Quality-oriented fresh vegetable supply chain: A pilot in Ahmedabad, India

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A pilot vegetable retail store named 'Clean-n-Fresh' was designed and operated at the campus of Indian Institute of Management (IIM), Ahmedabad. The aim was to deliver fresh produce of a better (and specified) quality preferred by the consumers. The consumers in the area were people with middle and higher income levels who indicated willingness to pay a premium of up to 20 per cent for clean and fresh produce. The processes and equipment for sorting, cleaning, washing, trimming etc. were specially developed for economy of water, electricity and space. Analysis of over a year of operational data showed that the extra costs incurred for vegetable treatment were about Rs. 1.5–2/kg (US$0.03–0.04/kg), which were within the selling price limit stipulated by consumers. The store began to break even after about six months of operation. This paper describes details of the engineering and business design and a summary of one year of operation.

Keywords: fresh produce, supply chain, vegetable retailing, India

Ahmedabad city has a population of 5.4 million people and is supplied with vegetables from growers within 100–200 km of the surrounding area. Produce is harvested by the afternoon, sorted, packed and placed at farm gates or roadsides for collection. It is transported by truckers to growers' agents at the primary wholesale market (Agricultural Produce Market Committee, APMC), Jamalpur, in Ahmedabad city, where it is sold the following morning (Figure 1).

The produce is bought by traders in two secondary markets, Khamasa and Kalupur. Vendors in the city source produce from all three markets, depending on their requirements and preferences for quality and price. Prices are lowest at Jamalpur, but the quality is mixed and there is a minimum lot size for sale. Prices are higher in secondary markets and the quality is higher because traders there carry out some sorting, although not to standard. Vendors cart the produce to their establishment by mid-morning. Thus consumers in

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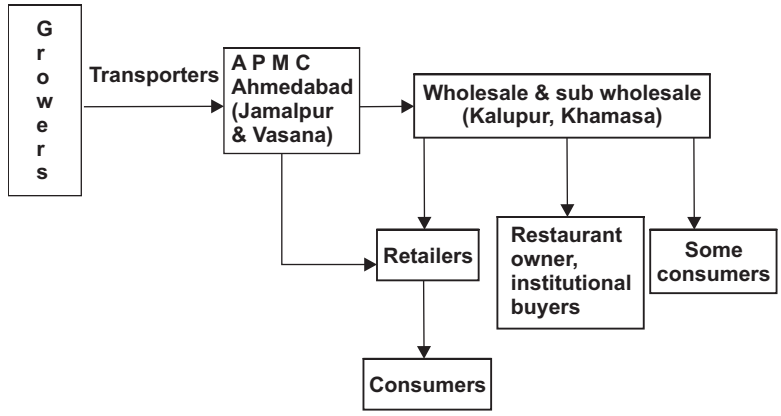

Figure 1. Vegetable supply chain, Ahmedabad area

Damage to fresh produce is caused by a number of factors

the city who buy vegetables from retail vendors in the morning get produce that left the fields at least 18 hours earlier and may have travelled up to 200 km. Mechanical injury and other types of damage are evident in the produce, which result from several factors: poor harvest tools and packaging; haphazard stacking in transport vehicles; shocks caused by rough roads and transferred to produce; exposure to weather; or rough handling. A random inspection of crops at the farm gate of a large grower and later on arrival at Jamalpur market found the extent of 'slight to serious' defects increased as shown in Table 1.

Contamination

Produce may also be contaminated by bacteria (Table 2), pesticide residues (Table 3) or heavy metals (Table 4) (all tests were carried

Table 1. Increase in damage to crops from farm gate to market

Crop	*Defects (%)*	
	At farm gate	*At Jamalpur market*
Okra	12	24
Eggplant	15	29
Cabbage	21	45
Cauliflower	19	39
Bottle gourd	24	50
Cowpea	31	40
Flat bean	3	11
Spinach	26	42

Source: Sharan and Rawale (2005)

Table 2. Microbial load in samples from APMC Jamalpur

Produce	*Microbial count (numbers per g)*			
	Vibrio cholerae	*Salmonella typhi*	*Escherichia coli*	*Coliforms*
Coriander	Absent	Absent	4,300	9,300
Spinach	Absent	Absent	24,000	24,000
Carrot	Absent	Absent	4,300	24,000
Spring onion	Absent	Absent	240,000	240,000
Tomatoes	Absent	Absent	Absent	1
Cucumber	Absent	Absent	4	15
Cabbage	Absent	Absent	Absent	24,000
Beetroot	Absent	Absent	43	2,400
Cauliflower	Absent	Absent	15	2,100
Fenugreek	Absent	Absent	43,000	240,000

Microbial counts in some vegetables exceeded the maximum specified limits by several hundred times

out at the Food Testing Laboratory of the Consumer Education and Research Centre, Ahmedabad).

The microorganisms detected in significant numbers were *E. coli* and coliforms. In tomato and cucumber, the coliform count is within the acceptable limits for raw vegetables, whereas, *E. Coli* is slightly higher than limits in South Africa but within limits used in Hong Kong, UK and Ireland. Microbial counts in carrot, spinach, spring onion and coriander exceeded by several hundred times the maximum specified limits. This may be caused by growers on the periphery of the city making use of untreated wastewater and other industrial effluents for irrigation.

Table 3. Pesticide residues in samples from APMC Jamalpur

Pesticide	*Concentration (mg/kg or ppm)*			
	Cauliflower	*Capsicum*	*Tomato*	*Spinach*
Lindane	0.0002	<0.0001	ND	ND
DDT	0.005	0.0005	0.0120	ND
Ethion	0.3331	ND	0.1621	0.1580
Aldrin	ND	<0.0001	<0.0001	<0.0001
Dieldrin	ND	ND	ND	0.0008
Endosulfan	ND	ND	0.0001	ND
α BHC	ND	0.0002	ND	ND
β BHC	ND	ND	0.0015	ND
Chlordane	ND	ND	ND	ND
Malathion	ND	ND	ND	ND
Dicofol	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND

ND = not detected

Residues of eight chemicals were detected (Table 3), but the concentrations were below the maximum residue limit (MRL) of both the Codex Alimentarius and the Indian Prevention of Food Adulteration (PFA) Act. The use of DDT, α BHC and β BHC has been banned for some years, and traces from earlier applications might have remained in the soil and become absorbed into plant tissues. Other chemicals are generally used in pest management and the concentrations that were found are within the limits prescribed by the Food and Agricultural Organization, World Health Organization, Codex and PFA.

Residues of six heavy metals were detected in the vegetable samples

Residues of all six heavy metals were detected in the vegetable samples (Table 4). However, concentrations were within the MRL of the PFA with the exception of copper in capsicum and tomato, which exceeded the MRL by 1.15 and 4.6 times, respectively, and the concentration of lead in eggplant, which exceeded the MRL by 5 times. Possible sources of copper contamination might be excessive use of copper chloride, which is regularly used as a fungicide, and other heavy metal contamination could arise from the soil, air pollution from small industries, vehicle or diesel generator emissions, or sewage and industrial effluents used for irrigation by some growers on the outskirts of the city.

Retail sales

Retailing takes place in small and large bazaars, 'convenience' (or over-the-counter) stores, and by hawkers with handcarts. Bazaars are congregations of handcart vendors, numbering 25–200 at one place. Convenience stores operate from permanent shops near to residential complexes. Retailers sell the produce as it is obtained from the bulk markets, with only minimal additional sorting and cleaning, if at all. Where sorting is done, it is not to standard, and cleaning is intended to only freshen up the appearance and not to deal with hazards. Growers receive about 40 per cent of the sale price, with the balance going to retailers in the supply chain (Sharan and Rawale, 2001). Daily

Table 4. Heavy metal contamination in samples from APMC Jamalpur

Metal	*Concentration (mg/kg or ppm)*					
	Cauliflower	*Capsicum*	*Tomato*	*Spinach*	*Okra*	*Eggplant*
Arsenic	0.0064 × 10-3	0.002 × 10-3	0.0124 × 10-3	0	0	0.0049 × 10-3
Copper	0.41	34.78	137.36	0	1.8933	2.06
Zinc	14.33	7.47	1.52	12.17	5.42	3.63
Cadmium	0	0.2029	0	0	0.2565	0.2015
Chromium	0	1.1459	0.8647	1.1410	0.6519	0.6044
Lead	0	0	0	0	0	12.55

There is now a demand for higher quality produce, but the supply chain has failed to respond

turnover is presently more than 2,000 tons and has grown at 5.23 per cent per year over the last 50 years. The growth corresponds closely to increases in the city population, suggesting that it has responded adequately to changes in demand. However, there is now a demand for higher quality produce in the city, that is hazard-free, chemical-free and organic, but the supply chain has failed to respond.

The author visited some fresh produce daily markets in France (Clermont-Ferrand), Italy (Turin, Naples) and Germany (Munster) for this study. These operated from a designated park where vendors assembled in the morning for a few hours. There was a water and electricity supply and waste disposal provision. Produce was clean and fresh and so was the market place. These markets can be better models for bazaars, which lack supportive provisions.

Quality at the point of sale is a cumulative result of the events and processes that occur along the supply chain and, to improve it, the quality-degrading factors at all stages should be addressed in a coordinated way. This is not easy in supply chains that involve several independent stakeholders, as in the Ahmedabad area, and a consultation was therefore convened to discuss possible ways to trigger innovation and change. The participants included representatives of traders, Department of Horticulture officials, APMC market officials, post-harvest engineers and consumers (Sharan and Rawale, 2001; Prussia et al., 2001). There were differing views on 'quality' and ways to move forward. There was agreement on the need to improve quality but no consensus on how to start. A view emerged that a wider consensus could be obtained from a study to determine consumers' preferences for quality and their willingness to pay for improvements. It was decided to explore the possibility of bringing about improvement locally at small scale via innovative procedures and equipment that could be adopted by store-owning vendors. Accordingly, a project was started with the following objectives:

A study would determine consumers' preferences for quality and willingness to pay for improvements

- To determine the quality attributes required by city consumers and their willingness to pay for improvements.
- To design simple equipment for treating produce by cleaning, trimming and sorting-to-standard before sale; with the additional costs not exceeding 20–25 per cent of vendors' prices.
- To operate an improved store to study its performance and the response of consumers, and if successful, encourage vendors in the city to adopt similar practice.

The new store was built at the campus of IIMA. It was recognized that this may lead to difficulties later in transferring the concept to city vendors. But since considerable experimentation was anticipated in the initial phase it was felt that it would be easier to manage that on campus.

Consumers' views of quality and willingness to pay for improvements

Sample consumers were housewives belonging to middle- and high-income families

Sample consumers were housewives belonging to middle- and high-income families living in the neighbourhood of the IIM campus, who normally purchased vegetables from nearby stores. Thirty respondents were selected and briefed on the aims of the project. Over 10 days, each day respondents were given a 1 kg sample of produce obtained from Jamalpur market and asked to inspect the sample and separate it into three categories: category one to be the best from their viewpoint, category two, and rejects. After sorting, each respondent was interviewed to understand the basis of their selection (colour, size, etc.). Ten respondents were polled for each type of produce and a total of 15 vegetables and 3 fruits were studied. This led to specifications for each type of produce and those for okra are given in Table 5 as an example.

Similar specifications were developed for 25 vegetables and fruits (Sharan and Rawale, 2005, 2007). The main finding was that in almost all cases the attributes most desired were fresh and clean, free from visual defects and injuries, and a bright appearance. Dimensional uniformity was not important. Consumers indicated a willingness to pay a premium of 15–20 per cent for produce that was consistently clean and fresh. Respondents also stated that shopping for vegetables was tedious and time-consuming because they had to choose from unsorted lots in baskets and haggle over prices. This was later confirmed by tracking a sample of customers visually and also via video. Of the total time spent with a vendor 30 per cent was spent in just enquiring about prices, 44 per cent in getting orders fulfilled and 26 per cent in making payment. Based on the findings, the experimental store was

Consumers were willing to pay a premium of 15–20% for produce that was consistently clean and fresh

Table 5. Specifications for okra

Produce	*Attributes valued by Ahmedabad consumers*
Okra-1	Similar characteristics and mature; pods need not be uniform length but not over-size; stem length not to exceed 1 cm; tender (tip snaps easily); 80% or more not misshapen, curved; fresh, not wilted or shrivelled, smooth textured and healthy appearance. Seeds not protruding. Free from sap, dirt; free from disease, insect injury, black or brown spots, bore hole, tip break, bruises, cuts or splits. Some (not to exceed 5%) may have superficial blemishes on the surface
Okra-2	Similar characteristics and mature; pod need not be uniform length; stem length not to exceed 1 cm; tender (tip snaps easily); some may be fibrous; pods pale to dark green, bright appearance; 80% or more well shaped; fresh, not wilted or shrivelled; slightly rough textured but healthy appearance; seeds may be protruding; free from sap, dirt, disease, insect injury, bore hole, tip break, cuts or splits; may have slight bruises, black or brown spots

termed 'Clean-n-Fresh' and the sequence of treatments were designed to achieve the first and second quality characteristics indicated by the respondents (termed Ahmedabad-1 and Ahmedabad-2).

Clean-n-Fresh vegetable store

The store was designed to include a section to treat the produce and one to display and sell it

The store was designed to include a section to treat the produce and one to display and sell it (Sharan and Rawale, 2007). The physical dimensions of the store were similar to typical vegetable stores in the city (a 7 m × 3 m × 3 m room). Vegetable treatment equipment needed to be low-cost with low energy and water usage so that additional costs did not exceed the amount consumers would be willing to pay. It included work tables for sorting and trimming; a tumble-drum washer and a spray jet washer; a forced air surface drying table; and a weighing, packaging and labelling table. The retail section had display racks; a humid chamber for leafy vegetables; and computerized billing and checking.

Produce was sourced from Khamasa and brought to the store early in the morning in plastic cartons on an auto-rickshaw. Workers were trained to carry out treatments as per the protocols developed: for example: 5 kg of potatoes should be treated within 12 minutes (sorting 2 min, drum washing 4 min, drying 4 min, packing 2 min). Protocols for 28 items are described by Sharan and Rawale (2007).

Sorting was carried out by visual inspection and separating the lot into two categories in accordance with the specifications developed previously. Three 20 W fluorescent lamps illuminated the workbench. Cleaning removed sap sticking to the produce and contaminants on the surfaces, and reduced the microbial load. Some produce was cleaned using a dry brush and others were washed with a tumble-drum washer, a spray-washer or a washbasin. The manual drum washer was specially designed to fit into a washbasin and consists of a perforated stainless steel drum, 40 cm in diameter and 40 cm in length. The lower part of the drum is submerged in water while in operation, and a 5 kg batch of potatoes for example can be washed and surface dried within 12 minutes. Water is chlorinated and changed when it is turbid. Other produce was placed in plastic trays and dipped in a water-filled basin. Cauliflower, for example, was washed using a combination of dipping and spray washing.

Packaging made shopping convenient and reduced product contamination and moisture loss to extend the shelf-life

Water on the surface of produce was removed by natural drainage and if needed by air blown over it using fans mounted above the table. The produce was weighed, placed in perforated high-density polypropylene bags of different sizes to suit customers' needs. The packaging made shopping convenient and quick; it reduced contamination by airborne insects and dust while on display; and it reduced moisture loss, to extend the shelf-life and enhance product appearance

while on display racks. The number of holes required for adequate ventilation was determined using the procedure described in Hall (1970). Using perforated pouches, moisture loss in okra was 2 per cent after 6 hours at a room temperature of 19–24°C, compared with 8.6 per cent in unpackaged produce. Okra can therefore be stored safely in ventilated pouches at ambient conditions for one and half days. Similarly, moisture loss in French beans was 6 per cent after 18 hours at 23–29°C in ventilated packages, compared with 11.7 per cent in the control, and they too can be stored safely at ambient conditions for one and half days. The shelf-life of other produce is reported by Sharan and Rawale (2007).

Leafy vegetables placed in the humid chamber remained fresh and crisp for 24 hours

Display racks were made of stainless steel and a humid chamber was developed to provide evaporative cooling for leafy vegetables, made of perforated shelves clad in thick *khadi* cloth. The cladding is wetted two or three times each day to keep the chamber at a high relative humidity and lower temperature than ambient by 4–5°C. Leafy vegetables were wrapped in a thin wet cotton cloth and placed in the chamber, and remained fresh and crisp for 24 hours. The chamber cladding was washed and dried twice per week to prevent microbial growth.

Pricing was determined each morning after all produce was sorted and processed into three categories. A small macro was coded in Excel which computed the sale price given the actual proportion of category 1, 2 and 3 found in the lot, and the procurement price. There was variation in the relative proportion of the three categories in raw produce depending on the source, but it was often not possible to trace the source-grower. When possible a history of source quality was maintained to avoid sourcing from those whose produce had a larger proportion of inferior produce. The third category was disposed of as waste. Attempts were made regularly to see that sale prices did not exceed appreciably the prices of neighbourhood vendors.

Consumer feedback

A majority of the regular customers reported that vegetables were of 'excellent' quality

Consumer feedback was obtained periodically and used to amend the project operation. A majority (66 per cent) of the regular customers reported that vegetables were of 'excellent' quality and 34 per cent rated them as 'very good'. All respondents said that they were satisfied with the quality specifications and preferred Ahmedabad-1. They indicated that the self-service format was more convenient, took less time to shop and the shop had a pleasant ambience. Responses of customers from outside the campus were similar: a majority (61 per cent) rated the quality as 'excellent', 30 per cent 'very good' and 9 per cent as 'good'. A majority of respondents (72 per cent) reported that they would like more such shops in their neighbourhood. Many suggested

Awareness programmes for vendors and consumers included an information package disseminated via workshops, conferences and the IIMA website

that awareness programmes should be carried out for vendors and consumers in the city to promote this concept more widely. This was done at the end of the project. An information package on the new store was disseminated via workshops, conferences and the website of IIMA. Three requests were received and responded to for consulting advice for scaling up and starting similar systems in Chennai, Maharashtra and Kutch. Customers also suggested that fruits be added and the range of items increased. All respondents were prepared to pay 10–30 per cent more if their vendors were able to consistently supply the quality of Ahmedabad-1 vegetables.

Economics

The Clean-n-Fresh store employs two workers for vegetable treatment who work for four hours each day and one manager who procures materials, supervises vegetable treatment and mans the sales counter throughout the day. The total investment in treatment line and shopping equipment was Rs.75,000 ($2,000), without the cost of a billing computer.

After six months the operation began to break even

Operational costs were higher than total sales for the initial six months, after which the operation began to break even (Figure 2).

In the first month of operation (November 2004) total operating costs (wages, rent, utilities, water, phone, transport and the cost of raw produce) were 1.12 times the total sales. This continued to be so for six months after which the store began to break even. During the initial period, total daily sale was about 150 kg of produce, which increased gradually to above 400 kg. There was considerable experimentation and learning in the initial period: procurements were made from different markets to assess differences in quality and

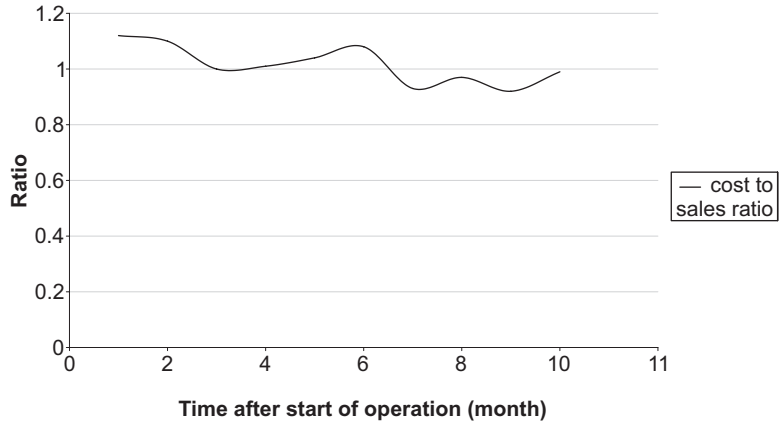

Figure 2. Cost to sales ratio over the first ten months of operation

Procurements were made from different markets to assess differences in quality and price

prices and it was found that produce from Jamalpur had the highest reject fraction; learning was needed in inventory management to reduce left-over produce at the end of the day while having sufficient stock to meet sales requirements; workers needed to be trained to produce the required quality as per specifications and the vegetable treatment unit manager worked with staff to ensure that sorting, washing and so on was done properly. The equipment also required alteration after initial experience of its operation. The vegetable treatment unit became profitable when daily sales volumes increased to over 400 kg.

Conclusion

The supply chain that has delivered over 2,000 tons vegetables each day to Ahmedabad for decades operates essentially as a one-way transport and distribution network, bringing produce from growers to the bulk markets but not conveying the concerns of the consumers back to growers. The entry of big retail businesses, a recent phenomenon, has made some improvement in the retail format but not in quality, which is often the same as or worse than vendors.

Innovations must address the concerns of consumers and be worth the additional price

The experience of the Clean-and-Fresh store is that some improvement in quality and safety can be brought about by innovation at the local level. Innovations must address the concerns of the consumers and be worth the additional price they may be called upon to pay. The store included a treatment line to sort, trim, clean and pack vegetables, which added Rs.1.5–2 per kg of produce. Consumers in relatively high income areas indicated that they would be willing to pay a premium of 15–20 per cent for clean and fresh produce.

Thus, the price of vegetables sold at the store was higher than that of vendors by about 20 per cent, but was close to the price that consumers indicated they would be willing to pay. The retailing section was self-service for quick and convenient shopping. The extra investment to furnish an existing store with the required equipment was $2000. Break-even was reached with sales upwards of 400 kg/day, well within the daily turnover at convenience stores in the city. The Clean-n-Fresh model could be adopted by city vendors to add value, especially by those who run convenience stores near residential complexes.

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