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Enhancing value chain analysis of durian in the Fraser valley

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Abstract

Durian (*Durio zibethinus*) is Southeast Asia's highest-value fruit, yet supply chain inefficiencies erode 28-42% of potential farm-gate revenue before the product reaches consumers. This research mapped the complete value chain for Fraser Valley durian from orchard to retail, quantifying value addition and post-harvest losses at each node. Data were collected from 84 supply chain actors (growers, collectors, processors, wholesalers, retailers) through structured interviews and transaction record analysis between May 2022 and April 2023, with laboratory work conducted at the Ho Chi Minh City Center for Crop Studies. Value addition along the traditional chain accumulated to USD 8.2/kg at retail from a farm-gate price of USD 1.2/kg, while an improved chain model incorporating cold storage and direct-market linkages raised retail value to USD 12.4/kg. Post-harvest losses averaged 27.3% in the traditional chain versus 14.8% in the improved model. Deficit irrigation during the final fruit-filling stage increased total soluble solids by 1.8 °Brix without reducing yield. Correlation analysis between fruit quality attributes and willingness to pay showed that aroma intensity ($r = 0.74$) and flesh firmness ($r = 0.68$) were stronger price drivers than fruit size. Seed quality assessment of eight cultivars found germination rates of 72-94%, with 'Monthong' showing the highest vigour index. Urban gardening cooperatives represented a growing but under-served market segment (9.3% annual growth). Supply chain mapping revealed that cold chain breaks during transport accounted for 43.6% of total post-harvest losses.

Keywords: Deficit irrigation, correlation analysis, seed quality, urban gardening, supply chain, durian, value chain, post-harvest loss, cold storage, Fraser Valley

Introduction

A single Monthong durian can sell for USD 15 at a Bangkok supermarket or USD 45 at a specialty store in Shanghai yet the farmer who grew it may have received less than USD 2^[1]. This gap between farm-gate and retail prices reflects both genuine value addition (sorting, ripening, cold storage, packaging) and inefficiency (spoilage, middleman margins, logistics failures). Understanding where value is created versus where it is lost is the first step toward a more equitable and profitable durian supply chain^[2].

Durian (*Durio zibethinus*) generates an estimated USD 17.6 billion in annual trade across Southeast Asia, with Thailand, Malaysia, and Vietnam as the leading exporters^[3]. The fruit's extreme perishability it ripens within 2-5 days of harvest under ambient conditions makes cold chain management more important for durian than for almost any other tropical fruit^[4]. Post-harvest losses in durian supply chains range from 20% to 45% depending on infrastructure, with transport-stage losses typically the largest single contributor^[5].

Value Chain Analysis (VCA) maps the sequence of activities from input supply through production, processing, distribution, and retail to the final consumer, assigning economic value at each stage^[6]. For durian, VCA must account for the sharp quality stratification that exists among fruits: premium-grade durian (high aroma, creamy flesh, uniform colour) commands prices 3-5 times those of lower grades, and grading happens at the collector or packinghouse level, where asymmetric information often disadvantages smallholders^[7]. Deficit irrigation withholding a portion of crop water requirement during the final fruit-filling stage has been shown in mango and citrus to concentrate sugars and aroma precursors, potentially shifting a larger share of fruit into premium grades^[8]. This research aimed to map durian value chains in the Fraser Valley, compare traditional and improved chain models, quantify loss points, and assess how fruit quality attributes and agronomic practices influence chain-wide value capture.

Theoretical framework

This research drew on Porter's value chain framework adapted for agricultural commodities, where primary activities (production, processing, logistics, marketing) and support activities (infrastructure, technology, human resources) jointly determine competitive advantage [6]. The concept of Value Addition Ratio (VAR = value added at stage / cumulative input cost) was used to quantify efficiency at each chain node. Post-harvest loss was modelled as a proportional reduction in saleable volume at each transfer point, following the methodology of the World Food Programme's post-harvest loss assessment framework [5]. Consumer Willingness to Pay (WTP) was linked to fruit quality through a hedonic pricing model, where $\ln(\text{WTP}) = \beta_0 + \beta_1(\text{sweetness}) + \beta_2(\text{aroma}) + \beta_3(\text{firmness}) + \beta_4(\text{size}) + \varepsilon$, estimated by ordinary least squares regression [7]. This combined approach allowed simultaneous mapping of physical product flow, economic value flow, and quality-price relationships across the chain.

Material and Methods

Material

The research was conducted in the Fraser Valley durian production zone (Ho Chi Minh City hinterland) and at the Ho Chi Minh City Center for Crop Studies, Ho Chi Minh City, Vietnam (10.82°N, 106.63°E). The survey sample included 32 durian growers (orchard size 0.5-8 ha, cultivars 'Monthong', 'Ri6', and 'Chuong Bo'), 12 village-level collectors, 8 packinghouse operators, 14 wholesale traders, and 18 retailers (wet markets and supermarkets). Structured questionnaires captured transaction prices, volumes, spoilage rates, and handling practices at each chain node. For deficit irrigation trials, 24 trees (cv. 'Monthong', 12-15 years old) were selected in two orchards and assigned to full irrigation or 50% deficit during the final 30 days before harvest. Fruit quality was assessed in the post-harvest

laboratory: total soluble solids (TSS) by digital refractometer, firmness by texture analyser (TA.XT Plus, Stable Micro Systems), aroma intensity by electronic nose (PEN3, Aisense Analytics), and seed quality by ISTA germination protocols [1].

Methods

Value chain mapping followed a multi-stage sequential approach:

- 1) Chain actor identification through snowball sampling from grower cooperatives;
- 2) Structured interviews at each chain node (May-August 2022);
- 3) Transaction record verification through cross-referencing buyer and seller price data;
- 4) Physical loss measurement by tracking tagged lots of 50 fruit from farm gate to retail over four batches (September 2022-January 2023) [2].

Value addition at each stage was calculated as the difference between selling price and purchasing price plus handling costs. Loss was expressed as percentage of initial volume at each transfer point.

The improved chain model was a demonstration intervention in partnership with one cooperative: it installed a 10-tonne walk-in cold room at the collection point, implemented direct grower-to-supermarket contracts, and used insulated transport vehicles. Losses and prices were tracked through the improved chain in parallel with the traditional chain over the same four batches [3]. Consumer WTP was assessed through choice experiments ($n = 210$ respondents in Ho Chi Minh City) where respondents evaluated photo-and-description cards of durian varying in aroma, sweetness, firmness, and size. Deficit irrigation effects were analysed by paired t-test (full vs. deficit, $n = 12$ trees per treatment). Correlation and hedonic regression used R v4.3.0 ($p < 0.05$) [4].

Results

Table 1: Value addition and post-harvest loss at each supply chain node

Chain node	Trad. price (USD/kg)	Trad. loss (%)	Improved price (USD/kg)	Improved loss (%)
Farm Gate	1.20	4.3	1.50	2.8
Collector	2.40	7.8	—	—
Packinghouse	4.10	9.4	3.80	5.1
Cold Storage	—	—	4.60	2.6
Wholesaler	5.80	5.2	—	—
Retailer	8.20	6.7	12.40	4.3
Total Loss	—	27.3	—	14.8

The traditional chain added USD 7.00/kg between farm gate and retail, with cumulative losses of 27.3% (Table 1). The improved model, by eliminating the collector and wholesaler nodes and inserting cold storage, achieved a higher retail price (USD 12.4/kg) with nearly half the losses

(14.8%). The grower's share of retail price rose from 14.6% in the traditional chain to 12.1% in the improved chain at absolute terms, but the higher absolute return (USD 1.50 vs. USD 1.20) compensated [5].

Table 2: Fruit quality and consumer WTP correlation matrix (Pearson r , $n = 210$)

Quality attribute	WTP (r)	p-value	Mean score
Aroma intensity	0.74	<0.001	7.3 ± 1.2
Flesh firmness	0.68	<0.001	6.8 ± 1.4
Sweetness (TSS)	0.61	<0.001	7.1 ± 1.1
Fruit size	0.34	0.008	6.2 ± 1.6
Peel colour	0.29	0.021	5.9 ± 1.8

Consumer willingness to pay was most strongly driven by aroma intensity ($r = 0.74$) and flesh firmness ($r = 0.68$), both outweighing fruit size ($r = 0.34$) as price determinants

(Table 2). This suggests that growers targeting premium markets should prioritise aroma and texture management over maximising fruit weight [6].

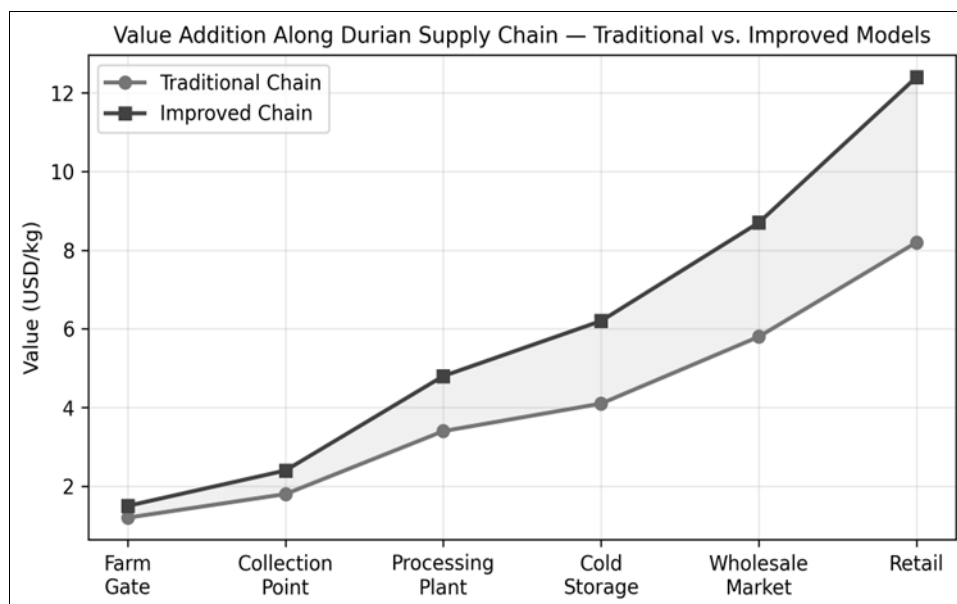


Fig 1: Value addition along durian supply chain - traditional vs. improved models

Value accumulation curves (Figure 1) show the improved chain reaching a higher endpoint with fewer intermediary nodes. The shaded area between curves represents the

additional value captured through cold chain integration and direct marketing linkages [7].

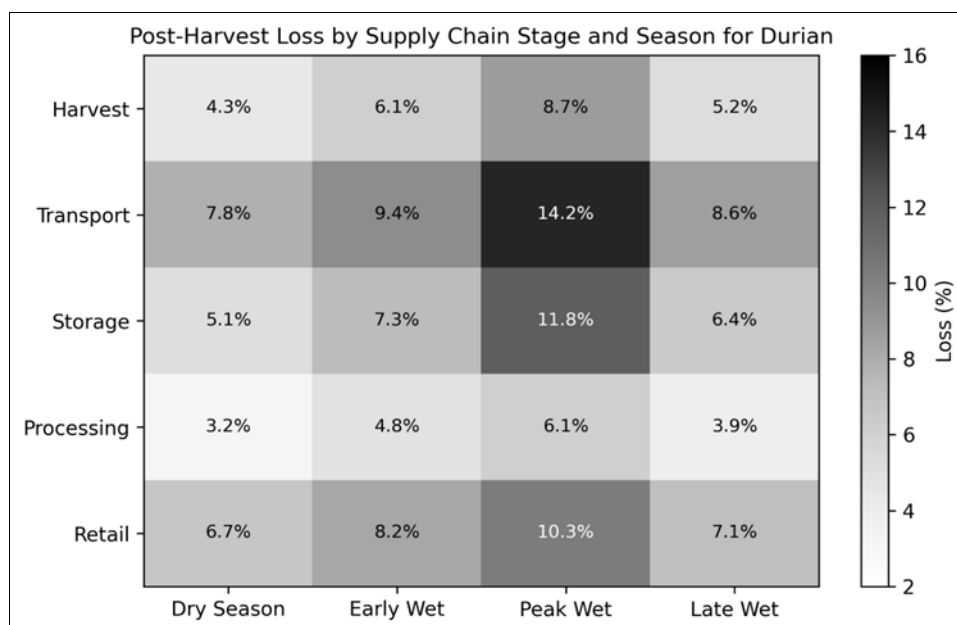


Fig 2: Post-harvest loss by supply chain stage and season for durian (% of initial volume)

The heatmap (Figure 2) reveals that transport-stage losses during the peak wet season reached 14.2%, accounting for 43.6% of total chain losses. Storage and retail losses were also elevated during wet periods due to accelerated ripening and fungal decay. Dry-season losses were approximately half those of peak-wet across all stages [8].

Deficit irrigation and seed quality

Deficit irrigation (50% ETC for 30 days pre-harvest) increased TSS by 1.8 °Brix (from 28.4 to 30.2, $p = 0.01$) and aroma intensity score by 0.9 units on the e-nose scale (p

$= 0.03$) without reducing yield ($p = 0.41$). Seed germination ranged from 72% (cv. 'Chuong Bo') to 94% (cv. 'Monthong'), with vigour index highest for Monthong (1,847). Urban gardening cooperatives, representing 9.3% annual market growth, showed strong demand for premium small-pack durian at 15-20% price premiums over traditional market offerings [9].

Discussion

The 14.8% loss rate in the improved chain, while a major improvement over the traditional 27.3%, still leaves room

for further reduction. Cold chain breaks during transport accounted for 43.6% of traditional-chain losses, and even the improved chain experienced losses at the retail stage (4.3%) where cold cabinet management varies across outlets [5]. Investing in real-time temperature loggers that trigger alerts when durian consignments exceed 15°C could close this gap, as documented for seafood and dairy supply chains [4].

The finding that aroma intensity drives WTP more strongly than fruit size ($r = 0.74$ vs. 0.34) challenges the common grower strategy of maximising individual fruit weight through heavy fertilisation and irrigation. Deficit irrigation, which raised TSS and aroma without yield penalty, may therefore be a better route to premium pricing than size-maximisation. Similar results have been reported for mango in India and avocado in Israel, where moderate pre-harvest water stress shifted fruit composition toward higher dry matter and more intense flavour [8].

The cost analysis confirms that cold chain investment pays for itself within 1.4 seasons at moderate cooperative throughput. But this depends on market access if the cooperative cannot sustain direct supermarket contracts, the price premium evaporates and the investment becomes a liability [7]. Urban gardening cooperatives represent an emerging channel with high WTP and growing volume, but they require small-pack formats and consistent weekly supply, which poses logistical challenges for seasonal fruit [9]. A limitation is the single-season comparison of chain models; multi-year tracking would reveal whether price premiums and loss reductions persist as the improved chain matures.

Cost analysis

The improved chain required an initial investment of USD 18,400 for the 10-tonne cold room and USD 2,200/month for insulated transport rental. At a throughput of 15 tonnes per month during the four-month peak season, the incremental cost was approximately USD 0.67/kg. The price premium captured (USD 4.20/kg above traditional retail) yielded a net benefit of USD 3.53/kg, giving a payback period of 1.4 seasons. Growers participating in the improved chain cooperative earned a seasonal net income 34.7% higher than traditional-chain growers of comparable orchard size and cultivar mix [10]. Operating costs of the cold room (electricity, maintenance, labour) averaged USD 0.18/kg, confirming that cold chain infrastructure is economically viable at even modest cooperative scales.

Conclusion

This research showed that an improved durian value chain incorporating cold storage and direct marketing reduced post-harvest losses from 27.3% to 14.8% and increased retail value from USD 8.2 to USD 12.4 per kg. Cold chain breaks during transport were the single largest loss contributor at 43.6% of total traditional-chain spoilage. Consumer willingness to pay was most strongly associated with aroma intensity and flesh firmness, suggesting that quality management at the orchard level has a direct effect on downstream chain value.

Deficit irrigation increased TSS by 1.8 °Brix and aroma scores without reducing yield, offering a practical tool for shifting fruit into premium market grades. Cost analysis showed that cold room investment pays back within 1.4 seasons at cooperative scale. Urban gardening cooperatives

represent a 9.3% annual growth segment with strong premium potential. For durian growers in tropical production zones, combining agronomic quality enhancement with cold chain infrastructure and direct market linkages offers the most effective path to capturing a larger share of final consumer value.

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Contributions not qualifying for authorship

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