



RESEARCH ARTICLE

Economics and supply chain analysis of major spices in Middle Gujarat

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Abstract

India is a leading producer and exporter of spices, renowned for their distinctive aroma, texture and taste. Sustaining this position requires improvements not only in production and productivity but also in supply chain efficiency. This study examines the economics, supply chain structure, marketing efficiency, post-harvest losses and production constraints of three major spice crops—dry chilli, turmeric and ginger—in a representative spice-producing region of India. Primary data were collected from 300 farmers and key market intermediaries using a structured survey. The results indicate that ginger had the highest cost of cultivation (₹ 505509.27 ha⁻¹), while dry chilli exhibited the highest benefit-cost ratio (2.30), reflecting superior economic viability. Although turmeric recorded the highest yield (305.60 q ha⁻¹), its profitability remained moderate due to higher marketing costs and post-harvest losses. Short-distance marketing channels were found to be more efficient, offering higher producer shares and lower price spreads. Post-harvest losses ranged from 24.91 % to 25.81 % with the highest losses occurring at the retail level due to inadequate handling, storage and transportation. The study highlights that supply chain inefficiencies and post-harvest management significantly influence farm profitability. Strengthening market linkages and investing in post-harvest infrastructure are essential to enhance farmers' income and ensure sustainable spice production.

Keywords: cost and returns; marketing efficiency; post-harvest losses; spices; supply chain

Introduction

Horticultural crops play a vital role in enhancing farm income, generating rural employment and promoting diversification in agricultural systems. Compared to traditional field crops, horticulture offers higher productivity and profitability per unit area, making it a key driver of sustainable agricultural growth, particularly in developing economies (1). In India, the horticulture sector encompasses a wide range of crops, including fruits, vegetables, flowers, plantation crops, medicinal and aromatic plants, as well as spices, with spices occupying a prominent position due to their economic value, strong domestic demand and expanding global market presence (2, 3).

Spices contribute significantly to agricultural income and rural livelihoods and are cultivated predominantly by small and marginal farmers. India is globally recognised as one of the leading producers, consumers and exporters of spices, owing to its favourable agro-climatic diversity and long-standing dominance in spice cultivation and trade. Dry chilli, turmeric and ginger are among the most commercially important spice crops, widely used in culinary, medicinal and industrial applications. These crops not only contribute to value addition and export

earnings but also play a critical role in improving farm-level profitability when supported by efficient production and marketing systems (4, 5). The state of Gujarat ranks second in spice production in India. As per recent estimates, Gujarat's annual output includes around 8.82 lakh metric tonnes of spices, 77.63 lakh metric tonnes of fruits and 100.50 lakh metric tonnes of vegetables (6). The Middle Gujarat region contributes significantly to the spice production.

Between 2015–16 and 2020–21, the area under dry chilli cultivation has increased by 6.82 % at the India level, rising from 657.20 to 702.00 thousand hectares. In Gujarat, the area expanded by 4.74 % (from 11.39 to 11.93 thousand hectares), while Middle Gujarat witnessed a significant increase of 17.24 % (from 2.90 to 3.40 thousand hectares). For ginger, the cultivated area increased by 6.37 % at the India level (from 192.60 to 204.80 thousand hectares), 20 % in Gujarat (from 4.22 to 5.06 thousand hectares) and 16.67 % in Middle Gujarat (from 3.60 to 4.20 thousand hectares). In the case of turmeric, the area under cultivation increased by 8.67 % at the India level (from 269.40 to 292.90 thousand hectares), 12.89 % in Gujarat (from 4.15 to 4.69 thousand hectares) and 17.48 % in Middle Gujarat (from 2.06 to 2.42 thousand hectares). During 2020–21, dry chilli production in India

reached 2049.20 thousand metric tonnes with Gujarat contributing 23.34 thousand metric tonnes and Middle Gujarat accounting for 6.52 thousand metric tonnes. For turmeric, national production was 1123.90 thousand metric tonnes, of which Gujarat produced 90.95 thousand metric tonnes and Middle Gujarat contributed 46.58 thousand metric tonnes. Regarding ginger, production at the national level was 2224.80 thousand metric tonnes, while Gujarat and Middle Gujarat produced 110.89 and 95.18 thousand metric tonnes respectively (7, 8).

Despite their economic importance, spice value chain in India is characterised by several structural inefficiencies. An efficient supply chain is essential to ensure remunerative prices for producers while delivering quality produce to consumers at reasonable costs (9). However, spice supply chains remain fragmented with limited access to organised markets, inadequate storage and processing infrastructure, weak market linkages and high transaction costs (10). Furthermore, the sector suffers from chronic underinvestment, outdated farming practices and technology, limited research and development (R&D) support and a general lack of marketing expertise (11). Smallholder farmers are particularly vulnerable due to low marketable surplus, weak bargaining power and dependence on multiple intermediaries, which often results in lower producer shares and higher price spreads (12).

Recent research emphasises that agricultural technologies and production systems must demonstrate not only environmental sustainability but also economic viability to attract investment and ensure long-term adoption. From an agribusiness and policy perspective, profitability, marketing efficiency and risk reduction are central to investment decisions in agricultural value chains. In this context, analysing the economics and supply chain performance of spice crops is essential to identify income leakages, assess marketing efficiency and design targeted interventions that enhance competitiveness and resilience.

Against this backdrop, the present study analyses the cultivation of dry chilli, turmeric and ginger through an integrated economic and supply chain framework. The study is guided by the hypothesis that inefficiencies in marketing channels and post-harvest management exert a stronger influence on farm profitability than production performance alone. By examining cost structures, marketing channels, post-harvest losses and constraints faced by farmers, the study seeks to generate policy-relevant and industry-oriented insights for improving income sustainability and supply chain efficiency in

spice cultivation systems.

Material and Methods

The study was purposively carried out in the Middle Gujarat region, covering six major spice-producing districts, namely Anand, Kheda, Dahod, Panchmahal, Godhra, Mahisagar and Vadodara. A multi-stage sampling technique was employed for the selection of respondents. In the first stage, major spice-producing districts were identified based on the concentration of area under the selected crops. In the second stage, villages and farm households engaged in spice cultivation were selected. A total of 300 farmers were surveyed, comprising 100 farmers each cultivating dry chilli, turmeric and ginger. In addition, key market intermediaries involved in the movement of spices from producers to consumers, including commission agents, local traders, processors, wholesalers and retailers, were selected to capture the complete supply chain structure. Primary data were collected during the agricultural year 2019–20 using a pre-tested structured interview schedule administered through personal interviews. The survey captured detailed information on input use, labour utilisation, cost of cultivation, yields, prices received, marketing practices, post-harvest handling, losses at different stages and constraints faced by farmers and intermediaries. Secondary data were obtained from published literature, government reports and official statistical sources to support trend analysis and contextual interpretation (Table 1).

Cost concepts

The Commission for Agricultural Costs and Prices (CACP) concept was used to calculate cost and returns analysis (13). The details of the cost concepts used in this study are as follows:

Cost A includes all actual expenses incurred by the farmer in cash as well as in kind during the production process. It consists of the following components;

1. Value of hired human labour
2. Value of hired bullock labour
3. Value of owned bullock labour
4. Value of tractor charges
5. Value of seed/seedlings (both farms produced and purchased)
6. Value of manure and cakes (owned farm and purchased)
7. Value of fertilisers
8. Value of insecticides and pesticides

Table 1. Distribution of sample farmers and market intermediaries selected for the study

Crops	Districts	Number of farmers	Number of commission agents/ local traders	Number of wholesalers/ pre-harvest contractors/ processors	Number of retailers
Ginger	Anand	25	10	10	10
	Dahod	25	10	10	10
	Panchmahal	25	10	10	10
	Mahisagar	25	10	10	10
	Total	100	40	40	40
Turmeric	Anand	35	10	10	10
	Godhra	30	10	10	10
	Dahod	35	10	10	10
	Total	100	30	30	30
	Kheda	25	10	10	10
Dry chilli	Anand	25	10	10	10
	Vadodara	25	10	10	10
	Dahod	25	10	10	10
	Total	100	40	40	40

9. Irrigation charges
10. Depreciation on farm buildings and farm implements
11. Interest on working capital
12. Other paid out expenses, if any.

Cost B includes Cost A, along with the rental value of owned land and interest on the value of owned fixed capital (excluding land).

Cost B = Cost A + Rental value of owned land + Interest on value of owned fixed capital (excluding land) (Eqn. 1)

Cost C₁ is obtained by adding the imputed value of family labour to Cost B.

Cost C₁ = Cost B + imputed value of family labour (Eqn. 2)

Cost C₂ is calculated by adding managerial charges (10 % of Cost C₁) to Cost C₁.

Cost C₂ = Cost C₁ + 10 % of cost C₁ (as managerial charges) (Eqn. 3)

Gross returns (or gross income) represent the total monetary value obtained from both the main product and by-products of the selected spice.

Net income indicates the actual profit earned by the farmer after covering all production costs.

Net income = Gross returns - Cost C₂ (Eqn. 4)

Per unit cost of production represents the average cost incurred for cultivating one hectare of land.

Per hectare cost of production = $\frac{\text{Total cost}}{\text{Area under crop (ha)}}$ (Eqn. 5)

The cost-benefit ratio measures the economic efficiency of spice production.

Cost-benefit ratio = Gross income / Cost C₂ (Eqn. 6)

Marketing analysis

For marketing analysis, the following formulas were employed (14):

(i) Producer's share in consumer's rupee

Producer's share is defined as the proportion of the retail price received by the producer, expressed as a percentage. The producer's share across different marketing channels was calculated using the following formula:

$$P_s = \frac{P_f}{P_r} \times 100 \quad (\text{Eqn. 7})$$

Where,

P_s = Producer's share in consumer's rupee

P_r = Price received by the producer

P_f = Price paid by the consumer

(ii) Marketing costs

Total marketing costs include all expenses incurred in cash or in kind by the producer and intermediaries involved in moving the produce from the point of production to the ultimate consumer. The total cost was computed as:

$$C = C_f + C_{m1} + C_{m2} + \dots + C_{mi} \quad (\text{Eqn. 8})$$

Where,

C = Total marketing cost per quintal of spice

C_f = Cost incurred by the producer on marketing

C_{mi} = Cost incurred by the ith middleman

(iii) Marketing margins

Marketing margin is defined as the difference between the total payments (costs + purchase price) and receipts (sale price) of the middlemen. The absolute and percentage margin of middleman involved in marketing were calculated as follows:

Absolute marketing margin of ith middleman = P_{ri} - (P_{pi} + C_{mi}) (Eqn. 9)

Percentage margin of ith middleman = $\frac{P_{ri} - (P_{pi} + C_{mi})}{P_{ri}} \times 100$ (Eqn. 10)

Where,

P_{ri} = Sale price of the ith middleman

P_{pi} = Purchase price of the ith middleman

C_{mi} = Cost incurred on marketing by the ith middleman

(iv) Modified measure of marketing efficiency (MME)

A higher ratio indicates greater marketing efficiency.

$$\text{MME} = \frac{\text{RP}}{(\text{MC} + \text{MM})} - 1 \quad (\text{Eqn. 11})$$

RP = FP + MC + MM

Where,

RP = Prices paid by the consumer

MC = Total marketing costs

MM = Net marketing margins

FP = Prices received by the producer

(v) Price spread

Price spread is the difference between two prices, i.e., the price paid by the consumer and the price received by the producer. For example,

$$\text{Price spread} = P_1 - P_2 \quad (\text{Eqn. 12})$$

Where,

P₁ = Price at one level or stage in the market

P₂ = Price at another level

Constraint analysis

Garrett's Ranking technique and Weighted Average Mean (WAM) were used to identify and prioritise the major constraints faced by farmers (13).

In Garrett's Ranking technique, the percentage score is calculated as,

$$\text{Percent score} = 100 \times \frac{(R_{ij} - 0.50)}{N_j} \quad (\text{Eqn. 13})$$

Where,

R_{ij} = Rank given for the ith constraint by the jth individual

N_j = Number of constraints ranked by the j^{th} individual

The percent position of each rank was converted into scores using Garrett's Table. For each constraint, the scores of individual respondents were summed and divided by the total number of respondents who responded. The mean score for each constraint was then ranked in descending order.

Weighted Average Mean was used as a supplementary method in some parts of the analysis to assess the relative importance of constraints by assigning weights to each rank.

Post-harvest losses were estimated at different stages of the supply chain—field level, wholesale level and retail level—using tabular analysis. Losses were quantified in percentage terms and classified based on major causes such as mechanical damage, pest and disease infestation, improper handling and storage-related deterioration.

Results and Discussions

Cost of cultivation of selected major spices in Middle Gujarat

Table 2 presents the average cost of cultivation, returns and profitability of selected major spice crops. Among the three crops studied, ginger cultivation incurred the highest cost across almost all input components. The value of human labour was highest in dry chilli cultivation (₹ 40425 ha⁻¹) followed by ginger (₹ 38640 ha⁻¹) and turmeric (₹ 30232.28 ha⁻¹). Machine labour costs were substantially higher in ginger cultivation (₹ 72000 ha⁻¹), indicating greater dependence on mechanisation for land preparation and intercultural operations, whereas turmeric and dry chilli recorded much lower machine labour costs of ₹ 12220 ha⁻¹ and ₹ 9800 ha⁻¹ respectively.

The cost of seed material constituted the largest share of total expenditure in ginger cultivation, amounting to ₹ 138342.84 ha⁻¹ followed by turmeric (₹ 88120 ha⁻¹) and dry chilli (₹ 18000 ha⁻¹). The higher seed cost in ginger is mainly due to the use of bulky rhizome seed material, higher seed rates and the requirement for quality planting material. Expenditure on fertilisers and manures was ₹ 79400 ha⁻¹ for ginger, ₹ 31034.80 ha⁻¹ for turmeric and ₹ 63440 ha⁻¹ for dry chilli. Pesticide costs were relatively higher in ginger (₹ 34000 ha⁻¹) and dry chilli (₹ 29400 ha⁻¹)

compared to turmeric (₹ 10300.84 ha⁻¹), reflecting greater pest and disease incidence in these crops.

The total Cost A, comprising all variable costs along with depreciation and interest on working capital, was highest for ginger (₹ 380480.52 ha⁻¹) followed by turmeric (₹ 188183.92 ha⁻¹) and dry chilli (₹ 176762.24 ha⁻¹). With the inclusion of the rental value of land and interest on fixed capital, Cost B increased to ₹ 433793.88 ha⁻¹ for ginger, ₹ 235079.80 ha⁻¹ for turmeric and ₹ 228769.80 ha⁻¹ for dry chilli. After adding the imputed value of family labour, Cost C₁ was estimated at ₹ 459553.88 ha⁻¹ for ginger, ₹ 250991.52 ha⁻¹ for turmeric and ₹ 247144.80 ha⁻¹ for dry chilli. With the addition of 10 % managerial charges, the final Cost C₂ amounted to ₹ 505509.27 ha⁻¹ for ginger, ₹ 276090.67 ha⁻¹ for turmeric and ₹ 271859.28 ha⁻¹ for dry chilli.

In terms of productivity, turmeric recorded the highest yield at 305.60 q ha⁻¹ followed by ginger (280 q ha⁻¹) and dry chilli (50 q ha⁻¹). However, differences in market prices led to substantial variation in total income, which was highest for ginger (₹ 875700 ha⁻¹) followed by dry chilli (₹ 625000 ha⁻¹) and turmeric (₹ 471540.80 ha⁻¹). Net income over Cost C₂ was ₹ 370190.73 ha⁻¹ for ginger ₹ 353140.72 ha⁻¹ for dry chilli and ₹ 195450.13 ha⁻¹ for turmeric.

The benefit-cost ratio, a key indicator of economic viability, was highest for dry chilli (2.30) followed by ginger (1.73) and turmeric (1.71). Although ginger cultivation involved substantially higher investment due to costly seed rhizomes, higher mechanisation and intensive input use, dry chilli emerged as the most economically viable crop. The comparatively moderate cost of cultivation in dry chilli—from seed procurement and input application to harvesting, post-harvest handling, packaging and market delivery—combined with favourable market prices, resulted in higher returns per unit of investment, making it the most cost-efficient spice crop among those studied.

Mechanisms used in various supply chains of selected major spices in Middle Gujarat

The adoption of appropriate post-harvest technologies plays a critical role in reducing both quantitative and qualitative losses in spices, thereby preserving product quality until it reaches consumers. It is estimated that nearly 30–40 % of fruits and

Table 2. Average cost of cultivation in selected major spices crops (₹ ha⁻¹)

Particulars	Ginger (n = 100)	Turmeric (n = 100)	Dry chilli (n = 100)
Value of human labour	38640.00	30232.28	40425.00
Value of machine labour	72000.00	12220.00	9800.00
Value of seeds	138342.84	88120.00	18000.00
Value of fertilisers and manures	79400.00	31034.80	63440.00
Value of pesticides	34000.00	10300.84	29400.00
Irrigation charges	3518.40	5616.00	5664.00
Depreciation	6395.56	2171.00	1664.84
Interest on working capital	8183.72	8489.00	8368.40
Total Cost A	380480.52	188183.92	176762.24
Rental value of land	50000.00	44000.00	49000.00
Interest on fixed capital	3313.36	2895.88	3007.56
Cost B	433793.88	235079.80	228769.80
Family labour	25760.00	15911.72	18375.00
Cost C ₁	459553.88	250991.52	247144.80
10 % of Cost C ₁	45955.39	25099.15	24714.48
Cost C ₂	505509.27	276090.67	271859.28
Total production	280.00	305.60	50.00
Market price received	3127.50	1543.00	12500.00
Total income	875700.00	471540.80	625000.00
Net income	370190.73	195450.13	353140.72
Benefit-cost ratio	1.73	1.71	2.30

Source: Field Survey (2019)

vegetables are lost annually due to inadequate handling, storage, packaging and transportation facilities (17). Consequently, greater emphasis on efficient post-harvest management practices is essential not only to enhance farmers' income but also to strengthen national food security and improve overall supply chain efficiency.

Method of harvesting

Harvesting of spices is predominantly a manual and labour-intensive operation involving hand-picking and hand-collecting of produce. This process is time-consuming and physically demanding and often leads to mechanical damage when carried out without adequate skill or supervision, thereby contributing to post-harvest losses.

Sorting and grading

Sorting is primarily carried out at the farm level to remove diseased, damaged or rotten produce with approximately 71 % of farmers adopting this practice. Grading is mainly based on physical attributes such as size and shape, classifying produce into large, medium and small categories, generally through manual inspection. In some cases, grading is also performed on the basis of weight. Limited adoption of standardised grading practices often affects price realisation and market acceptance.

Packaging

A variety of packaging materials are used in spice marketing, including plastic bags, gunny bags and nylon net sacks. Packaging plays a vital role in minimising post-harvest losses by protecting produce from mechanical damage, contamination and moisture. The choice of packaging material depends largely on the distance to the market; gunny bags are generally preferred for long-distance transportation, whereas plastic bags are more commonly used for nearby markets.

Gunny bags

Gunny bags, typically with a capacity of around 50 kg and adequate aeration, are widely used for packing dry chilli and ginger. Their durability and ease of handling make them suitable for transporting large quantities over long distances.

Transportation

Transportation and distribution constitute crucial components of the spice marketing system. Rapid and damage-free transport is essential for maintaining product quality, particularly for perishable commodities. Local transportation is generally carried out using tractors, trolleys and bullock carts, while road transport remains the dominant mode for long-distance marketing despite higher costs. Farmers commonly use tempos, rickshaws, mini-trucks and private vehicles, whereas traders and cooperatives rely on larger trucks for bulk transportation. Road transport is preferred due to its flexibility and accessibility from farm to market.

Post-harvest operations in ginger

Ginger rhizomes are thoroughly washed and sun-dried for one day. For dry ginger preparation, rhizomes harvested after about eight months are soaked in water for 6–7 hr and rubbed to remove impurities. The outer skin is carefully scraped using bamboo splinters to avoid damaging oil cells. The peeled rhizomes are then washed and uniformly sun-dried for approximately one week before final cleaning. For salted ginger, fresh rhizomes harvested at 170–180 days are washed and soaked in a 30 % salt solution containing 1 % citric acid. After about 14 days, the product becomes ready for consumption and can be stored under refrigerated conditions.

Factors affecting post-harvest losses in ginger

According to traders, major factors contributing to post-harvest losses in ginger include the absence of cold storage facilities, lack of mechanical washing equipment, use of non-refrigerated transport and improper packaging practices. Limited awareness of market quality requirements and inadequate product quality management during storage, washing, packaging and transportation further aggravate losses.

Post-harvest operations in turmeric

Harvested turmeric rhizomes undergo several post-harvest processes, including curing, drying, polishing and colouring, to convert them into a stable and marketable product. Curing is typically carried out within 3–4 days after harvest with fingers and mother rhizomes processed separately due to differences in cooking duration.

Post-harvest management aspects in turmeric

Harvest maturity is indicated by drying of plants and stems, generally occurring 7–10 months after planting, depending on cultivar and agro-climatic conditions. Rhizomes are carefully dug out manually or loosened using small diggers followed by the removal of foliage. They are cleaned by soaking in water to remove soil and debris before being processed or stored.

For seed purposes, rhizomes are stored in well-ventilated rooms and covered with dry leaves to minimise rot and dehydration. Alternatively, pit storage using sawdust, sand or *Glycosmis pentaphylla* (panal) leaves is practised for insect control. The Indian Institute of Spices Research (IISR) recommends pre-storage dipping of seed rhizomes in quinalphos (0.075 %) and mancozeb (0.3 %). Mainly, mother rhizomes are generally preferred over fingers as seed material (16).

Post-harvest handling in turmeric: curing, drying and polishing

Curing involves boiling turmeric rhizomes until soft, which gelatinises starch, removes raw odour and ensures uniform colour distribution. According to recommendations of the IISR and the Agricultural Technology Information Centre (ATIC), boiling for 45–60 min until froth appears is optimal (15). Alkaline treatment using sodium carbonate or lime enhances colour quality. Proper curing reduces drying time, improves appearance and facilitates polishing, although excessive boiling may reduce curcuminoid extractability (16).

Supply chain of selected major spices in Middle Gujarat

Supply chain mapping was undertaken to understand the flow of produce, inputs, costs and value addition across different stakeholders from production to consumption. Mapping the supply chain helps identify critical points of inefficiency, excessive intermediary involvement, cost accumulation and stages where post-harvest losses are most pronounced. It also facilitates the assessment of producer share in consumer prices and highlights opportunities for improving marketing efficiency, reducing transaction costs and strengthening farmer-market linkages. In the present study, supply chain mapping provided a comprehensive framework for analysing economic performance and identifying policy-relevant interventions across dry chilli, ginger and turmeric value chains.

Dry chilli

Producer: The cultivation of dry chilli requires seeds (improved varieties or hybrids), fertilisers, pesticides, irrigation inputs and hired or family labour. These inputs or raw materials are sourced

from agro-dealers or cooperative societies. Farmers used these raw materials to cultivate and harvest chillies and carry out essential post-harvest activities such as drying, cleaning, grading and packing, often using 40–70 kg gunny bags. Larger farmers typically use their own vehicles for transport, while small and medium farmers collectively hire transport to deliver the produce to nearby Agricultural Produce Market Committees (APMCs) or market yards.

Commission agent: The commission agent acts as an intermediary in the regulated market, facilitating sales between farmers and traders or wholesalers. They charge a fixed commission (usually around 3 %) for services such as weighing, arranging labour (hamali) and enabling price negotiations. They do not take ownership of the produce.

Wholesaler: Wholesalers buy the produce in bulk from commission agents and sell it further to retailers or processors. They may store the produce temporarily but often face challenges due to limited storage facilities, especially cold storage.

Retailer: Retailers purchase smaller quantities of dry chilli or chilli powder from wholesalers and sell directly to end consumers. They are the final link in the marketing chain and operate in local markets or retail shops.

Consumer: Consumers purchase dry chilli in small quantities as per their requirement for household or commercial use, typically as whole spice or ground powder used in cooking (Fig. 1).

Ginger

Producer: Ginger farming requires high-quality rhizome seed material, organic or chemical fertilisers, plant protection chemicals and irrigation. Inputs or raw materials are sourced from local nurseries, agro-dealers or farmer cooperatives. Ginger farmers used these raw materials to cultivate and carry out harvesting, sorting, grading and initial packaging of fresh rhizomes. The produce is packed in gunny or plastic bags and transported either directly to local markets or processing units. Some producers also make pre-harvest agreements with processors or wholesalers.

Processor: Processors handle cleaning, mechanical washing, scraping, drying (for dry ginger) or curing and salting (for salted ginger). Processing includes soaking, peeling, drying and sometimes storage. They play a key role in value addition and preservation of ginger.

Wholesaler: Wholesalers purchase processed ginger in bulk from processors or directly from farmers. They manage transportation, storage, sorting and occasionally minor cleaning before supplying the produce to retailers.

Retailer: Retailers procure smaller lots from wholesalers and sell fresh or processed ginger to consumers in local markets or retail outlets.

Consumer: The consumer purchases fresh, dry or salted ginger for culinary, medicinal or industrial purposes (Fig. 2).

Turmeric

Producer: Turmeric cultivation requires quality rhizome seeds, fertilisers (especially organic manure), irrigation and pest management inputs. These are obtained through agri-input dealers or agricultural extension centres. Turmeric producers used these raw materials to cultivate and undertake several essential post-harvest operations, including curing (boiling), drying, polishing and colouring of turmeric rhizomes. The produce is then packed and sent to local traders or market yards.

Local trader: Local traders purchase turmeric directly from farmers, especially in short-distance markets. They handle transport, loading/unloading and sometimes basic cleaning or sorting. They act as intermediaries before the produce reaches wholesalers or is directly sold in local markets.

Wholesaler: In long-distance markets, wholesalers (sometimes combined with commission agents) buy turmeric in bulk for further sale to retailers. They coordinate logistics, manage inventory and bear some portion of post-harvest loss.

Retailer: Retailers buy turmeric from wholesalers or local traders and sell it in small packets or loose form. They may sell either whole turmeric or ground turmeric powder in grocery shops or spice markets.

Consumer: Consumers purchase turmeric for regular household cooking, health remedies, cosmetic use and religious purposes (Fig. 3).

Marketing channels of selected major spices in Middle Gujarat

Dry chilli

The prevailing marketing channels for dry chilli in Middle Gujarat were as follows: there were two main channels through which dry chilli was marketed after harvest. Around 55.46 % of the produce was supplied through short-distance market Channel-II, while 44.54 % was supplied via long-distance market Channel-I (Table 3).

Channel-wise marketing cost of dry chilli in Middle Gujarat

Table 4 shows that the total marketing cost incurred by dry chilli producers amounted to ₹ 143.46 q⁻¹ in Channel-I and ₹ 162.71 q⁻¹ in Channel-II. Among the various cost components in Channel-I, labour charges were the highest (₹ 65.25 q⁻¹), accounting for 21.68 % of the total cost followed by post-harvest losses

Table 3. Marketing channels of dry chilli in Middle Gujarat

Marketing channel	Particulars	Percentage of produce moved	Net price received by the farmer (₹ q ⁻¹)	Net price paid by the Consumer (₹ q ⁻¹)
Channel-I	Producer-Commission agent-Wholesaler-Retailer-Consumer (Long-distance market)	44.54 % (P-29, Co-40, W-12, R-17)	16000	17143.55
Channel-II	Producer-Wholesaler-Retailer-Consumer (Short-distance market)	55.46 % (P-71, W-28, R-23)	17500	18539.16

Source: Field Survey (2019)

Note: Figures in parentheses indicate the number of respondents associated with each marketing channel (P = Producer, Co = Commission agent, W = Wholesaler, R = Retailer).

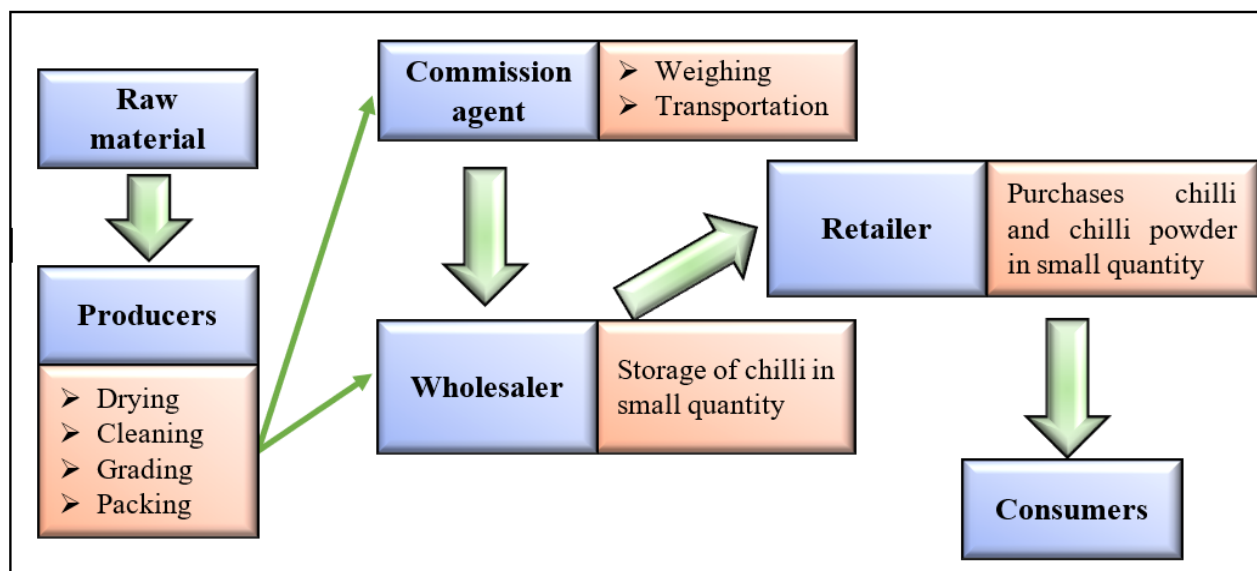


Fig. 1. Supply chain of dry chilli in Middle Gujarat: A schematic overview. Source: Field Survey (2019)

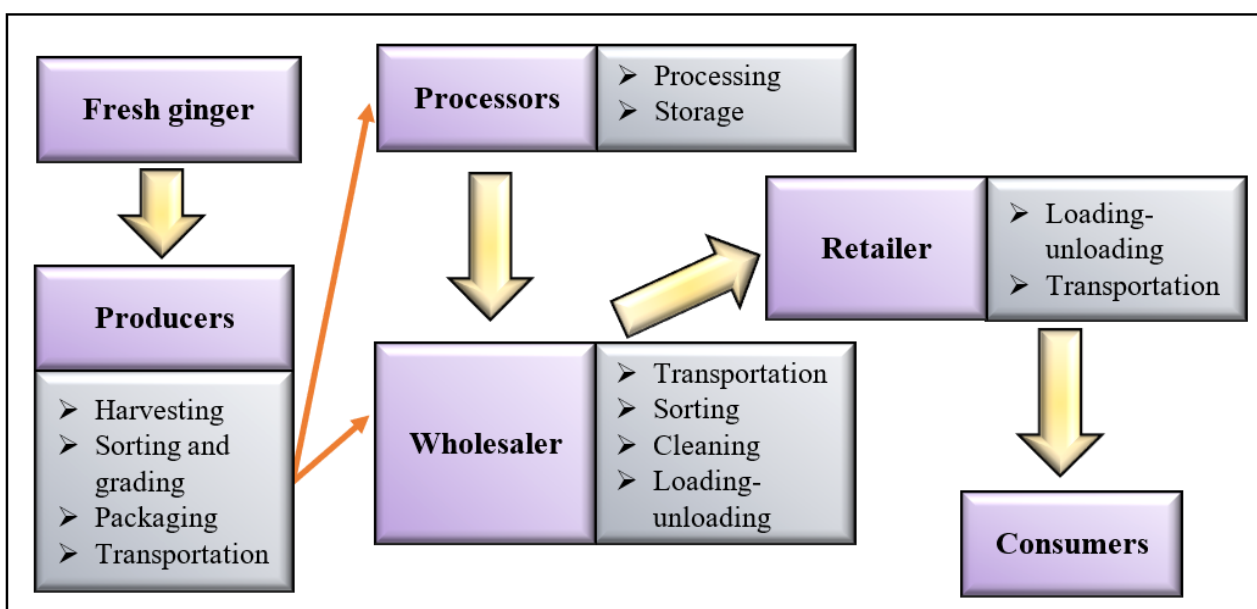


Fig. 2. Supply chain of ginger in Middle Gujarat: A schematic overview. Source: Field Survey (2019)

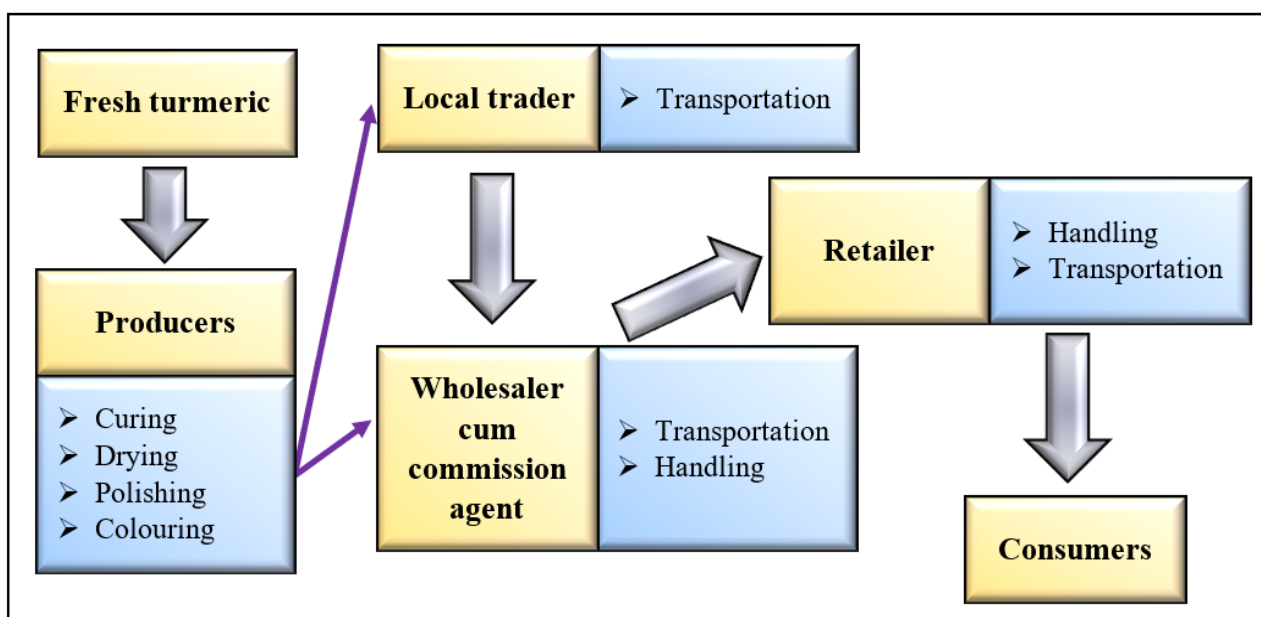


Fig. 3. Supply chain of turmeric in Middle Gujarat: A schematic overview. Source: Field Survey (2019)

Table 4. Channel-wise marketing cost of dry chilli in Middle Gujarat (₹ q⁻¹)

Marketing cost	Marketing channel of dry chilli	
	Channel-I	Channel-II
Cost incurred by the producer		
i) Labour cost	65.25 (20.83)	65.25 (25.45)
ii) Packaging charges	30.00 (9.57)	30.00 (11.70)
iii) Transportation charges	-	15.50 (6.04)
iv) Loading charges	12.36 (3.94)	12.36 (4.82)
v) Other charges	-	3.75 (1.46)
vi) Cost of post-harvest losses	35.85 (11.45)	35.85 (14.00)
Total (i to vi)	143.46 (45.79)	162.71 (63.47)
Cost incurred by the commission agent		
i) Transportation charges	15.50 (4.94)	-
ii) Commission	55.21 (17.63)	-
iii) Other charges	5.50 (1.76)	-
Total (i to iii)	76.21 (24.33)	-
Cost incurred by the wholesaler		
i) Transportation charges	25.25 (8.06)	25.25 (9.86)
ii) Loading-unloading charges	6.30 (2.01)	6.30 (2.46)
iii) Other charges	4.45 (1.42)	4.45 (1.74)
iv) Cost of post-harvest losses	13.20 (4.21)	13.20 (5.14)
Total (i to iv)	49.20 (15.70)	49.20 (19.20)
Cost incurred by the retailer		
i) Transportation charges	8.60 (2.74)	8.60 (3.36)
ii) Loading-unloading charges	7.60 (2.42)	7.60 (2.96)
iii) Cost of post-harvest losses	28.25 (9.02)	28.25 (11.01)
Total (i to iii)	44.45 (14.18)	44.45 (17.33)
Total marketing cost	313.32 (100.00)	256.36 (100.00)

Source: Field Survey (2019)

Note: Figures in parentheses are the percentage of the total marketing cost.

(₹ 35.85 q⁻¹), packaging charges (₹ 30.00 q⁻¹) and loading charges (₹ 12.36 q⁻¹). Similarly, in Channel-II, labour charges remained the highest (₹ 65.25 q⁻¹) followed by post-harvest losses (₹ 35.85 q⁻¹), packaging charges (₹ 30.00 q⁻¹), transportation charges (₹ 15.50 q⁻¹) and loading charges (₹ 12.36 q⁻¹).

The table also showed that the marketing cost borne by commission agents was ₹ 76.21 q⁻¹. Wholesalers in both channels incurred a marketing cost of ₹ 49.20 q⁻¹, while retailers incurred a cost of ₹ 44.45 q⁻¹. Among the various components, post-harvest loss accounted for the largest share in both channels.

Price spread and marketing margin in the supply chain of dry chilli in Middle Gujarat

As shown in Table 5, the price spread was lowest in Channel-II at 5.60 %, where dry chilli was marketed directly to wholesalers. In this channel, producers received the highest share of the consumer's price (94.40 %). The price spread of dry chilli marketed through Channel-I was 6.65 % and the producer's share in the consumer's price was 93.35 %, which was lower than that of Channel-II. This difference could be attributed to the fact that in Channel-I, dry chilli was marketed in distant markets with the higher marketing costs and margins for wholesalers, commission agents and retailers. The results were found to be consistent across both short and distant markets, aligning with findings in chilli and banana marketing (1, 15).

Marketing efficiency of dry chilli in Middle Gujarat

Table 6 depicts that the most efficient marketing channel was Channel-II (17.82), whereas Channel-I had a marketing efficiency of 13.99. The marketing efficiency of short-distance channels was also found to be similar and highest in potato marketing (13).

Ginger

The existing marketing channels for ginger prevailing in Middle Gujarat are presented in Table 7. There were two primary channels through which ginger was marketed after harvest.

Channel-wise marketing cost of ginger in Middle Gujarat

Table 8 revealed that in Channel-I, the producer incurred a cost of ₹ 967.84 q⁻¹ (86.89 %) to bring the produce to the Agricultural Produce Market Committee (APMC). These costs included packaging charges, transport charges, loading-unloading and post-harvest losses. The wholesaler incurred ₹ 56.25 q⁻¹ (5.05 %), covering transportation charge, sorting and cleaning, loading-unloading and post-harvest losses. The retailer incurred ₹ 89.75 q⁻¹ (8.06 %) for selling the ginger to consumers. The total marketing cost in Channel-I summed up to ₹ 1113.84 q⁻¹.

In Channel-II, the producer incurred the same cost of ₹ 967.84 q⁻¹, representing 82.87 % of the total. The processor, involved in the processing of ginger, incurred a cost of ₹ 60 q⁻¹ (5.13 %), which included only storage charges. The wholesaler incurred a cost of ₹ 59.00 q⁻¹ (5.05 %) including transportation, loading-unloading charges and post-harvest losses. The retailer incurred ₹ 81.00 q⁻¹ (6.94 %). The total marketing cost in Channel-II amounted to ₹ 1167.84 q⁻¹. Among the various components, post-harvest losses accounted for the largest share in both channels.

Price spread and marketing margin in the supply chain of ginger in Middle Gujarat

The margins added by intermediaries in the two channels are presented in Table 9, which indicates that the highest marketing margin was found in Channel-II (₹ 975 q⁻¹) followed by Channel-I (₹ 800 q⁻¹). Producer's share in the consumer's rupee was highest in Channel-I (76.57 %), where farmers sold their produce directly to wholesalers; however, Channel-II (75.21 %) had a lower producer's share in the consumer's rupee. The findings are aligned with earlier reports indicating that the producer's share in the consumer's rupee was higher in direct marketing channels (1).

Marketing efficiency of ginger in Middle Gujarat

The marketing efficiency of ginger in different marketing channels is presented in Table 10. It was revealed that the marketing efficiency

Table 5. Price spread in marketing of dry chili in Middle Gujarat (₹ q⁻¹) through two marketing channels

Marketing cost	Marketing channel of dry chilli	
	Channel-I	Channel-II
Net price received by the producer	16000.00 (93.35)	17500.00 (94.40)
Marketing cost to the producer	143.46 (0.78)	162.71 (0.88)
Marketing cost to the commission agent	76.21 (0.44)	-
Marketing cost to the wholesaler	49.20 (0.28)	49.20 (0.27)
Marketing cost to the retailer	44.45 (0.25)	44.45 (0.23)
Total marketing cost	313.32 (1.81)	256.36 (1.38)
Marketing margin of the commission agent	228.63 (1.34)	-
Marketing margin of the wholesaler	246.00 (1.44)	294.60 (1.59)
Marketing margin of the retailer	355.60 (2.06)	488.20 (2.63)
Total marketing margin	830.23 (4.84)	782.80 (4.22)
Consumer's purchase price	17143.55 (100.00)	18539.16 (100.00)
Price spread	1143.55	1039.16
(Total marketing cost + margins)	(6.65)	(5.60)

Source: Field Survey (2019)

Note: Figures in parentheses are the percentage of the consumer's purchase price.

Table 6. Marketing efficiency of dry chilli in Middle Gujarat

Sl. No.	Particulars	Channel-I	Channel-II
1	Retailer's selling price/ consumer's price (₹ q ⁻¹)	17143.55	18539.16
2	Total marketing cost (₹ q ⁻¹)	313.32	256.36
3	Total marketing margin (₹ q ⁻¹)	830.23	728.80
4	Net price received by the farmer (₹ q ⁻¹)	16000.00	17500.00
5	Marketing efficiency	13.99	17.82

Source: Field Survey (2019)

Table 7. Marketing channels of ginger in Middle Gujarat

Marketing channel	Particulars	Percentage of produce moved	Net price received by the farmer (₹ q ⁻¹)	Net price paid by the consumer (₹ q ⁻¹)
Channel-I	Producer-Wholesaler-Retailer-Consumer (Short-distance market)	27.28 % (P-31, W-13, R-16)	6255	8168.84
Channel-II	Producer-Processor-Wholesaler-Retailer-Consumer (Long-distance market)	72.72 % (P-69, Pr-40, W-27, R-24)	6500	8642.84

Source: Field Survey (2019)

Note: Figures in parentheses indicate the number of respondents associated with each marketing channel (P = Producer, Pr = Processor, W = Wholesaler, R = Retailer).*

Table 8. Channel-wise marketing cost of ginger in Middle Gujarat (₹ q⁻¹)

Marketing cost	Marketing channel of ginger	
	Channel-I	Channel-II
Cost incurred by the producer		
i) Packaging charges	75.00 (6.73)	75.00 (6.42)
ii) Transportation charges	7.14 (0.64)	7.14 (0.61)
iii) Loading-unloading charges	10.00 (0.90)	10.00 (0.86)
iv) Cost of post-harvest losses	875.70 (78.62)	875.70 (74.98)
Total (i to iv)	967.84 (86.89)	967.84 (82.87)
Cost incurred by the processor		
i) Storage charges	-	60.00 (5.14)
ii) Cost of post-harvest losses	-	-
Total (i to ii)	-	60.00 (5.14)
Cost incurred by the wholesaler		
i) Transportation charges	6.50 (0.58)	9.25 (0.79)
ii) Sorting & cleaning charges	9.50 (0.85)	9.50 (0.81)
iii) Loading-unloading charges	6.50 (0.58)	6.50 (0.56)
iv) Cost of post-harvest losses	33.75 (3.04)	33.75 (2.89)
Total (i to iv)	56.25 (5.05)	59.00 (5.05)
Cost incurred by the retailer		
i) Transportation charges	10.00 (0.90)	12.00 (1.03)
ii) Loading-unloading charges	8.50 (0.76)	6.50 (0.56)
iii) Cost of post-harvest losses	71.25 (6.40)	62.50 (5.35)
Total (i to iii)	89.75 (8.06)	81.00 (6.94)
Total marketing cost	1113.84 (100.00)	1167.84 (100.00)

Source: Field Survey (2019)

Note: Figures in parentheses are the percentage of the total marketing cost.

Table 9. Price spread and marketing margin in the supply chain of ginger in Middle Gujarat (₹ q⁻¹)

Marketing cost	Marketing channel of ginger	
	Channel-I	Channel-II
Net price received by the producer	6255.00 (76.57)	6500.00 (75.21)
Marketing cost of the producer	967.84 (11.85)	967.84 (11.20)
Marketing cost of the processor	-	60.00 (0.69)
Marketing cost of the wholesaler	56.25 (0.69)	59.00 (0.68)
Marketing cost of the retailer	89.75 (1.10)	81.00 (0.94)
Total marketing cost	1113.84 (13.64)	1167.84 (13.51)
Marketing margin of the wholesaler	300.00 (3.67)	325.00 (3.76)
Marketing margin of the retailer	500.00 (6.12)	650.00 (7.52)
Total marketing margin	800.00 (9.79)	975.00 (11.28)
Consumer's purchase price	8168.84 (100.00)	8642.84 (100.00)
Price spread (Total marketing cost + margins)	1913.84 (23.43)	2142.84 (24.79)

Source: Field Survey (2019)

Note: Figures in parentheses are the percentage of the consumer's purchase price.

Table 10. Marketing efficiency of ginger in Middle Gujarat

Sl. No.	Particulars	Channel-I	Channel-II
1	Retailer's selling price /Consumer's price (₹ q ⁻¹)	8168.84	8642.84
2	Total marketing cost (₹ q ⁻¹)	1113.84	1167.84
3	Total marketing margin (₹ q ⁻¹)	800.00	975.00
4	Net price received by the farmer (₹ q ⁻¹)	6255.00	6500.00
5	Marketing efficiency	3.26	3.03

Source: Field Survey (2019)

Table 11. Marketing channels of turmeric in Middle Gujarat

Marketing channel	Particulars	Percentage of produce moved	Net price received by the farmer (₹ q ⁻¹)	Net price paid by the consumer (₹ q ⁻¹)
Channel-I	Producer -Local trader-Consumer (Short-distance market)	30.52 % (P-17, Lt-30, R-11)	3000	4436.44
Channel-II	Producer -Wholesaler cum commission agent-Retailer-Consumer (Long-distance market)	69.48 % (P-83, WcCa-30, R-19)	3250	5017.16

Source: Field Survey (2019)

Note: Figures in parentheses represent the number of respondents associated with each marketing channel (P = Producer; Lt = Local trader; WcCa = Wholesaler-cum-commission agent; R = Retailer).

was highest in Channel-I (3.26) followed by Channel-II (3.03).

Turmeric

Although turmeric was the least cultivated crop in the region, it was still grown by some farmers. Table 11 shows the different marketing channels through which turmeric was passed to reach the customers.

In Middle Gujarat, while marketing turmeric, the majority of farmers reported the absence of a regulated market and expressed concerns about their exploitation by private agencies. Some farmers also suggested that the lack of proper grading and packaging facilities in the market yard was a major challenge in the effective marketing of turmeric.

Channel-wise marketing cost of turmeric in Middle Gujarat

The costs incurred by different middlemen involved in the marketing of turmeric are presented in Table 12. In Channel-I, the producer

incurred a marketing cost of ₹ 215.32 q⁻¹ (27.00 %) while taking the produce to the APMC. This cost comprised labour charges for harvesting, loading charges, packing charges and other related expenses. The wholesaler-cum-commission agent incurred the highest share of marketing cost at ₹ 370.95 q⁻¹ (46.51 %) in marketing turmeric, which included market fees, commission charges, loading-unloading charges and post-harvest losses. The retailer incurred a cost of ₹ 211.30 q⁻¹ (26.49 %) in marketing of turmeric to consumers. The total marketing cost incurred was ₹ 797.57 q⁻¹ with the shares of the producer, wholesaler-cum-commission agent and retailer in the total marketing cost being 27.00, 46.51 and 26.49 % respectively.

In Channel-II, producers incurred a cost of ₹ 215.32 q⁻¹ (55.43 %) in taking the produce to the APMC. The local merchant incurred a cost of ₹ 173.10 q⁻¹ (44.57 %) in marketing turmeric, which included transportation charges, loading-unloading charges and post-harvest losses. Together, producers and local merchants

Table 12. Channel-wise marketing cost of turmeric in Middle Gujarat (₹ q⁻¹)

Marketing cost	Marketing channel of turmeric	
	Channel-I	Channel-II
Cost incurred by the producer		
i) Labour cost	45.75 (5.74)	45.75 (11.75)
ii) Packing charges	45.00 (5.64)	45.00 (11.58)
iii) Transportation charges	75.00 (9.40)	75.00 (19.32)
iv) Loading charges	15.36 (1.93)	15.36 (3.95)
v) Other charges	10.00 (1.25)	10.00 (2.57)
vi) Cost of post-harvest losses	24.21 (3.04)	24.21 (6.23)
Total (i to vi)	215.32 (27.00)	215.32 (55.43)
Cost incurred by the wholesaler cum commission agent		
i) Market fees	20.00 (2.51)	-
ii) Commission	140.00 (17.55)	-
iii) Loading-unloading charges	32.45 (4.07)	-
iv) Cost of post-harvest losses	178.50 (22.38)	-
Total (i to iv)	370.95 (46.51)	-
Cost incurred by the local merchant		
i) Loading-unloading charges	-	34.50 (8.88)
ii) Transportation charges	-	60.10 (15.47)
iii) Cost of post-harvest losses	-	78.50 (20.22)
Total (i to iii)	-	173.10 (44.57)
Cost incurred by the retailer		
i) Transportation charges	35.60 (4.46)	-
ii) Loading-unloading charges	20.70 (2.60)	-
iii) Cost of post-harvest losses	105.00 (13.16)	-
iv) Market fees	50.00 (6.27)	-
Total (i to iv)	211.30 (26.49)	-
Total marketing cost	797.57 (100.00)	388.42 (100.00)

Source: Field Survey (2019)

Note: Figures in parentheses represent the percentage of the total marketing cost incurred a total cost of ₹ 388.42 q⁻¹ in the sale of turmeric.

A comparison of both channels indicates that marketing costs were considerably higher in Channel-I, mainly due to the involvement of multiple intermediaries, which led to a total cost of ₹797.57 q⁻¹, more than double that of Channel-II. Among the various components, post-harvest losses accounted for the largest share in both channels.

Price spread and marketing margin in the supply chain of turmeric in Middle Gujarat

Marketing cost, margin and price spread of turmeric are presented in Table 13. It can be observed that the per-quintal marketing cost incurred by producers remained nearly the same across both marketing channels. In Channel-I, the wholesaler-cum-commission agent incurred a total marketing cost of ₹ 370.95 q⁻¹, while the retailer's cost accounted for ₹ 211.13 q⁻¹.

The producer's share in the consumer's rupee was higher in Channel-I at 67.63 %, compared to 64.78 % in Channel-II. However, the price spread-the difference between the price paid by the consumer and that received by the producer-was ₹ 1436.44 q⁻¹ in Channel-I and significantly higher at ₹ 1767.16 q⁻¹ in Channel-II.

These findings highlight that while producers receive a relatively larger share in Channel-I, the overall marketing efficiency may vary depending on the number and nature of intermediaries involved.

Marketing efficiency of turmeric in Middle Gujarat

Table 14 shows that the most efficient marketing channel was Channel-I (3.09), whereas Channel-II had a marketing efficiency of 2.84.

Table 13. Price spread in marketing of turmeric in Middle Gujarat (₹ q⁻¹)

Marketing cost	Marketing channel of turmeric	
	Channel-I	Channel-II
Net price received by the producer	3000.00 (67.63)	3250.00 (64.78)
Marketing cost of the producer	215.32 (4.85)	215.31 (4.29)
Marketing cost of the wholesaler cum commission agent	370.95 (8.36)	-
Marketing cost of the local merchant	-	173.10 (3.45)
Marketing cost of the retailer	211.13 (4.76)	-
Total marketing cost	797.4 (17.97)	388.41 (7.74)
Marketing margin of the wholesaler cum commission agent	217.32 (4.17)	-
Marketing margin of the local merchant	-	1378.75 (27.48)
Marketing margin of the retailer	421.72 (9.50)	-
Total marketing margin	639.04 (14.40)	1378.75 (27.48)
Consumer's purchase price	4436.44 (100.00)	5017.16 (100.00)
Price spread (Total marketing cost + margins)	1436.44 (32.37)	1767.16 (35.22)

Source: Field Survey (2019)

Note: Figures in parentheses are the percentage of the consumer's purchase price.

Table 14. Marketing efficiency of turmeric in Middle Gujarat

Sl. No.	Particulars	Channel-I	Channel-II
1	Retailer's selling price /consumer's price (₹ q ⁻¹)	4436.44	5017.16
2	Total marketing cost (₹ q ⁻¹)	797.40	388.41
3	Total marketing margin (₹ q ⁻¹)	639.04	1378.75
4	Net price received by the farmer (₹ q ⁻¹)	3000.00	3250.00
5	Marketing efficiency	3.09	2.84

Source: Field Survey (2019)

Primary constraints of selected major spices in Middle Gujarat

In Middle Gujarat, ginger, turmeric and dry chilli were the selected major spice crops cultivated. In order to identify the key constraints in the input sub-system, marketing sub-system and post-harvest management, methods such as weighted average mean and Garrett's ranking technique were applied based on the responses of the surveyed farmers. The results are presented below.

Dry chilli**Constraints in the input sub-system**

The primary constraints in the dry chilli input system, as reported by farmers, began with the unavailability of labour, which was identified as the most significant constraint. This was followed by fewer extension services and the rising prices of key inputs. The quality of inputs emerged as the next major concern followed by issues related to timely availability of inputs and the long distance to input

markets. Insufficient delivery of inputs was reported as the least significant constraint (Table 15).

Constraints in the marketing sub-system

The marketing sub-system constitutes a critical component of the spice supply chain and significantly influences farmers' income realisation. In the dry chilli marketing system, farmers reported several constraints, including spoilage of produce during harvesting, the use of unsuitable harvesting methods, inadequate space for post-harvest handling, price- and payment-related issues, distant markets, high transportation costs, labour shortages for harvesting and packaging, lack of market information, high commissions charged by wholesalers and commission agents and inadequate market infrastructure. As indicated in Table 16, the inability to receive a fair price for produce emerged as the most severe constraint faced by farmers. This was followed by high commission charges imposed by intermediaries, shortage of labour for harvesting and packaging

Table 15. Constraints in the input sub-system of dry chilli cultivation

(n = 100)

Sl. No.	Constraints	WAM	Rank
1	Shortage of labour	4.64	1
2	Inadequate extension services	4.39	2
3	Rising prices of inputs	4.26	3
4	Poor quality of inputs	3.87	4
5	Non-availability of inputs at the required time	3.74	5
6	Long distance to input markets	3.41	6
7	Delay in delivery of inputs	2.93	7

Source: Field Survey (2019)

Table 16. Constraints in the marketing sub-system of dry chilli market

(n = 100)

Sl. No.	Constraints	Garrett score	Mean value	Garrett rank
1	Non-remunerative prices of produce	19023	79.26	1
2	High commission charges by market intermediaries	16828	70.12	2
3	Shortage of labour	15373	64.05	3
4	Delay in receiving payment	13970	58.21	4
5	Spoilage and post-harvest losses of produce	12582	52.43	5
6	Higher transportation cost	11083	46.18	6
7	Requirement of large space for post-harvest handling	9707	40.45	7
8	Long distance to markets	8567	35.70	8
9	Lack of market information	7470	31.13	9
10	Inadequate market infrastructure	4917	20.49	10

Source: Field Survey (2019)

operations and delays in payment settlements. In contrast, lack of market information was perceived as the least significant constraint in the dry chilli marketing sub-system.

Constraints in post-harvest management

In dry chilli cultivation, several critical constraints in post-harvest management were reported by farmers, suppliers, wholesalers and retailers. These constraints included inadequate post-harvest technologies, limited awareness and technology gaps, lack of market infrastructure, excess supply in the market, improper handling by labourers, problems related to grading and standardisation and the use of unsuitable packaging materials. As presented in Table 17, the most severe constraint identified was the absence of pre-cooling and storage facilities, which substantially contributed to high post-harvest losses. This was followed by improper harvesting practices by labourers, leading to physical damage to the produce and improper handling after harvesting,

such as bulk packaging and stacking of produce in vehicles. The use of unsuitable packaging materials and inconsistencies in grading and standardisation across distant markets were also identified as major constraints adversely affecting product quality and marketability.

Ginger

Constraints in the input sub-system

The primary constraints in the ginger input system, as reported by farmers, were led by the unavailability of labour, which often compelled farmers to enter into pre-harvest contracts with wholesalers and processors. The second most important constraint was the long distance between farms and input markets followed by the rising prices of key inputs, which have increasingly escalated production costs over time. The timely availability of inputs emerged as the fourth major constraint, particularly in the case of fertilisers, as input sources were located

Table 17. Constraints in post-harvest management of dry chilli

(n = 100)

Sl. No.	Constraints	Garrett score	Mean value	Garrett rank
1	Absence of pre-cooling and storage facility	18391	76.63	1
2	Improper harvesting method	16701	69.59	2
3	Improper handling after harvesting	14513	60.47	3
4	Unsuitable packaging materials	13464	56.10	4
5	Grading and standardisation problem	13132	54.72	5
6	Excess supply in markets	11716	48.82	6
7	Awareness related to post-harvest management	10443	43.51	7
8	Inadequate post-harvest technology	8614	35.89	8
9	Wide gap in technology available and awareness	7342	30.59	9
10	Lack of training and awareness campaign problems	5204	21.68	10

Source: Field Survey (2019)

Table 18. Constraints in the input sub-system of ginger cultivation

(n = 100)

Sl. No.	Constraints	WAM	Rank
1	Unavailability of labour	4.58	1
2	Long distance of the input market	4.37	2
3	Increasing prices	3.67	3
4	Availability on time	3.11	4
5	Insufficient delivery	2.91	5
6	Quality of input	2.73	6
7	Less extension service	2.08	7

Source: Field Survey (2019)

Table 19. Constraints in the marketing sub-system of ginger market

(n = 100)

Sl. No.	Constraints	Garrett score	Mean value	Garrett rank
1	Do not get the proper price	9319	77.66	1
2	Delayed payment	8136	67.80	2
3	High cost of transportation	7506	62.55	3
4	Distance market	7008	58.40	4
5	Unavailability of labour	6526	54.38	5
6	Spoilage of produce	5827	48.56	6
7	Large space is required for post-harvest handling	4833	40.28	7
8	Commission problem	4180	34.83	8
9	Lack of market information	3448	28.73	9
10	Improper infrastructure	2977	24.81	10

Source: Field Survey (2019)

far from farms, necessitating repeated trips to procure essential materials. The least severe constraints reported were issues related to input quality and limited extension services (Table 18).

Constraints in the marketing sub-system

The primary constraints in the ginger marketing sub-system, as presented in Table 19, indicate that the most severe challenge faced by farmers was the inability to obtain fair prices for their produce due to the absence of regulated markets. This was followed by delayed payments by pre-harvest contractors, processors and mandi wholesalers. High transportation costs emerged as the third major constraint, as farmers were often required to transport their produce to distant markets, thereby increasing overall marketing expenses. Distance to markets was identified as the fourth constraint. Labour shortages for harvesting and loading-unloading operations ranked fifth followed by spoilage of produce and the requirement for large on-farm space for packaging and post-harvest handling activities. Other issues, including commission charges, lack of market information and inadequate market infrastructure, were ranked lower but contributed to overall inefficiencies in the ginger marketing system.

Constraints in post-harvest management

Table 20 presents the major constraints in post-harvest management of ginger. The results indicate that the most severe constraint was inadequate post-harvest technology for efficient harvesting and material handling. This was followed by a wide gap between the availability of post-harvest technologies and farmers' awareness of their use, limited awareness of recommended post-

harvest management practices, absence of pre-cooling and storage facilities, improper harvesting methods and inadequate knowledge related to grading and standardisation of the produce. The least severe constraints included excess supply in the market, poor handling practices after harvesting, unsuitable packaging materials and lack of training opportunities, which collectively contributed to post-harvest losses and inefficiencies in the ginger supply chain.

Turmeric

Constraints in the input sub-system

In turmeric cultivation, several major constraints in the input sub-system were reported by farmers. The most significant constraint was the rising prices of fertilisers and biopesticides, which are extensively used in spice production. This was followed by fewer extension services, unavailability of labour, untimely availability of inputs and the long distance of input markets from farms. These constraints collectively increased production costs and adversely affected the efficiency of turmeric cultivation (Table 21).

Constraints in the marketing sub-system

In the turmeric marketing sub-system, the major constraints faced by farmers, ranked from one to five, included the inability to receive fair prices for their produce, unavailability of labour, delayed payments to farmers, distant markets and commission charges imposed by suppliers and pre-harvest contractors. In addition, spoilage of produce due to pest infestation and improper handling after harvesting was identified as a significant concern. The least severe constraints included limited space for post-

Table 20. Constraints in post-harvest management of ginger

(n = 100)

Sl. No.	Constraints	Garrett score	Mean value	Garrett rank
1	Inadequate post-harvest technology	8847	73.73	1
2	Wide gap in the technology available and awareness	7792	64.93	2
3	Awareness related to post-harvest management	7639	63.66	3
4	Absence of pre-cooling and storage facility	4123	34.36	9
5	Improper harvesting method	7021	58.51	4
6	Grading and standardisation problem	6076	50.63	5
7	Excess supply in markets	5056	42.13	7
8	Improper handling after harvesting	4422	36.85	8
9	Unsuitable packaging materials	5814	48.45	6
10	Lack of training and awareness campaign problem	2970	24.75	10

Source: Field Survey (2019)

Table 21. Constraints in the input sub-system of turmeric cultivation

(n = 100)

Sl. No.	Constraints	WAM	Rank
1	Increasing prices	4.44	1
2	Less extension service	3.83	2
3	Unavailability of labour	3.18	3
4	Availability on time	2.92	4
5	Long distance of the input market	2.59	5
6	Quality of input	2.01	6
7	Insufficient delivery	1.78	7

Source: Field Survey (2019)

Table 22. Constraints in the marketing sub-system of turmeric market

(n = 100)

Sl. No.	Constraints	Garrett score	Mean value	Garrett rank
1	Do not get the proper price	9580	79.83	1
2	Unavailability of labour	8296	69.13	2
3	Delayed payment	7617	63.48	3
4	Distance market	6939	57.83	4
5	Commission problem	6155	51.29	5
6	Spoilage of produce	5749	47.91	6
7	Higher cost of transportation	5018	41.82	7
8	Large space required for post-harvest handling	4465	37.21	8
9	Lack of market information	3274	27.28	9
10	Improper infrastructure	2667	22.23	10

Source: Field Survey (2019)

harvest handling, lack of market information and inadequate market infrastructure, which were considered relatively less critical due to the seasonal nature of turmeric cultivation (Table 22).

Constraints in post-harvest management

Post-harvest management plays a crucial role in reducing post-harvest losses and maintaining product quality. In the study area, the most severe constraint identified was the inadequate post-harvest technologies required to minimise losses. This was followed by low awareness regarding post-harvest management among farmers and market intermediaries. Lack of knowledge regarding grading and standardisation emerged as the third major constraint, adversely affecting product quality and market acceptance. The fourth and fifth constraints were improper handling practices by labourers after harvesting and the use of unsuitable packaging materials, such as newspapers and plastic wrappers, particularly in short-distance markets (Table 23).

Post-harvest loss of selected major spices in Middle Gujarat

The overall post-harvest losses in selected major spices in Middle Gujarat are presented in Table 24. The results indicated that post-harvest losses amounted to 24.91 % in dry chilli, 25.81 % in turmeric and 25.26 % in ginger, reflecting a substantial reduction in marketable surplus across all three crops.

These losses occurred at different stages of the supply chain, including sorting and grading at the field level, handling at the wholesale stage and marketing at the retail level. In dry chilli, losses were highest at the retail stage (10.32 %) followed by field-level operations (8.27 %) and wholesaler handling (6.32 %), mainly due to improper harvesting practices, mechanical damage, insect infestation and poor handling. Ginger recorded losses of 8.46 % at the field level, 7.45 % at the wholesale level and 9.35 % at the retail stage, largely attributable to mechanical injuries, fungal diseases, lack of cold storage facilities, improper packaging and non-

refrigerated transportation. Turmeric experienced the highest overall losses with 8.56 % at the field level, 6.35 % at the wholesale level and 10.90 % at the retail stage, primarily due to harvesting injuries, bacterial and fungal infections, press damage during storage and inadequate curing and handling practices.

These production and post-harvest-related constraints adversely affect farmers by lowering net returns despite favourable prices, increasing income uncertainty and discouraging investment in spice cultivation. For wholesalers and retailers, high spoilage levels raise operational costs, reduce profit margins and contribute to price volatility, thereby reducing overall supply chain efficiency. To mitigate these losses, interventions such as adopting scientific harvesting techniques, training farmers in grading and packaging and strengthening extension services are essential at the production stage. At the post-harvest and marketing stages, investments in pre-cooling units, cold storage infrastructure, mechanical washing facilities, improved packaging and efficient transportation systems, along with streamlined marketing channels, can substantially reduce losses and enhance income sustainability for farmers and other stakeholders in the spice value chain.

Conclusion

This study revealed that, among the three crops analysed, dry chilli emerged as the most economically viable option due to its superior benefit-cost ratio, higher marketing efficiency, lower price spread and greater producer share in the consumer's rupee. The findings further reveal that high production alone does not guarantee profitability, as observed in ginger and turmeric, where elevated input costs, post-harvest losses and inefficient marketing channels significantly eroded net returns. Persistent inefficiencies across spice supply chains, particularly inadequate post-harvest infrastructure, limited storage and pre-cooling facilities, dependence on multiple

Table 23. Constraints in post-harvest management of turmeric

(n = 100)

Sl. No.	Constraints	Garrett score	Mean value	Garrett rank
1	Inadequate post-harvest technology	8252	68.77	1
2	Awareness related to post-harvest management	8193	68.28	2
3	Grading and standardisation problem	7414	61.78	3
4	Improper handling after harvesting	6547	54.56	4
5	Unsuitable packaging materials	6098	50.82	5
6	Wide gap in technology available and awareness	5699	47.49	6
7	Excess supply in markets	5249	43.74	7
8	Absence of pre-cooling and storage facility	5222	43.52	8
9	Improper harvesting method	3863	32.19	9
10	Lack of training problems and awareness campaign	3223	26.86	10

Source: Field Survey (2019)

Table 24. Post-harvest loss of selected major spices in Middle Gujarat

Sl. No.	Spices (n = 100)	Handling stage	Post-harvest loss (PHL) (%)	Major causes of PHL
1	Dry chilli	Sorting and grading at field level	8.27	Harvesting injury, immature and small fruits, damaged by insects
		Wholesaler level	6.32	Pressed damage
		Retail level	10.32	Crushed fruits
		Total	24.91	
2	Turmeric	Sorting and grading at field level	8.56	Harvesting injury, immature and small fruits, disease and insect-affected fruits
		Wholesaler level	6.35	Press damaged fruits
		Retail level	10.90	Bacterial and fungal infection
		Total	25.81	
3	Ginger	Sorting and grading at field level	8.46	Mechanical injury, harvesting injury, due to scab and fungal disease
		Wholesaler level	7.45	Pressed damage and fungal disease
		Retail level	9.35	Unsold fruits and mechanical injury
		Total	25.26	

Source: Field Survey (2019)

intermediaries and delayed payments, continue to constrain income realisation for farmers and other stakeholders.

From a forward-looking perspective, the study highlights the growing importance of integrating economic analysis with supply chain assessment to enhance the sustainability and competitiveness of spice cultivation. Future gains in farmer income are more likely to arise from improvements in post-harvest management, rationalisation of marketing channels, adoption of efficient logistics and reduction of avoidable losses rather than from yield enhancement alone. For policymakers and agribusiness investors, strengthening farmer-oriented marketing systems, promoting cooperative and digital marketing platforms and investing in post-harvest and cold-chain infrastructure will be critical to unlocking the full economic potential of spice value chains. These innovations are essential for ensuring both economic and long-term sustainability of spice cultivation systems in developing economies.

Authors' contributions

RSP and DRV were responsible for preparing the questionnaire and collecting the data. AR contributed to the study design, performed the sequence alignment and conducted the statistical analyses. BB conceived the study and participated in its design, coordination and drafted the manuscript. All authors read and approved the final version of the manuscript.

Compliance with ethical standards

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