimum acidity requirement for processing tomato should be 0.40% as the processed product from low acid tomato may be affected by *Bacillus coagulans* [16]. The mean acid content of hybrids ranged from 0.27 to 0.52 per cent (Table 3). The maximum fruit acidity was recorded in Vijay Lakshmi (0.52 %) followed by BCTH-4 (0.51%) and ARTH-1001 (0.50%). Genotypic variation on the acid content of tomato fruits was highlighted by previous workers [24,25]. Three pear

Entries	Source	Fruit shape	Fruit colour	Fruit Weight (g)	Polar diameter (cm)	Equatorial diameter (cm)	Locule No.	Pericarp thickness (cm)	Fruit yield (t/ha)
BCTH-62	Public	Round	Red	106.0	5.16	5.00	3.8	0.51	63.7
Ajeet-11	Private	Pear Shaped	Red	80.1	5.12	4.70	3.0	0.60	79.0
ARTH-1023	Private	Pear Shaped	Red	126.0	5.94	4.94	3.0	0.74	69.8
SHTH-3	Public	Flattish Round	Red	45.2	3.44	4.26	3.6	0.42	45.0
SHTH-1	Public	Round	Red	42.8	3.86	3.94	3.1	0.38	54.1
BSS-571	Private	Round	Red	95.6	4.86	5.46	3.2	0.56	72.5
BSS-575	Private	Round	Red	69.6	4.86	4.84	3.2	0.56	68.6
HTH-2-1	Public	Round	Red	54.4	3.64	4.48	3.4	0.48	62.0
UKC-10	Private	Flattish Round	Red	62.8	3.44	4.54	3.2	0.44	67.0
VNR-6A	Private	Round	Red	82.0	4.46	4.78	3.8	0.46	57.4
HTH-2-2	Public	Flattish Round	Red	42.0	3.18	6.36	4.4	0.36	48.6
ARTH-3	Private	Round	Orange Red	76.0	4.46	4.98	4.2	0.44	45.7
ARTH-1001	Private	Pear Shaped	Red	59.2	4.62	4.20	2.4	0.70	41.6
HATH-5	Public	Round	Red	58.4	3.72	4.50	3.4	0.58	32.3
HATH-9	Public	Round	Red	64.0	4.46	4.50	3.8	0.42	43.9
NTH-449	Private	Round	Red	90.0	4.98	5.72	3.2	0.64	34.1
JKTH-2040	Private	Pear Shaped	Red	86.8	4.52	5.32	3.0	1.02	33.3
TH-1827	Private	Round	Red	78.4	4.40	5.18	3.2	0.56	64.9
No.108	Private	Round	Red	101.2	5.32	5.24	3.2	0.68	56.6
BSS-437	Private	Pear Shaped	Red	82.0	5.54	4.76	2.4	0.78	65.6
JKTH-2002	Private	Pear Shaped	Red	66.0	5.28	5.66	3.0	0.72	39.5
Roopsi	Private	Pear Shaped	Light Red	58.0	5.12	4.18	2.2	0.70	42.0
BSS-423	Private	Pear Shaped	Red	83.0	5.46	4.93	2.3	0.78	62.1
Aruna	Private	Flattish Round	Red	134.4	5.06	6.14	4.0	0.65	64.0
Kundal-90	Private	Round	Red	68.4	4.84	4.56	3.0	0.66	30.5
BCTH-4	Public	Flattish Round	Red	81.0	4.86	6.10	4.0	0.56	64.7
COTH-2	Public	Round	Red	105.0	4.88	5.58	4.0	0.58	45.9
VLTH-1	Public	Round	Red	95.0	4.85	5.52	4.3	0.52	56.9
TH-1359	Private	Pear shaped	Red	92.0	5.96	5.00	2.0	0.92	65.1
Vijay Lakshmi	Private	Flattish Round	Red	84.0	4.14	5.72	3.1	0.54	60.4
Crystal-448	Private	Pear shaped	Light Red	115.0	6.48	5.96	3.0	0.68	47.7
Range				42.00-134.40	3.18-6.48	3.94-6.36	2.0-4.4	0.36-1.02	30.50-79.00
Mean				80.13	4.73	5.06	3.27	0.60	54.33
CD at 5%				9.84	0.08	0.02	0.01	0.09	2.58

Table 1: Physical characteristics of tomato hybrids.

Character	Pear shaped red fruited hybrid	Round shaped red fruited hybrid
Fruit weight > 80 g	ARTH-1023; JKTH-2040, BSS-423, BSS-437, TH-1359, Ajeet-11	Aruna, COTH-2, BCTH-62, No-108, BSS-571, BSS-575, VNR-6A, NTH-449, VLTH-1, Vijay Lakshmi, BCTH-4
No. of locules (2-4)	ARTH-1023; JKTH-2040, BSS-423, BSS-437, TH-1359, ARTH-1001	Aruna, COTH-2, BCTH-62, No-108, BSS-571, BSS-575, VNR-6A, NTH-449, VLTH-1, Vijay Lakshmi, BCTH-4
Pericarp thickness > 0.5 cm	JKTH-2040, ARTH-1023, BSS-437, ARTH-1001, Ajeet-11, JKTH-2002, BSS-423, Roopsi, TH-1359	BCTH-62, BSS-571, BSS-575, HATH-5, NTH-449, TH-1827, No-108, Aruna, Kundal-90, BCTH-4, COTH-2, VLTH-1, Vijay Lakshmi
TSS > 4.5° brix	BSS-423; TH-1359	BCTH-62, HATH-9, No-108, Aruna, Kundal-90, COTH-2, BCTH-4, Vijay Lakshmi
Acidity > 0.40 %	ARTH-1001, BSS-423; TH-1359	BCTH-4, Vijay Lakshmi, COTH-2, VLTH-1, SHTH-3, BSS-575, HATH-9,
pH < 4.5	BSS-423, ARTH-1023, TH-1359, Crystal-448	BCTH-62, Vijay Lakshmi, No-108, SHTH-3, SHTH-1, BSS-571, HTH-2-1, UKC-10, HTH-2-2, HATH-5, JKTH-2002, BCTH-4, VLTH-1
Vitamin C > 25 mg/100 g	ARTH-1001, BSS-437, Roopsi, TH-1359, Crystal-448, BSS-423	VNR-6A, TH-1827, BCTH-4, COTH-2, VLTH-1, Vijay Lakshmi
Lycopene > 3.0 mg/100g	BSS-423, ARTH-1001, ARTH-1023, TH-1359	BCTH-62, BCTH-4, NTH-449, HTH-2-2, VNR-6A, UKC-10, HTH-2-1, BSS-571, SHTH-1, SHTH-3, Ajeet-11, Vijay Lakshmi

Table 2: Selection of promising hybrids for processing purpose.

shaped and seven round shaped red coloured hybrids possessed acidity of more than 0.40% (Table 2). Tomatoes are not a low-acid food and thus require less drastic thermal treatments than foods classified as low acid (pH>4.6) for the destruction of spoilage microorganisms to ensure

food safety. It has been suggested that pH 4.4 is the maximum desirable for safety and the optimum target pH should be 4.25 [26]. Industrial processors of tomatoes in California typically specify a pH of 4.2 or 4.3 in their processed products. The pH of tomatoes is determined

primarily by the acid content of the fruit. The minimum pH (3.70) of the fruit was recorded in HATH-5 and the maximum (5.40) was shown by ARTH-1001 (Table 3). Four pear shaped and thirteen round shaped red coloured hybrids showed a pH value of less than 4.5 (Table 2).

High ascorbic acid in tomato not only improves the nutrition, it also aids in better retention of natural colour and flavour of the products [16]. In the present study, a significant variation was recorded for ascorbic acid content, maximum being in BCTH-4 (40.50 mg/100 g)

and minimum in No-108 (14.63 mg/100 g). A wide range of genotypic variation in the ascorbic acid content was recorded by various workers [25,27-28]. Six each of pear and round fruited red coloured hybrids exhibited ascorbic acid content of more than 25 mg/100 g (Table 2).

Colour of fruit is an important quality parameter both for table purpose and processing varieties. Potaczek and Michalik [29] have observed that environmental factors especially temperature and light intensity exerted a great influence on lycopene level than on carotene

Entries	TSS (°Brix)	Acidity (%)	pH	Vitamin C (mg/100g)	Lycopene (mg/100g)	Total carotenoids (mg/100g)
BCTH-62	4.52	0.35	3.9	21.14	4.91	7.26
Ajeet-11	4.36	0.38	5.2	21.83	3.28	4.39
ARTH-1023	4.26	0.28	4.0	22.00	3.90	4.67
SHTH-3	4.08	0.44	3.6	21.00	3.72	4.49
SHTH-1	4.00	0.27	4.3	24.00	3.70	4.28
BSS-571	4.48	0.32	4.2	18.94	4.00	5.07
BSS-575	4.04	0.41	4.6	21.00	2.95	3.27
HTH-2-1	4.28	0.39	4.0	24.98	3.28	4.27
UKC-10	4.14	0.33	4.0	23.00	3.68	4.20
VNR-6A	4.20	0.38	5.1	26.00	3.42	4.10
HTH-2-2	4.10	0.38	4.2	21.96	4.70	6.98
ARTH-3	4.12	0.40	4.8	18.00	1.30	2.76
ARTH-1001	4.14	0.50	5.4	28.90	3.60	4.17
HATH-5	4.28	0.32	3.7	24.30	2.28	3.60
HATH-9	4.80	0.44	5.2	17.12	2.26	3.52
NTH-449	3.84	0.42	4.7	19.00	4.62	6.25
JKTH-2040	3.92	0.39	4.6	21.04	2.21	3.48
TH-1827	4.00	0.42	4.6	27.52	1.64	3.04
No-108	4.86	0.30	4.2	14.63	1.92	3.40
BSS-437	4.04	0.38	5.0	27.62	2.25	3.58
JKTH-2002	4.00	0.40	4.2	19.00	1.90	3.24
Roopsi	3.82	0.37	5.0	25.10	1.98	3.51
BSS-423	4.90	0.35	4.1	25.93	3.37	4.02
Aruna	4.80	0.29	5.3	16.00	1.94	3.29
Kundal-90	5.00	0.38	5.2	21.00	2.72	3.70
BCTH-4	4.74	0.51	4.2	40.50	3.13	4.07
COth-2	4.48	0.42	4.9	26.50	1.45	2.60
VLTH-1	4.36	0.43	4.2	33.50	1.43	2.53
TH-1359	4.52	0.41	4.3	35.30	3.10	3.90
Vijay Lakshmi	5.10	0.52	4.3	31.00	3.15	4.12
Crystal-448	4.20	0.27	4.2	34.25	1.25	2.42
Range	3.82-5.10	0.27-0.52	3.70-5.40	14.63-40.50	1.25-4.91	2.42-7.26
Mean	4.33	0.38	4.49	24.26	2.87	4.00
CD at 5%	0.05	0.03	0.07	2.30	0.15	0.17

Table 3: Biochemical composition of tomato hybrids.

Characters	ED	LN	PT	TSS	TAC	PH	VITC	LYCO	TCAR
PD ^a	0.270	-0.280	0.606**	0.134	-0.243	0.074	0.171	-0.263	0.185
ED		0.456**	0.181	0.183	0.072	-0.061	0.143	-0.116	-0.139
LN			-0.405*	0.163	0.152	-0.132	-0.076	-0.105	-0.385*
PT				-0.025	-0.076	0.097	0.060	-0.263	0.141
TSS					0.085	0.231	0.010	-0.090	-0.127
TAC						0.343	0.373*	-0.014	0.193
PH							-0.026	-0.249	0.050
VITC								-0.134	-0.105
LYCO									0.434*

^a PD: Polar diameter; ED: Equatorial diameter; LN: Locule number; PT: Pericarp thickness; TSS: Total soluble solids; TAC: Titratable acidity; PH: pH of the fruit; VITC: Vitamin C; LYCO: Lycopene; TCAR: Total carotenoids

* and ** significant at 5% and 1% level of significance, respectively

Table 4: Pearson's correlation matrix of all variables.

contents in tomato fruits. Red-fruited cultivars also have higher lycopene content than yellow, orange and black-fruited cultivars [30]. Lycopene synthesis during growth is inhibited at temperatures below 12°C and prohibited at >32°C. Hybrids rich in lycopene generally produced bright red or deep red hues whereas hybrids with least amount of lycopene content were orange red or light red in colour. Such wide range (1.25-4.91 mg/100 g) was observed among the hybrids studied with maximum 4.91 mg/100 g in BCTH-62, followed by 4.70 mg/100 g in HTH-2-2 and 4.62 mg/100 g in NTH-449 while minimum of 1.25 mg/100 g in Crystal-448. There was a wide genotypic range of lycopene was observed by Mangels et al. [31]. Four pear shaped and twelve round shaped red coloured hybrids possessed lycopene of more than 3.0 mg/100 g (Table 2). Likewise, total carotenoids content ranged from 2.42 mg/100 g to 7.26 mg/100 g among the hybrids. The maximum content was found in BCTH-4 with 7.26 mg/100g and the minimum 2.42 mg/100 g in Crystal-448 (Table 3).

The correlation study (Table 4) among different physico-chemical parameters indicated some significant positive relationship between polar diameter and pericarp thickness, equatorial diameter and locule number, titratable acidity and ascorbic acid content, and lycopene and total carotenoids content of the fruit. Similarly, some significant negative association between locule number and pericarp thickness, and locule number and total carotenoids content of fruit has been observed.

From the combined study of different physico-chemical parameters of the hybrids, two pear shaped private bred hybrids (BSS-423; TH-1359) and three round shaped public (BCTH-62 and BCTH-4) and private (Vijay Lakshmi) bred hybrids have been identified as most suitable for processing purpose (Table 5). The yield potentialities of these hybrids were recorded to be more than 60.0 t/ha (Figure 1).

Combined characters	Pear shaped hybrid	Round shaped hybrid
Fruit weight > 80 g; No. of locules (2-4); Pericarp thickness > 0.5 cm; TSS > 4.5° brix; Acidity > 0.40 %; pH < 4.5; Vitamin C > 25 mg/100 g; Lycopene > 3.0 mg/100g	BSS-423; TH-1359	BCTH-62, Vijay Lakshmi, BCTH-4

Table 5: Identification of most promising hybrids for processing.

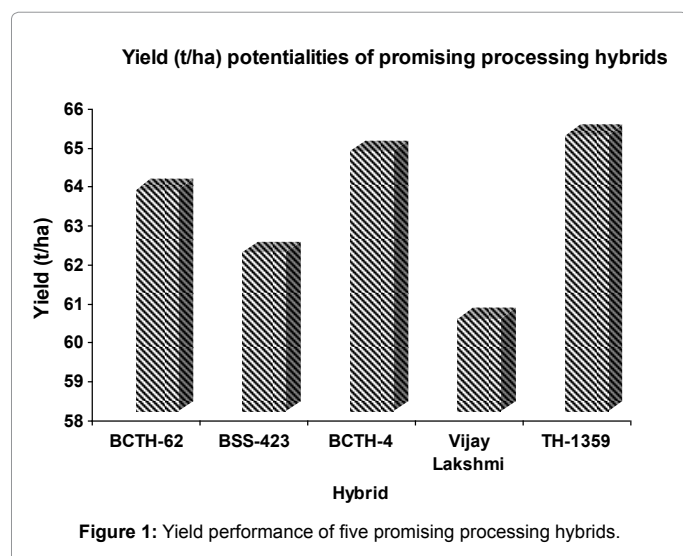


Figure 1: Yield performance of five promising processing hybrids.

Conclusions

Normally pear/oblong shaped variety/hybrid with lower locule number is generally preferred for processing. In the present study, two pear shaped (BSS-423; TH-1359) and three round shaped (BCTH-62, BCTH-4, and Vijay Lakshmi) hybrids were adjudged as most promising for processing purpose. These hybrids could also be grown by the farmers as table purpose during autumn-winter season of the Gangetic plains of eastern India owing to their high yield potentialities and other desirable characteristics.

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