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Divya Das
Research Scholar, Department of
Botany, Faculty of Science, The
Maharaja Sayajirao University of
Baroda, Baroda, Gujarat, India

Susy Albert
Professor, Department of Botany,
Faculty of Science, The Maharaja
Sayajirao University of Baroda,
Baroda, Gujarat, India

Survey-based assessment of mango product diversification, varietal utilization and waste- management practices in Gujarat, India

Divya Das and Susy Albert

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Abstract

Mango (*Mangifera indica* L.) holding an immense socio-economic value is the chief commercial fruit of the state of Gujarat, India. In the present study, a survey based assessment of mango-based industries of Gujarat was carried out with the aim to identify the mango-product diversification, varietal utilization, fruit procurement sources and waste-management practices followed. The secondary data was foremost collected with the help of online business / e-commercial platforms such as TradeIndia, Indiamart, ExportersIndia etc. A total of 233 industries were enlisted from 24 districts of the state, while no information was retrieved for other 9 districts and one union territory. Then, the primary data was then collected with the help of a structured questionnaire via telephonic survey. 233 industries were contacted, out of which 48 industries from 14 districts responded, giving an overall response rate of 20.60%. The survey depicted a clear varietal preference for the specific product. The Kesar, Hafuz/Alphonso and Totapuri were mainly used for ripe fruit-based products like pulp, slices, puree etc. While mostly Rajapuri is used for making pickles, murabba and chutney like raw-mango based products. It was found that mango procurement by industries were variety-specific, and the local markets, APMC (Agricultural Produce Market Committee) markets and inter-regional supply chains played the key role. The Waste-management practices varied widely among industries. It was found that the peel were mostly used for fertilizer, cattle feed, biogas substrate or directly discarded, while seeds were mostly sold out for making mukhwas (mouth freshner), nursery propagation, fertilizer, traditional medicinal use or directly sell or disposal. The findings indicate that there is a need for an efficient waste-management strategies. The systemic collection, segregation and valorization of the leftover peel and seed waste can help in waste reduction, additional income generation and circular economy based fruit-processing in Gujarat for future sustainable industrial applications.

Keywords: Mango processing, varietal utilization, peel and seed waste, waste management

Introduction

Fruits are the vital elements of food, nutrition and agro-industrial systems. The fruits like bananas, citrus fruits, watermelons and melons, apples, grapes and mangoes are the major fruits produced and consumed all around the world [1, 2]. *Mangifera indica* L. commonly known as “Mango” and “King of fruits” is one of the most important tropical fruits due to its high demand on fresh markets, suitability for processing, its diverse varieties and importance in international trade [1, 3]. India is the largest producer of mango, globally accounting for over 42.84% production [4]. The mangoes are consumed fresh in its raw as well as ripe form, processed into variety of products like pulp, nectar, puree, juice, canned slices, dried slices, pickles, murabba, chutney, spray dried mango powder and amchur powder [4, 5, 6]. According to a report, India exported 29,938.40 metric tonnes worth USD 80.34 million in year 2024-2025, representing the importance of both fresh and processed mango products in export commerce [4].

The state of Gujarat is one of the prominent producer and processor of mangoes in India. The mango production spans across 1,77,000 hectares of land i.e. 37% of the state's total horticultural crop area [7]. The state is famous for commercially important varieties like Kesar, Alphonso/Hafuz, Rajapuri, Totapuri, Sonpari etc. Mango is more prone to losses due to its seasonal and perishable nature.

Corresponding Author:
Divya Das
Research Scholar, Department of
Botany, Faculty of Science, The
Maharaja Sayajirao University of
Baroda, Baroda, Gujarat, India

Thus, the processing of mangoes increases the value addition and reduces the loss of marketable fruits, but eventually also creates a huge amount of organic waste. During the processing of mangoes, 35-60% of the fruit may be discarded as peel, seed, fibrous residues etc depending on the variety, maturity stage and processing method [8, 9, 10]. Leftover peel and seeds of mangoes represent 30-60% of the fruit mass and it is estimated that the mango processing will generate around 20 million tonnes of trash of the same [11]. Incorrect handling of these residues may lead to the generation of bad smells, contamination, attraction of insects, high organic load and economic losses by disposal [8, 12]. The by-products of mango processing are getting more attention currently as the valuable bio-resources rather than waste. Mango peel has high content of polyphenols, carotenoids, flavonoids, catechins, phenolic acids, cellulose, pectin, mangiferin and dietary fibre etc. which supports its potential as a functional food ingredient and natural anti-oxidant source [8, 13, 14, 15]. The mango kernel is a rich source of carbohydrates, fats, proteins, minerals, vitamins and bioactive substances, thus is appropriate for its potential usage in food, pharmaceutical, nutraceutical and cosmetic industrial applications [9, 16, 17, 18]. Mango peel and kernel powders have also been used to enhance the dietary fibre, phenolic content and anti-oxidant properties of biscuits, cookies and other bakery products [19, 20]. Various studies have reviewed the bioactive composition and value addition potential of mango peel and seed, whereas few studies have documented the actual waste management practices in the field followed by the mango processing industries [8, 9]. A recent study on fruit and vegetable processing plants based in Gujarat stated that the waste management practices may consist of composting,

biomethanation, bio-enzymatic treatment and conventional disposal, but also pointed towards barriers like irregular implementation, limited awareness, cost constraints and lack of structured systems [21]. However, there is minimal mango-specific information about the waste-management practice followed by industries in Gujarat. So, the present study was carried out to survey and document the district wise distribution, product profile, mango variety utilization, fruit procurement sources and waste-management strategies of the mango based industries in Gujarat.

Study Area

The Gujarat state of India has been selected for the present study (Fig. 1.1). It is situated on the country's west coast between latitudes 20°01' to 24°07' North and longitudes 68°04' to 74°04' East. The state with the total geographical area of 1,96,024 sq. km, consists of 33 districts and 1 union-territory. The 33 districts have been grouped into five zones of the state i.e. Kutch, Saurashtra, North-Gujarat, Central-Gujarat and South-Gujarat. The state with overall tropical conditions has three main sub-climatic zones i.e. sub-humid, arid and semi-arid spread over different regions of the state [22]. Large portions of the state's land is covered in loamy soils in the north, high plasticity clayey soils in the south and clayey soils with some coarser sand in the centre of the state. The five zones of this state i.e. Kutch, North-Gujarat, East Central, Saurashtra and South-Gujarat received average rainfall of 456 mm, 720 mm, 806 mm, 717 mm and 1476 mm respectively in the period of 1992-2021 [23]. Thus, a wide array of mango cultivars is grown over here due to the state's unique range of weather conditions.

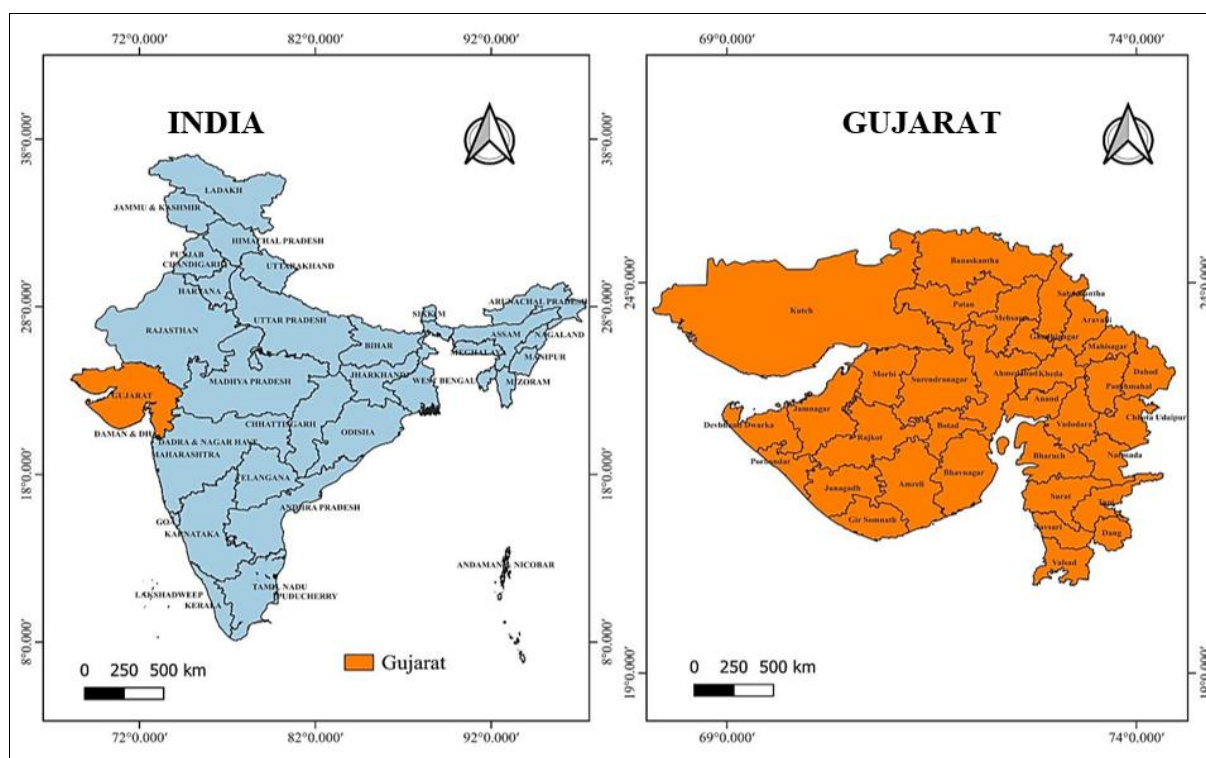


Fig 1.1: Map of the Study Area.

Materials & Methodology

The present survey of mango based industries was carried out with an aim to identify varietal utilization for specific product-making, fruit procurement sources and waste management strategies of the mango-based industries of Gujarat state. The study was carried out in two stages: secondary data collection

via e- commercial platforms and primary data collection via questionnaire - based survey. In the first stage, secondary data of industries processing mango for products such as pulp, puree, sweet and sour pickles, murabba, juice, frozen pulp, canned slices, frozen slices, dried mango slices, mango powder, jam, chutney, amchur powder, etc. were surveyed. The data such as

name, address, contact details, product type, variety usage etc. of these manufacturing industries was acquired from the google, online business / e- commercial platforms such as TradeIndia, Indiamart, ExportersIndia, Indian Yellow Pages, etc. Based on this information, a district-wise database of these mango-based industries was prepared. In the second stage, these enlisted industries were contacted through telephonic interaction using a structured questionnaire. The questionnaire consisted of the following questions:

- Which mango varieties are processed in your industry?
- Which specific mango variety is used for making a particular product?
- From which region or market is the particular variety procured?
- What are the waste-management strategies followed at your industry for the leftover peel and seed?
- Will the industry allow for a visit?
- Will the industry supply the generated mango-processing waste for further research purpose?

After the collection of this data, the information was analysed and interpreted. Since the survey was done on the industries present digitally, it may not fully include unregistered home-based or digitally absent / unlisted processing units.

Results

The entire survey has been carried out in two phases. Phase I is the secondary data collection from e-scraping and Phase II is the primary data collection through telephonic survey.

Phase 1: Digital Database Preparation.

The secondary data of industries processing mangoes was collected from google, e-commercial platforms like TradeIndia,

Indiamart, ExportersIndia, Indian Yellow Pages, etc. During this data collection, clear regional differences in data availability was found (Fig 1.2). No open access information for any of the registered company or industry could be obtained from 9 districts i.e. Amreli, Botad, Devbhoomi Dwarka, Gir-Somnath, Narmada, Aravalli, Chota-Udaipur, Dahod and Mahisagar and 1 union-territory i.e. Dadra and Nagar Haveli and Daman & Diu. The other 24 districts with available online commerce related data are namely Kutch, Bhavnagar, Jamnagar, Junagadh, Morbi, Porbandar, Rajkot, Surendranagar, Ahmedabad, Anand, Kheda, Panchmahal, Vadodara, Banaskantha, Gandhinagar, Mehsana, Patan, Sabarkantha, Tapi, Bharuch, Dangs, Surat, Valsad and Navsari.

A total of 233 registered mango based industries from these 24 districts were identified and listed along with their respective company details and product profile for further analysis. The detailed district corresponding product-category wise industrial distribution of these 233 industries showed that the Rajkot district, followed by Ahmedabad, Surat, Navsari, Junagadh and Valsad are with the highest number of industries, according to available data (Figure 1.3). Based on the collected data and corresponding product-wise distribution statistics (Figure 1.4), the mango-processing sector is dominated by pulp manufacturing units i.e. 102 in number, followed by pickle manufacturing units i.e. 83 in number. Mango slices/cubes, amchur powder, mango powder, jam, and chutney etc are among the other product categories that make up a comparative smaller but significant share of the overall industrial landscape. The Rajkot district, followed by Ahmedabad, Surat, Navsari, Junagadh and Valsad have pulp, pickle and amchur making industries in a very significant number. Among all 24 districts, Tapi and Dangs has been found with the lowest number of registered industries.

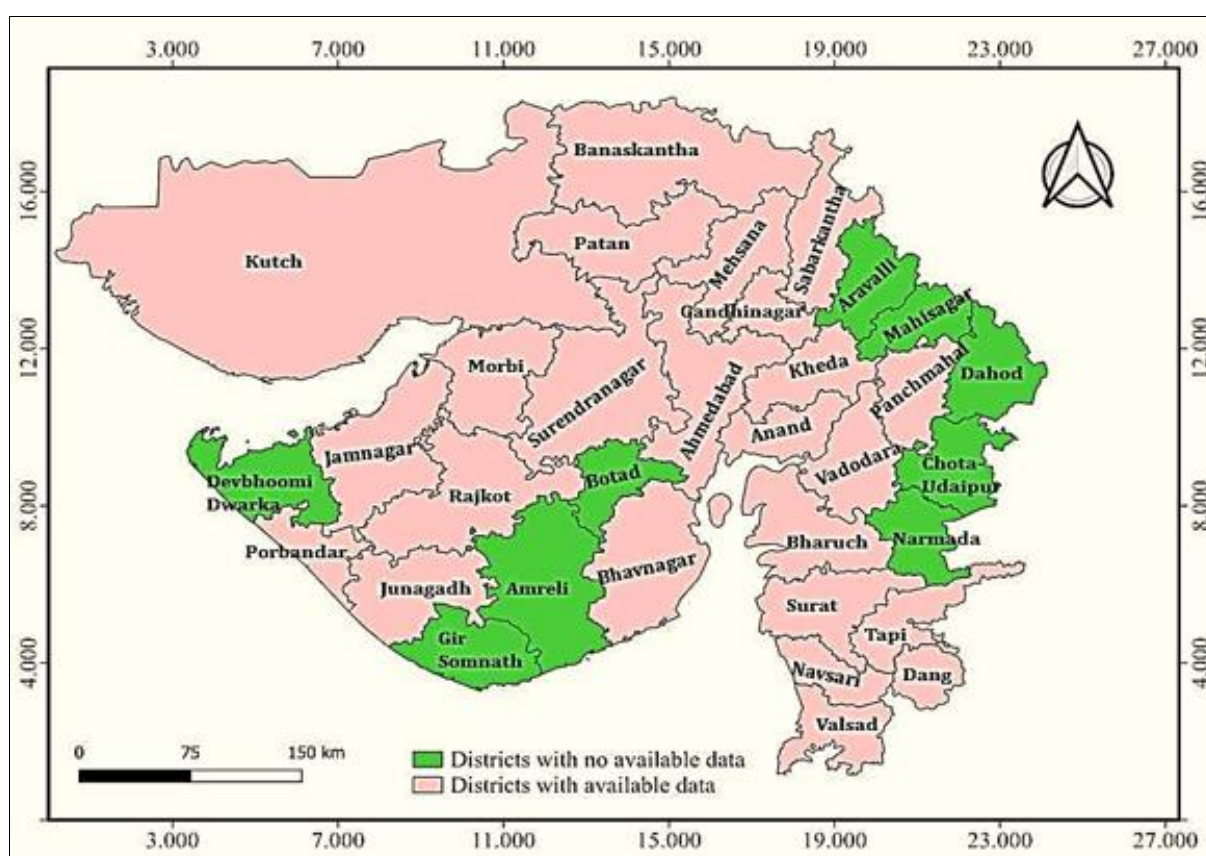


Fig 1.2: District-distribution map of Gujarat with respect to Digital Data Availability of Mango-based Industries across the state

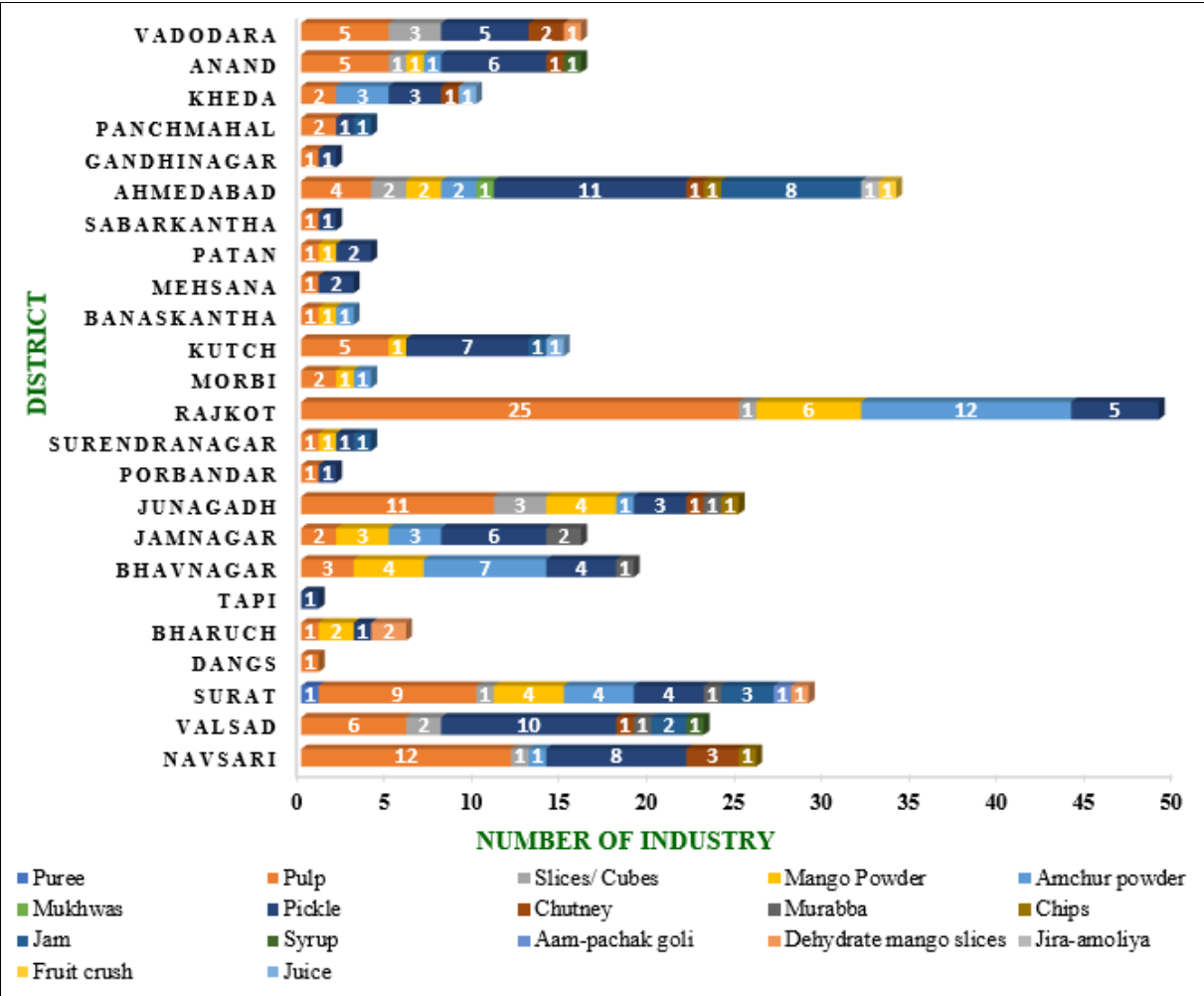


Fig 1.3: District and Category-wise distribution of Mango-based Industries in Gujarat

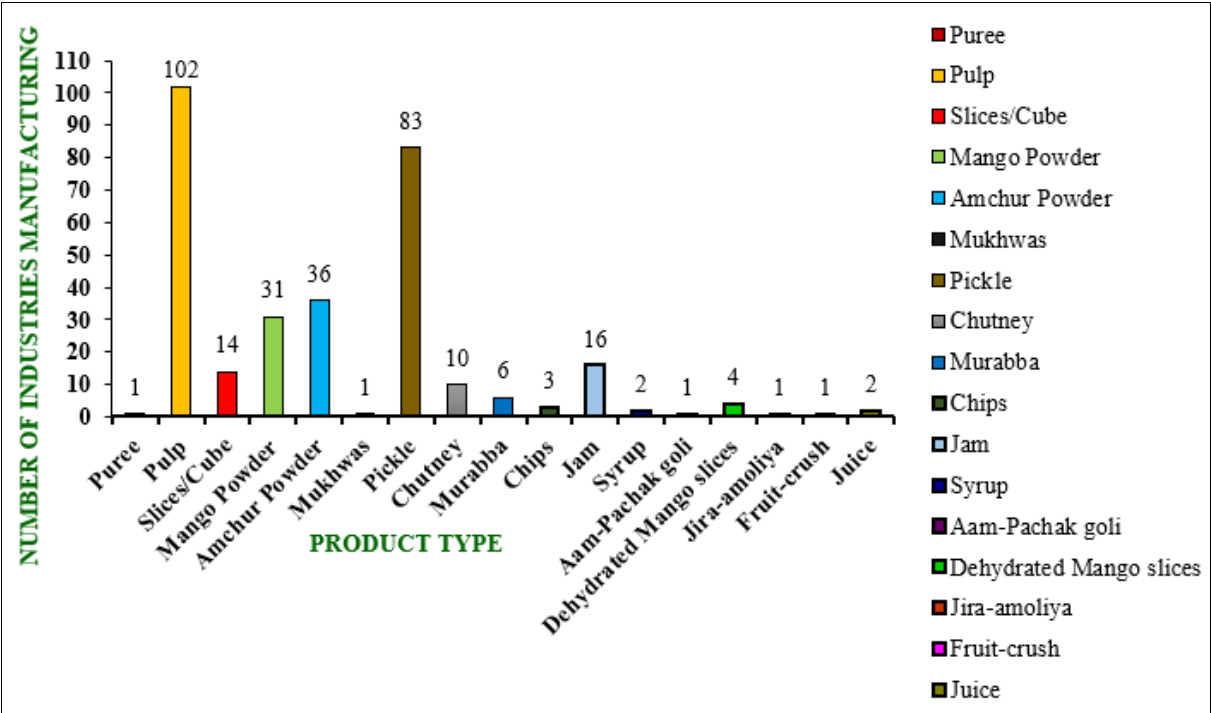


Fig 1.4: Product-wise Industries Distribution

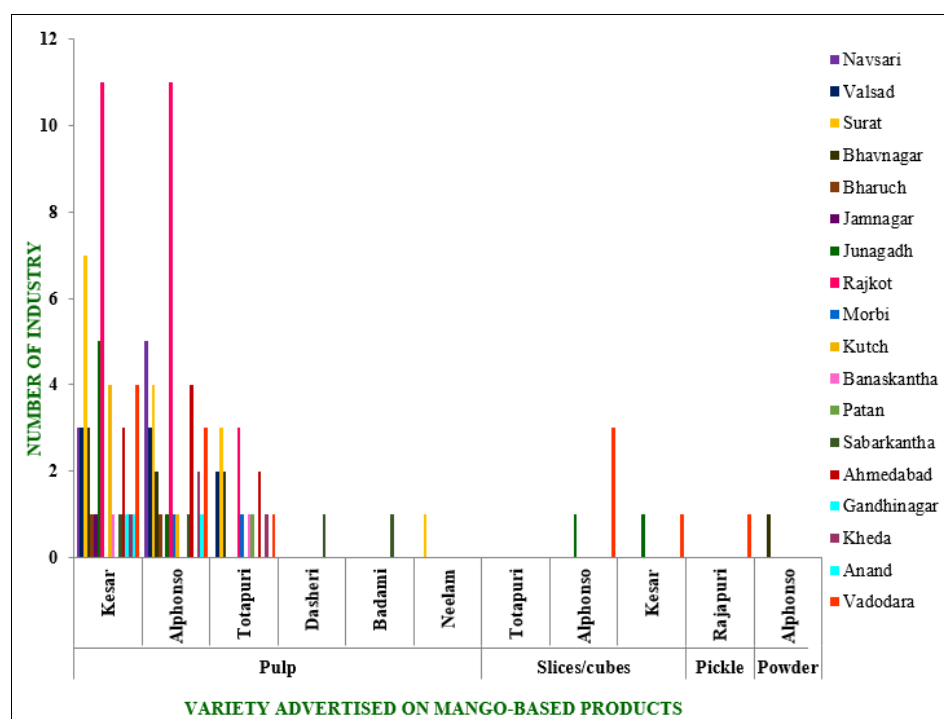


Fig 1.5: Advertisement based - Varietal Utilization by Industries

Several industries such as of pulp, canned slices, puree, mango powder, pickle etc. advertise their products by even mentioning the specific varieties alongside whichever they use. From the statistical data of different product-based industries and their advertised varietal utilization (Figure 1.5), it can be distinctly inferred that the majority of the pulp industries utilize the ripe fruits of Kesar, Alphonso and Totapuri varieties. Whereas very few number of industries also use varieties such as Dasheri, Badami and Neelam for pulp production. For products like canned slices/cubes etc., Kesar and Alphonso are the advertised varieties. A very little number of industries advertised the products like pickle and mango-powder etc. alongside their variety's name.

Phase 2: Telephonic Survey

All the listed out 233 industries belonging to 24 districts were contacted as a part of telephonic survey in which 48 industries belonging to 14 districts have responded i.e. only 20.60% of the total surveyed industries. The response has been obtained from industries in various districts of Saurashtra, Central Gujarat, North Gujarat and South-Gujarat. There has been absolutely no response from Kutch. The district-wise graphical data of number of industries contacted versus number of industries responded for the survey (Figure 1.6) across the state indicates that the highest number of response was recorded from Rajkot, followed by Valsad, Surat and Bhavnagar district etc. The other districts from where the response for the survey was recorded are Navsari, Valsad, Surat, Tapi, Bharuch, Mehsana, Patan, Gandhinagar, Vadodara, Ahmedabad, Rajkot, Junagadh, Jamnagar and Bhavnagar (Figure 1.7).

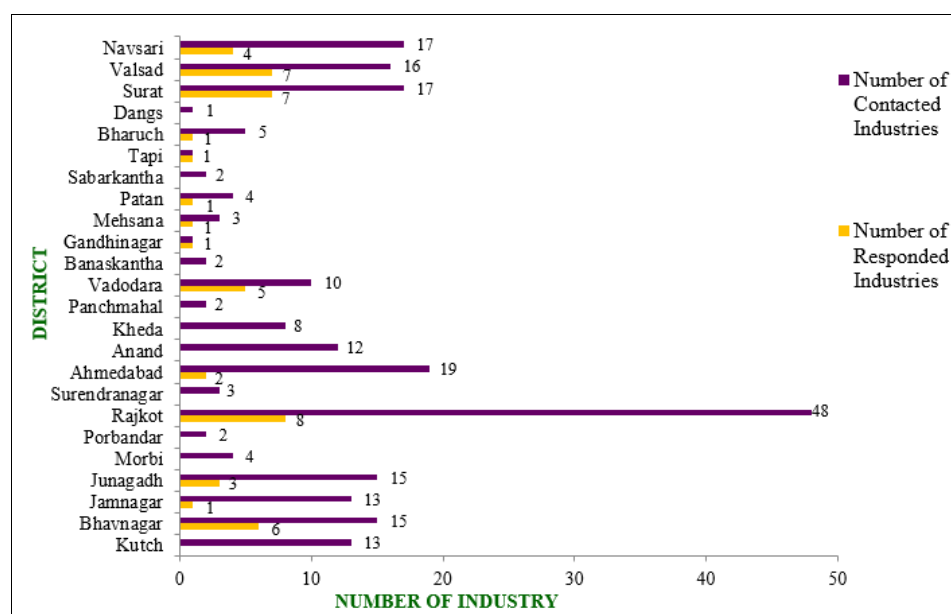


Fig 1.6: Graphical data of industries contacted vs. responded for the survey

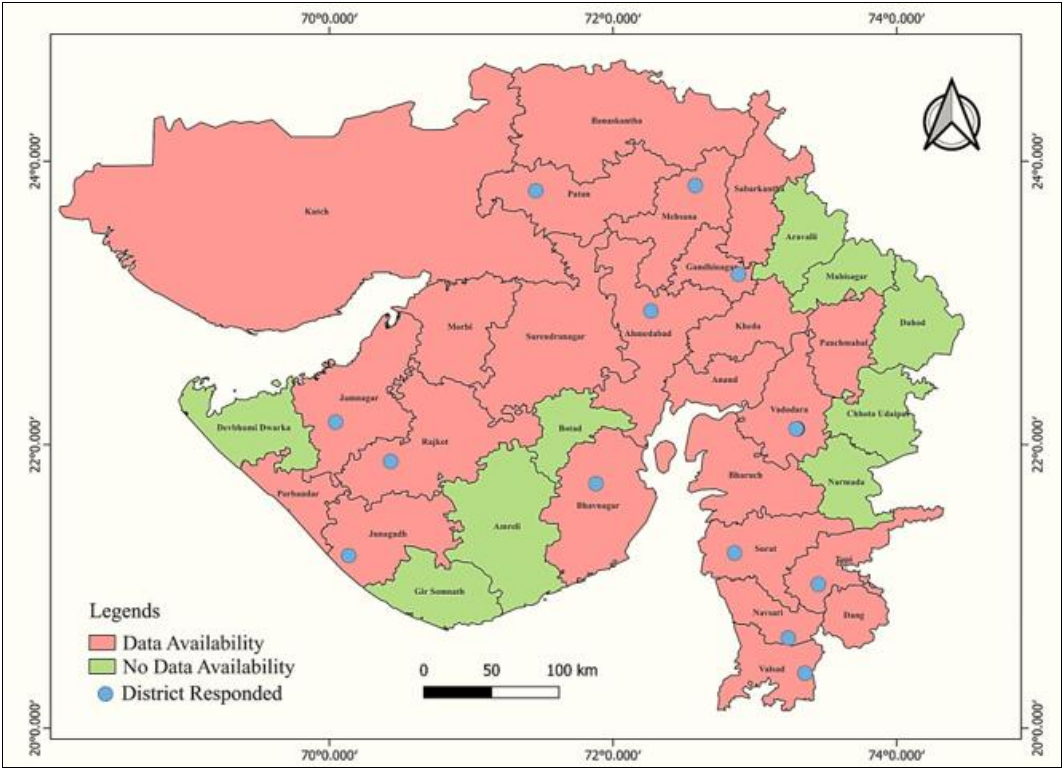


Fig 1.7: State-map marked with the districts from where the industries responded.

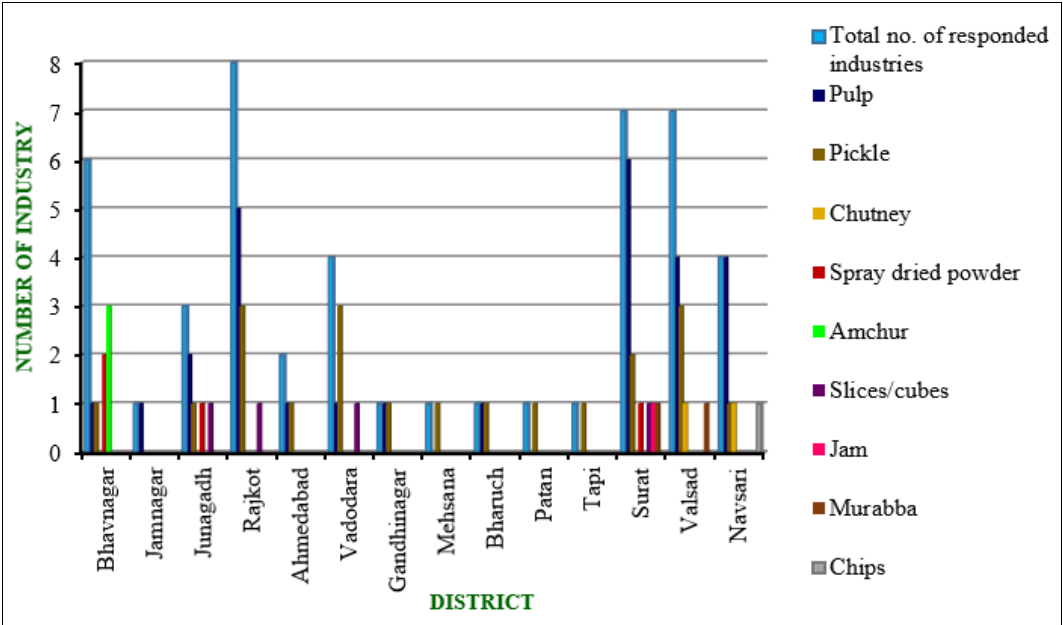


Fig 1.8: The district-wise graphical data of responded industries with respect to the manufactured product-type

The district-wise statistical data of the responded industries with respect to the manufactured product-type (Figure 1.8) indicates that the major response has been from pulp making and pickle making industries i.e. 27 and 20 respectively. The response has been significantly lower in industries making other mango-based products. The details regarding specific variety utilisation for specific product type, the fruit procurement place, waste management practices, etc. were also collected from the industries during the survey.

Gujarat is a treasure trove of mango varieties, especially South-Gujarat. The different varieties growing across the state are available in the markets during the full swing of the summer season. So, for the production of the different mango-based products, the fruits are procured from different specific mango

growing regions of Gujarat. From the interaction with the industrial representatives, it came to know that the industries mostly procure the large amount of fruits from locally present big market such as Agricultural Produce Market Committee (APMC) market, at the reasonable rates. Very small number of industries procure the fruits directly from the farm owners. Some industries' owner has their own lands with mango cultivation, thus making them self-sufficient in directly procuring fruits. Generally, the place of fruit procurement by any industry depends on its location; cost of fruits as raw material and logistics, and availability of the desired variety and quality of fruit that is specific to their product.

It has been observed that industries in the region of Saurashtra i.e. in Junagadh, Bhavnagar, Rajkot, Jamnagar districts etc.

mainly uses Kesar as the most favoured variety for its products, followed by Alphonso, Rajapuri and Desi varieties etc. although in lesser quantities. Kesar is procured from Talala region in Gir-Somnath district majorly, and also from Junagadh and Bhavnagar districts. Few of these region's responded industries procure Rajapuri as well as Desi varieties cultivated in Saurashtra and Alphonso variety mainly from Ratnagiri in Maharashtra. In the South-Gujarat zone, the responded industries of Navsari, Surat and Valsad district uses Kesar, Alphonso, Totapuri and Rajapuri varieties preferentially for manufacturing various products. Since a wide range of mango varieties are cultivated on a substantial amount of land in this region, industries from this area mostly utilize fruits grown over here. They majorly procure Kesar, Alphonso, Totapuri and Rajapuri varieties from the sellers at local or regional APMC markets of this area. Some industries also procure Alphonso variety from Ratnagiri (in Maharashtra) and Totapuri variety from South-Indian states such as Andhra Pradesh, Tamil-Nadu etc. In addition to these four types, a few industries in this zone also use Dasher, Desi, Malgoba, Barmasi, Pyrii, Pachatiya, Langda, and other varieties that are purchased from local markets. Dasher variety used by handful number of industries,

sometimes is been procured from North-Indian states. The few responded industries of Central Gujarat similarly use Kesar, Alphonso, Rajapuri, Totapuri and Desi variety for their products. These zonal industries procure Kesar i.e. Gir Kesar variety mostly from Saurashtra; Alphonso from South-Gujarat and Maharashtra; Totapuri from South-Gujarat and South-Indian states; Rajapuri from South as well as from certain Central Gujarat regions of Vadodara district and Desi variety cultivated in the same region. Few number of responded pickle industries from North-Gujarat utilizing Rajapuri variety procures the fruit from South-Gujarat region. The district-wise statistical data about the place of fruit procurement of most used varieties like Kesar, Alphonso, Rajapuri and Totapuri by the survey responded industries is represented in Figure 1.9 and the data about the place of fruit procurement of least used varieties like Dasher, Desi, Malgoba, Langda, Pyrii, Pachatiya and Barmasi is represented Figure 1.10. The survey indicates that most of the industries are specific of the varieties that are used but not so particular of the region from where the specific varieties are cultivated. For instance, Ratnagiri Alphonso is worldwide famous, yet few industries also bought it from Valsad.

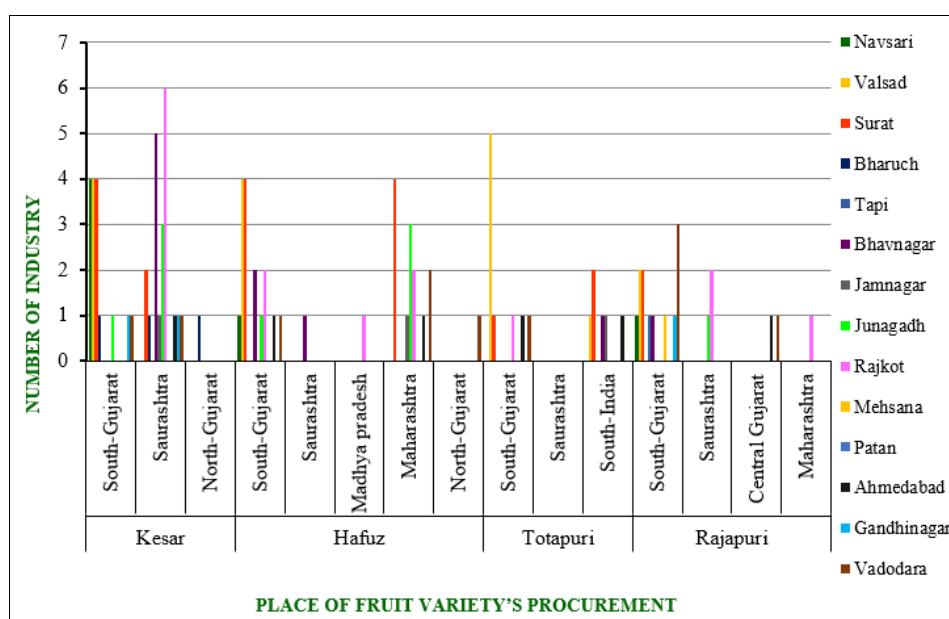


Fig 1.9: The district-wise graphical data of the place of procurement of Kesar, Hafuz (Alphonso), Rajapuri and Totapuri varieties by the survey - responded Industries

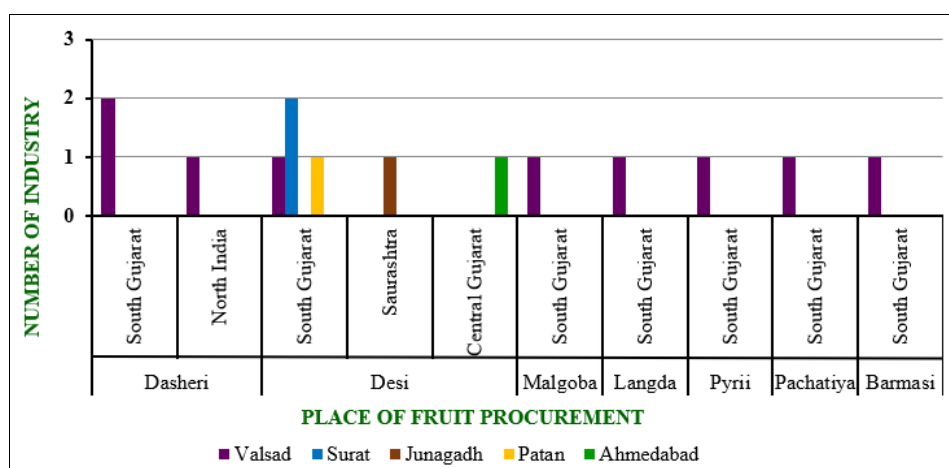


Fig 1.10: The district-wise graphical data of the place of procurement of Dasher, Desi, Malgoba, Langda, Pyrii, Pachatiya and Barmasi varieties by the survey - responded Industries

Industries select the specific mango varieties for their particular products depending upon its shelf-life, cost effectiveness, consumer rating, availability, and quality enhancement capacity. They use mango varieties of different maturation stages depending upon the product type they manufactured. Also, the preferred varieties vary significantly for ripe and raw mango processing industries for different products. Raw mangoes are used to make different types of sweet and sour mango pickles, murabba, chutney and amchur powder etc. From the survey it has come to know that, in terms of pickles, the raw fruit of the “Rajapuri” is the most popular. Murabba and Chutney are mostly prepared from raw “Totapuri” as well as “Rajapuri” fruits. However, several small-scale enterprises in South Gujarat use locally available varieties too, such as “Desi”, “Pachatiya”, “Malgoba”, and “Barmasi” to make raw mango processed items. For making the jam, pulp, puree, canned slices, spray dried mango powder etc, ripe mango fruits are utilised. According to the current survey, ripe fruits of “Kesar”, “Alphonso” and “Totapuri” are the most popular kinds for producing aforementioned processed goods. However, few industries also use varieties such as “Dasher”, “Langda”, “Pai”, and others to make the ripe mangoes’ items. The figure 1.11 represents the district-wise graphical data of the varietal utilization by the

responded industries manufacturing ripe-mango based products. Kesar in 26, Hafuz in 20 and Totapuri in 9 industries are top three favoured varieties for pulp production in Gujarat. While very little number of industries also uses Dasher, Pyri and Langda ripe fruits for pulp production. For slices/cubes as well as Mango powder, the graphical data shows Alphonso and Kesar are the most favoured varieties. For jam and mango chips production, only one and one industry has responded that too using Alphonso for the former one and Kesar for later one. The figure 1.12 represents the district-wise graphical data of the varietal utilization for raw mango based products by the responded manufacturing industries. The graph clearly shows that for 17 industries (i.e. highest number) uses Rajapuri for different types of pickle production. 5 small scale industries also use locally available Desi variety for pickles, followed by handful industries using Kesar, Totapuri and Alphonso for the same. For Chutney production, 3 responded industries from Bhavnagar use Kesar variety, whereas handful industries also use Totapuri, Rajapuri and Malgoba for it. Similarly for Murabba production, very few industries that too of Valsad and Surat districts have responded to use Rajapuri, Totapuri, Barmasi, Pachatiya and Desi varieties available there locally.

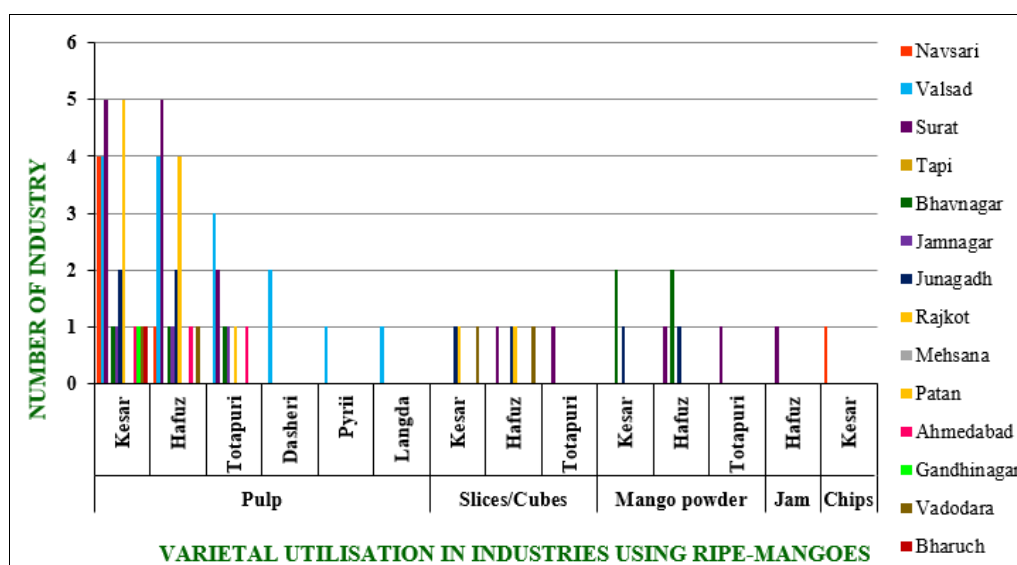


Fig 1.11: The district-wise graphical data of the varietal utilization by the responded industries manufacturing ripe-mango based products

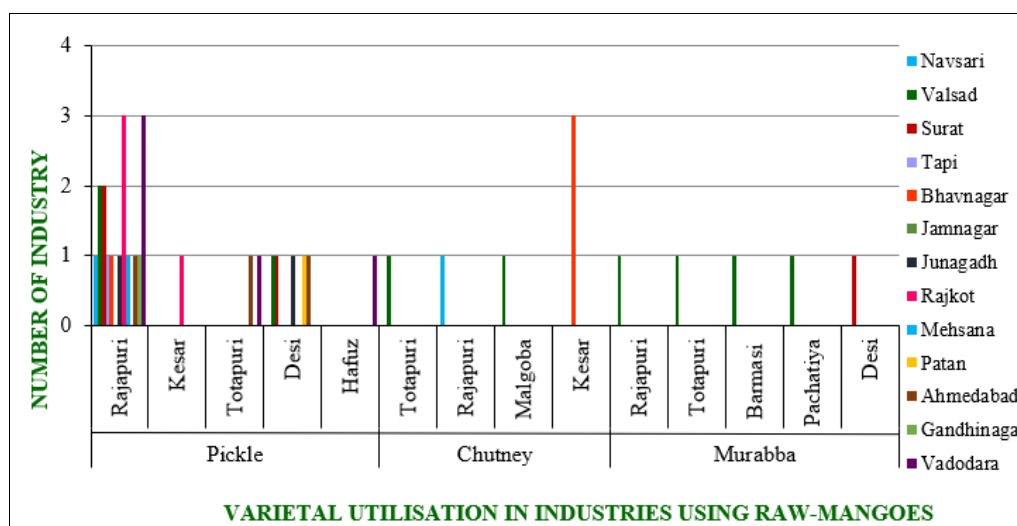


Fig 1.12: The district-wise graphical data of the varietal utilization by the responded industries manufacturing raw-mango based products.

Waste management practices of the responded industries has also been surveyed to understand the strategy followed by the industries to manage and utilize the large amount of the mango waste generated after the products are produced. In general, the waste management practice varies amongst industries due to differences in their scale, size, and resources. Following the fruit processing, industries are left with the significant amount of mango peel and stony endocarp with seed kernel contained inside it, as leftover waste. From the survey, it has been found that residual peel is further given away for mostly its use as fertiliser and as cattle feed. A good number of industries directly discard the peel as garbage, demonstrating an inefficient management strategy. Certain industries also said to use peel for biogas production, or its use as fuel after drying it. Some industries supply the peel to the known farmers or to the person requiring it for other purposes. The majority of the examined industries sell the leftover seeds for the production of mouth freshener (Mukhwas). A very good number of industries sell the seeds to the Nursery where seedling- plantlets are prepared. A

fair share of industries supplies the seeds to the required person who further uses seeds for various (not mentioned) purposes. Similarly considerable number of industries directly discards the seeds as waste, demonstrating no waste management strategies. Few of them use seeds for making fertilizers, traditional herbal medicines as well as for the biogas production and cattle feed. The above described result of the survey for each district, along with the statistical data is represented in figure 1.13 as the data of waste-management practices followed by the surveyed industries of Gujarat. It clearly shows for peel, the highest i.e. 11 industries use it for making fertilizer, followed by 7 industries directly discarding as waste and 6 industries for cattle feed and so on. In-case of leftover seeds, 19 (i.e. highest number) industries give way the seeds for Mukhwas production, followed by 11 industries providing seeds to the nurseries for making plantlets. The other waste-management practices of both peel and seeds are followed by considerably less number of industries.

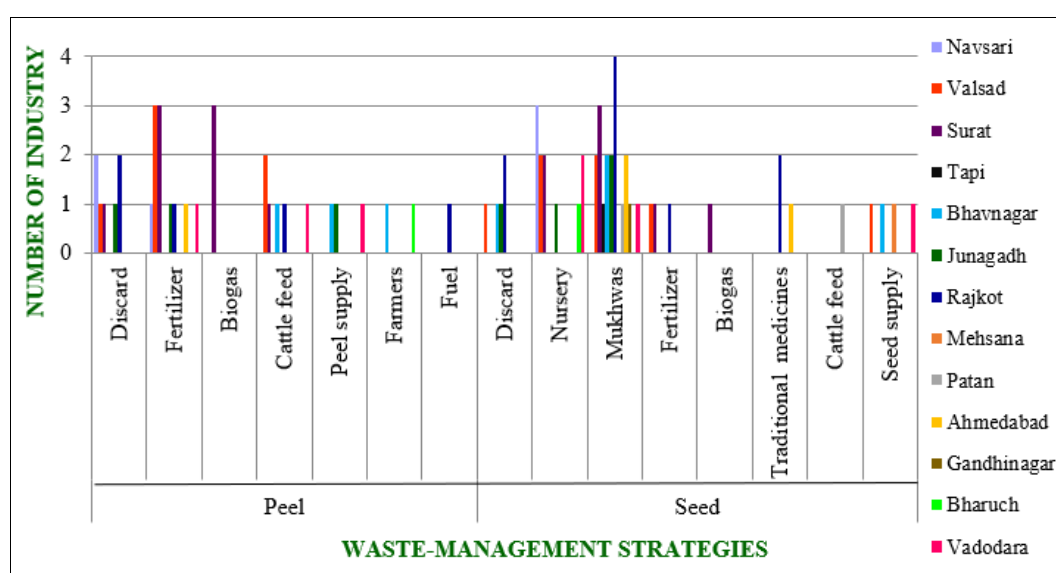


Fig 1.13: The district-wise graphical data of the waste-management practices of the survey-responded Industries.

The willingness for the allowance of industrial visits and supplying processing waste for research purposes was also recorded during the telephonic survey. Out of 48 responding industries, 14 industries allowed for the visit, 10 industries refused, 6 industries gave uncertain (maybe) response and 18 industries gave no response (NR). Similarly regarding the supply of the waste, 12 industries agreed to provide waste, 12 industries refused, 4 industries gave uncertain (maybe) response and 20 industries gave no response (NR). These results indicate that only limited number of industries were willing to actively participate for further research.

As a part of ground truth verification, a visit to Dharampur APMC (Agriculture Produce Market Committee) market, in the Valsad district of Gujarat state has been done in the month of May (2023). To better know about the varieties preference, price, purchase etc by the various mango-based industries such as pickle and pulp (also known as “Canning”) industries, this site-visit has remained crucial. Because mostly, the large scale industries procure the tonnes of mangoes for processing from the APMC market only. Farmers sell their produced mangoes to the traders at APMC market and industrial person purchases the mangoes from hereby. Thus, the APMC market is like a mediator and the persons regulating it know the better about the

requirements of these industries. From the interrogation with few traders of the Dharampur APMC market, it has come to know that several of the mango-based industries purchases and utilises the second- grade mangoes for their product manufacturing. Second-grade mangoes are one with the different spots on the peel or little smaller in size etc. The price difference between the same variety’s first-grade mangoes to second-grade mangoes can vary from 300 Rupees-1000 Rupees per 10 kilograms. Thus, the industries prefer the second-grade mangoes more. It has also come to light that majority of the first-grade mangoes are exported to other countries. Farmers from within 150 km radius from Dharampur, comes here for selling their produced mangoes. An interesting way of bargaining and finalising the deal of mango selling and purchasing goes on here. The two involved persons hide their hands under a cloth and by using their fingers during the handshake, they fix the monetary rates. The interrogated traders have highlighted the following facts: There are more than 150 varieties of mangoes growing in this Valsad district. The industries from different areas of Gujarat and Maharashtra buy Kesar and Alphonso predominantly from this market. The industries from Rajasthan buys Langda and Dasher varieties, from Uttar-pradesh buy Dasher and Chausa varieties and from Madhya-pradesh buy

Desi varieties. One of the interrogated person has also claimed that juice brands like Frooti and Maaza uses Totapuri variety for their product and that the pickle industries predominantly uses Rajapuri variety. It has also come to light that Amrapalli variety is recently gaining attention by few canning industries. Additionally, few canning industries have been known that mixes Amrapalli and Totapuri varieties for producing Kesar like taste and Dasheri with Totapuri for producing Alphonso-like taste. Overall, with this site visit, it was confirmed that mango-based industries of Gujarat shows mighty interest for Kesar, Alphonso and Rajapuri varieties for its ripe and raw mango-based products respectively. This result is similar to what we got in the survey.

Discussion

The secondary data from digital platforms, the primary data via telephonic survey and also a field visit to Dharampur APMC market, all confirmed Kesar, Hafuz / Alphonso and Rajapuri being the most prized and utilized variety by the industries. All the three varieties have their own unique essence. The three hotspots for Kesar variety cultivation were found to be in Saurashtra (especially areas nearby Gir), South-Gujarat (Valsad and Navsari) and Kutch. The Kesar variety cultivated at Gir/Saurashtra belt, especially Talala, Junagadh, Gir-Somnath or nearby areas is called as “Gir Kesar”, and is also given GI (geographical Indication) tag. It is considered to be the unique variety of Gujarat, highly prized for its saffron coloured pulp and intense aroma. The Valsadi Kesar and Kutchi Kesar are also gaining momentum for the consumer preference, nowadays. Alphonso, locally known as “Hafuz or Hapus” is called “King of mangoes”. Although the variety has its origin of Maharashtra, it is also cultivated and consumed in huge amount in South – Gujarat belt i.e. Valsad and Navsari districts. It is known for its saffron colour, rich sweetness and buttery fibreless texture. It is a seasonal staple across the state. The Rajapuri variety of mango is highly versatile and largely produced summer variety, native to Gujarat. This variety is firm, comparatively large in size, heavier in weight, with thick raw peel and a very sour taste while being raw, whereas it is extremely sweet when ripe. This variety is consumed at both raw and ripe stages for different purposes. Still, the Rajapuri variety owing to its unique feature has a significantly high shelf life compared to the other varieties and thus is most favoured by pickle industries. The preference of these three varieties appears to be both product-specific and market-driven. The fruit procurement patterns also depicted the relevance of these varieties. By understanding the industrial preference for these varieties, it will be useful for planning future waste collection, segregation and value-added utilization of mango processing waste.

There were certain limitations of this survey too. The information accessible on the various e-commerce platforms about the numerous mango-based enterprises is incomplete. Some industries may not have registered or advertised themselves on an internet platform. As a result, such industries could not be included in the current study. This concern is supported by a report of Ministry of Food Processing Industries (2022) claiming that in Gujarat, there are about 1500 unregistered mango processors and 200 registered ones [24]. According to this report, only 8% of mango production of the state is processed i.e. about 96,000 metric tonnes of mangoes. From this 8%, 6.5% is utilized for pulp and puree, 1% for pickles, 0.2% as cut fruits and 0.3% as mango powder. This trend is also seen in the present survey where the pulp and pickle industries formed the leading product categories. According to a

report, India exports pulp of worth USD 80.34 million in the year 2024-25 [25]. The low level of processing of huge amount of produced mangoes also indicates the untapped potential of value addition in the state. Further studies should integrate online database surveys with field level visits to APMC markets, processing units and local mango-farming belts. Such an approach would provide a greater scope for understanding and optimizing the more efficient ways for waste valorization across the state.

Conclusion

In the present study, the survey shows that online visibility and response involvement of mango based processing industries is not evenly distributed. 48 industries out of 233 industries have responded to the telephonic survey. The overall data analysis revealed that there was a clear relationship between the product type and choice of variety, with Kesar, Alphonso and Totapuri being chosen mainly for ripe mango products like pulp, puree, slices etc.; while Rajapuri and local desi varieties being used mainly for the pickles, murabba and chutney making. Varieties availability, regional markets, APMC network and inter-state supply chains influenced procurement of mangoes heavily. Waste management by the industries was found to be quite variable and sporadic. Peel being mostly used for fertilizer, cattle feed or discarded. Seed was mainly supplied for mukhwas production and for nursery usages. The results showed that although some reuse of mango waste leftovers were already present, their scientific valorisation is restricted. Thus, this survey provides primary industry-specific information that can serve as a baseline for understanding current status of mango-processing waste management practices in Gujarat and help in identifying the opportunities for scientific valorization, industrial revenue generation, and circular economy based utilization of mango peel and seed waste.

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References

1. Food and Agriculture Organization. Major tropical fruits market review 2023. Rome: FAO; 2024.
2. Gonzatto MP, Santos JS. Introductory chapter: Worldwide fruit crops production and research. In: Gonzatto MP, Santos JS, editors. Fruit Crops Science - Ecophysiological and Horticultural Perspectives. London: IntechOpen; 2025.
3. OECD/FAO. OECD-FAO Agricultural Outlook 2025-2034. Paris: OECD Publishing/Rome: FAO; 2025.
4. Agricultural and Processed Food Products Export Development Authority. Mango. 2025. <https://apeda.gov.in/Mango>
5. Ministry of Food Processing Industries. Sector profile: Fruits and vegetables. New Delhi: Government of India; 2025. https://mofpi.gov.in/sites/default/files/KnowledgeCentre/Sector%20Profile/F%26V_Sector_Profile%281%29.pdf
6. Owino WO, Ambuko JL. Mango fruit processing: Options for small-scale processors in developing countries. Agriculture. 2021;11(11):1105.
7. ETGovernment. Gujarat mango exports surge to 856 MT in 2024-25; total exports exceed 3,000MT in five years. <https://government.economictimes.indiatimes.com/news/ps>

- u/gujarat-mango-exports-surge-to-856-mt-in-202425-total-exports-exceed-3000-mt-in-five-years/122814041
8. Garcia-Mahecha M, Soto-Valdez H, Carvajal-Millan E, Madera-Santana TJ, Lomeli-Ramirez MG, Colin-Chavez C. Bioactive compounds in extracts from the agro-industrial waste of mango. *Molecules*. 2023;28(1):458.
 9. Jahurul MHA, Zaidul ISM, Ghafoor K, Al-Juhaimi FY, Nyam KL, Norulaini NAN, *et al.* Mango (*Mangifera indica* L.) by-products and their valuable components: A review. *Food Chem*. 2015;183:173–180.
 10. Okino Delgado CH, Fleuri LF. Orange and mango by-products: Agro-industrial waste as source of bioactive compounds and botanical versus commercial description - A review. *Food Rev Int*. 2016;32(1):1–14.
 11. Nicolas-Garcia M, Borrás Enriquez AJ, Gonzalez Escobar JL, Calva Cruz OJ, Perez Perez V, Sanchez Becerril M. Phenolic compounds in agro-industrial waste of mango fruit: Impact on health and its prebiotic effect - A review. *Pol J Food Nutr Sci*. 2023;73(1):5–23.
 12. Campos DA, Gomez-Garcia R, Vilas-Boas AA, Madureira AR, Pintado MM. Management of fruit industrial by-products: A case study on circular economy approach. *Molecules*. 2020;25(2):320.
 13. Ajila CM, Bhat SG, Prasada Rao UJS. Valuable components of raw and ripe peels from two Indian mango varieties. *Food Chem*. 2007;102(4):1006–1011.
 14. Marcal S, Pintado M. Mango peels as food ingredient/additive: Nutritional value, processing, safety and applications. *Trends Food Sci Technol*. 2021;114:472–489.
 15. Wongkaew M, Chaimongkol P, Leksawasdi N, Jantanasakulwong K, Rachtanapun P, Seesuriyachan P, *et al.* Mango peel pectin: Recovery, functionality and sustainable uses. *Polymers*. 2021;13(22):3898.
 16. Kittiphoom S. Utilization of mango seed. *Int Food Res J*. 2012;19(4):1325–1335.
 17. Kittiphoom S, Sutasinee S. Mango seed kernel oil and its physicochemical properties. *Int Food Res J*. 2013;20(3):1145–1149.
 18. Mwaurah PW, Kumar S, Kumar N, Panghal A, Attkan AK, Singh VK, *et al.* Physicochemical characteristics, bioactive compounds and industrial applications of mango kernel and its products: A review. *Compr Rev Food Sci Food Saf*. 2020;19(5):2421–2446.
 19. Ajila CM, Leelavathi K, Prasada Rao UJS. Improvement of dietary fiber content and antioxidant properties in soft dough biscuits with the incorporation of mango peel powder. *J Cereal Sci*. 2008;48(2):319–326.
 20. Bandyopadhyay K, Chakraborty C, Bhattacharyya S. Fortification of mango peel and kernel powder in cookies formulation. *J Acad Ind Res*. 2014;2(12):661–664.
 21. Chirumamilla V. Waste disposal and management practices in fruit and vegetable processing plants in Gujarat. *Discov Sustain*. 2026;7:631.
 22. Patel S, Joshi JP, Bhatt B. An assessment of spatio-temporal variability of land surface temperature using MODIS data: A study of Gujarat state, India. *Geogr Compass*. 2017;11(4).
 23. Gujarat Institute of Disaster Management. Rainfall variability over Gujarat state 2022. Gandhinagar: GIDM; 2022. <https://gidm.gujarat.gov.in/sites/default/files/Rainfall-variability-over-Gujarat-in-2022.pdf>
 24. Ministry of Food Processing Industries. Assessment of infrastructure gaps and development of potential value chains: Mango. New Delhi: Government of India; 2022. https://www.mofpi.gov.in/sites/default/files/study_on_infrastructure_gaps_-_mango_0.pdf
 25. Agricultural and Processed Food Products Export Development Authority. Mango pulp. 2025. <https://apeda.gov.in/MangoPulp>