Quality assurance initiatives for peri-urban food production in India

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Summary

The levels of air pollutants are rapidly increasing in many 'megacities' of the developing world. Air pollution reduces both the yield and nutritional quality of crop plants, and is also a major source of particulate contaminants that can accumulate at toxic levels in the edible portion of crop plants grown in urban and peri-urban (UPU) areas. This paper presents new knowledge on the impacts of UPU environmental pollution and on food safety attributes of the vegetable marketing systems in India. It explores the appropriate balance between public and private quality assurance initiatives and identifies wholesale markets as a potential entry point for quality assurance. Finally it locates the Indian system of regulated wholesale markets within and integrated quality assurance framework for public and private mechanisms to improve food safety.

Keywords

food safety, India, quality assurance, air pollution, public/private sector

1 Introduction: peri-urban air pollution and food quality

"… behind the rising prosperity in the developing world lurks the shadow of lethal air pollution from motor vehicles, smokestacks and hearths" (World Bank, 1998: 99).

Almost 3000 million people live in urban areas. Most of the growth in the world's population is taking place in developing countries, and most of the projected increase of 1000 million people between 1999 and 2010 is likely to be absorbed by developing country cities. The 'ecological footprints' of cities can be vastly greater than their physical area because of the demand for energy, food and other resources, and the regional impact of their wastes and emissions to air, soil and water. Among the most serious environmental problems in the developing world is air pollution, which is reaching crisis dimensions in many 'megacities' - urban populations greater than 10 million (United Nations Environment Programme, 1999).

Respiratory hazards from air pollution in urban areas are widely acknowledged. Another reason for concern is the major threat posed by air pollution to crop production in urban and peri-urban (UPU) areas, where the livelihoods of urban inhabitants are dependent on access to cheap and safe food of high nutritional quality. The contribution of UPU production to urban food demand throughout the world, particularly of perishables, can vary from 25-100%, and may involve a high percentage of families (Birley and Lock, 1999). The majority of highly perishable products, including many vegetables that are consumed in cities, are produced in UPU areas.

Air pollution reduces both the yield and nutritional quality of crop plants, with important implications for consumers and producers, particularly the poor. Air pollution is also a major source of heavy metals that can accumulate at toxic levels in the edible portion of crop plants (Marshall and Wildig, in press). Compared with degradation of the physical environment, the management of health hazards associated with environmental contaminants has been neglected. Nevertheless, public awareness of the health, education and economic implications of unsafe food systems in developing economies is growing fast. According to Motarjemi, "it should be remembered that the developing countries bear the heaviest burden of foodborne diseases in the world" (1996: 82). For lifestyle reasons, poor populations are more susceptible to environmental metal poisoning (Nriagu, 1992).

There is currently little information on the integrity of supply chains for horticultural produce in UPU areas of developing countries. Pre- and post-harvest contamination is likely to be widespread. Health data are scarce, but levels of morbidity and economic losses affecting poor people are likely to be considerable. Moreover, the regulatory regime for environmental pollutants, and for hazardous technologies and production practices is likely to be weak.

This paper reports the first stage of an interdisciplinary study of the impacts of air pollution on urban food quality in the developing world, and suggests approaches to improve quality assurance (QA). The focus for this work is India but will have implications for agrifood systems in other regions.

The next section discusses air pollution impacts on UPU food systems. Section 3 introduces the QA concepts and approaches to mitigate these hazards. Section 4 explores the potential of Indian regulated wholesale markets as a QA entry point and presents results from exploratory studies into the marketing system in Delhi. The concluding section locates the potential incentive and constraint mechanisms of the wholesale market initiative within an integrated QA framework.

2 Air pollution impacts on UPU food systems

2.1 Sources of pollution

The adverse effects of urban air pollution are associated with three major sources. They are sulphur oxide and solid particulates from fossil fuels; photochemical oxidants and carbon monoxide from motor vehicles; and miscellaneous pollutants such as hydrogen sulphide, lead and cadmium emitted by smelters, refineries, manufacturing plants and vehicles (Birley and Lock, 1999). Population pressures leading to increased numbers of motor vehicles, power generation, domestic fuel use, refuse burning and other sources all contribute to the problem. Particular cities present particular problems: India's economy relies heavily on coal, which contributes high levels of SO_2 emissions. In Delhi, where the population, currently over 12 million, is growing at 3.8% per annum - and in Mumbai - levels of particulate matter exceed World Health Organization recommended levels by a factor of three (United Nations Environment Programme, 1999). Sources and types of air pollutants in one Indian city are summarised in Table 1.

Table 1 Sources and types of urban air pollution, Varanasi, India

Industry	Pollutants
Metal products	Fluoride, SO_2, NO_2, heavy metals
– Aluminium, steel, brass & copper	
Chemical products	Organic vapours, SO_2, NO_2
– Soaps, detergents & pharmaceuticals	
Textile printing	SO_2, NO_2
– Saris & hosiery thread	
Coal and products	SO_2, NO_2, ash (heavy metals)
– Bakeries & commercial food preparation	
– Household use	
– Textiles & other small scale industries	
Transportation & vehicle servicing	SO_2, NO_2, HC, CO, heavy metals
Miscellaneous	Fluoride, SO_2, NO_2, organic vapours, heavy metals & other particulates
– Plastics and ceramics	
– Carpets & jari work	
– Brick kilns and construction	

Compiled from Agrawal (2001a) and Marshall (2000).

2.2 Impacts on crop output and value

Primary pollutants such as sulphur dioxide can cause significant crop yield losses in the vicinity of urban industries, whilst ozone is the pollutant of greatest concern for crop production on the outskirts of cities (Ashmore and Marshall, 1999). Elevated levels of ozone have been found to have both yield and quality effects on crop production in field experiments in the UK and elsewhere (Wilbourn, Davison and Ollerenshaw, 1995; Ollerenshaw and Lyons, 1999; Ollerenshaw, Lyons and Barnes, 1999). Crop damage has been found to be more severe in countries with greater solar intensity because strong sunlight accelerates the series of chemical reactions that leads to ozone formation in the lower atmosphere. There are also indications that some tropical crop cultivars and agricultural systems may be particularly sensitive to ozone (Ashmore and Marshall, 1999).

Phytotoxic gases have been found to cause major yield reductions on a range of important crops in the developing world (Ashmore, Bell, Marshall and Milne, 2000). For example, yield reductions of 40% or more have been recorded at ambient levels of air pollution for rice and wheat on the outskirts of Lahore, Pakistan (Wahid, Maggs, Shamsi, Bell and Ashmore, 1995a; Wahid, Maggs, Shamsi, Bell and Ashmore, 1995b); and on spinach and mustard in Varanasi, India (Marshall, Wildig, Stonehouse, Bell, Ashmore and Batty, 2000). Air pollution also has the potential to reduce the nutritional quality of crop plants, with important implications for consumers, particularly the poor (Marshall, Ashmore and Hinchcliffe, 1997; Ashmore and Marshall, 1999). Air pollution can cause visible damage to the edible portion of the crop (Taylor, Ashmore and Bell, 1987), increase susceptibility to post-harvest pest and disease attack (Bell, McNeill, Houlden, Brown and Mansfield, 1993), and reduce shelf life, with important economic losses throughout the market chain.

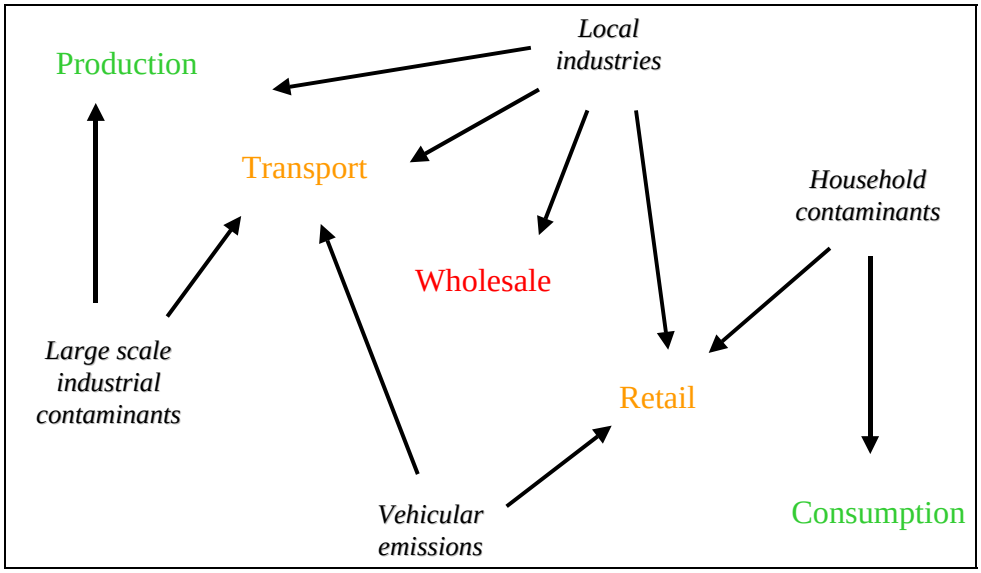
2.3 Impacts on crop safety

There are also major concerns over toxicity in food crops caused by emissions of fluorides (particularly associated with brick kilns that are prevalent in peri-urban areas) and heavy metal deposition (for example lead, cadmium, zinc and copper) from a wide range of industries. These can accumulate at toxic levels in the edible portion of crop plants, with potentially serious long-term consequences. Exposure to heavy metals has been linked with developmental retardation and reduced IQ among children, various cancers, kidney damage, and the development of autoimmunity. Children appear to be especially vulnerable (United Nations Environment Programme, 1999: 31): “There is particular and growing concern about the threats that chemicals pose to children's health. The main problems include both acute exposure leading to poisoning, and chronic, low level exposure causing functional and organic damage during periods of special vulnerability, when neurological, enzymatic, metabolic and other systems are still developing. Exposure of unborn children to toxic chemicals may produce irreversible effects… Recent research suggests that these chemicals may affect the ability of children to learn, integrate socially, fend off disease, and reproduce”.

2.4 Initial contamination results, Varanasi

Critical points of potential contamination in the vegetable supply chain begin with the impact of large and small-scale industries at sites of production. Such sources may also lead to deposition of contaminants during transportation to wholesale and retail markets. Contamination from vehicular emissions and local industry is likely during retailing when the products are exposed at roadsides. Households may exacerbate food contamination through domestic gaseous emissions and through direct contamination of food within the household. These critical points are illustrated in Figure 1.

Figure 1 Critical points in the vegetable supply to UPU areas, India



Initial results of research in Varanasi, India, have found highly toxic levels of cadmium in fresh vegetables (Marshall, 2000). After a calendar year of testing air and plant samples, results showed high levels of both air pollution and vegetable contamination, particularly in the summer season. A significant correlation between zinc deposition and levels in vegetables was found in the rainy season and winter season. For cadmium there was a significant correlation between deposition and levels in vegetables in all seasons. Overall, a high percentage of retail sites that were analysed were found to exceed permitted levels (Agrawal, 2001b).

To conclude this section, the following observations may be made. Data from the literature, from previous research, and from a growing body of empirical evidence from the current project signal that air pollution is a source of food safety hazard in the supply of vegetables to Indian cities from UPU agricultural areas. Initial results from product analyses from various sites within Varanasi show high levels of cadmium and other heavy metals that appear to be deposited post-harvest.

The wholesale and retail functions of the marketing system have been highlighted in work to date as critical points both as sources of contamination and as potential entry points for QA mechanisms. The meaning of 'quality', and approaches to quality assurance, are discussed in the next section. Empirical data from exploratory studies of quality aspects of the vegetable wholesale market system from a socioeconomic perspective are presented in section 4.

3 Quality concepts and approaches to food quality assurance

'Quality' is a complex of properties of a good or service that satisfy a customer's implicit and explicit needs. Food safety is a subset of the broader concept of food quality, and includes a number of dimensions:

- product safety: freedom from environmental and other contaminants and sources of toxicity (chemical and biological) injurious to health;
- product consumption attributes: both objective (nutritional and other physical characteristics such as shelf life, appearance, flavour, texture; attributive (other presentational aspects including labelling, packaging, branding, reputation), and subjective (utility in respect of economic value, consumer preferences and satisfaction, including range of choice);
- production and post-harvest handling techniques: process, or 'best practice' in respect of technology and inputs including choice and application of agrochemicals and/or organic fertilizers, processing and storage; socially responsible labour and commercial practices.

Food quality can be a 'search' good if the consumer is able to obtain information through inspection. Alternatively, quality is an 'experience' good if the consumer can access readily available information (eg through labelling), or through repeated purchases, or reputation effects (eg branding) (Nelson,

1970). QA systems for such attributes are likely to use market-mediated incentives (Segerson, 1999). Other attributes are 'credence' goods, for which information cannot be discerned even after repeated consumption (Darby and Karni, 1973), and for which QA may involve control, reduction or elimination by regulation. However, even in the absence of market-driven incentives, regulation or controls may not be necessary if firms can be induced by incentives or constraints. These food quality attributes, incentives and potential QA mechanisms for hazards resulting from airborne contaminants are summarised in Table 2.

Table 2 Quality attributes, incentives and potential assurance mechanisms

Attributes	Example	Incentive framework	Assurance mechanisms
'Search' goods	**Physical appearance** – freshness & variety – size & shape – colour & maturity – visible injury	**Market-mediated**	**Information** – inspection
'Experience' goods	**Organoleptic characteristics** – flavour – texture – smell	**Market-mediated**	**Information** – reputation effects & repeat purchase – labelling & branding – provenance
'Credence' goods	**Production and post-harvest technologies, and nutritional value** – freedom from environmental contaminants such as heavy metals – nutrient content, especially vitamins and minerals	**Public sector initiatives** – mandatory interventions – facilitatory initiatives **Incentives and constraints** – public information provision	**Control** – testing and implementation of accepted standards – certification & regulation – institutions creating and enforcing liability **Information** – 'best practice' production technology, post-harvest and household handling

3.1 Approaches to regulation: public or private?

In economic terms, food safety is a 'luxury' good. Thus, the demand for food safety depends *inter alia* on income and prices; on perceived risk (a function of the level and value of available information); on individual attributes such as age, education and risk tolerance. Where incentives and information flows are imperfect, the market alone may fail to supply the level of food safety demanded by society.

Market failure to deliver the level of safety to meet public health requirements and consumer demands constitutes economic grounds for public policy intervention (Unnevehr and Jensen, 1999). However, the existence of market failure does not mean that intervention can necessarily improve the performance of unregulated markets.

Approaches to public food regulation range from low to high levels of intervention. Unnevehr and Jensen (1999) distinguish between information-based incentives for private market solutions and direct 'command and control' interventions. The former may be provision of information to consumers, lowering information costs through improved testing mechanisms, branding, labelling, (self-)certification schemes, and laws creating enforceable liability. Reputation effects and trust are additional private mechanisms that are of considerable importance in advanced economies, and probably no less important in developing economies: it has been said "in India you do business with people with whom there is prior mutual trust" (Basu, 1992: 344).

Interventionist regulations can take two broad forms, according to Hilmer, *et al.* (2000). Performance standards specify a quality level that a firm's output must meet, involving enforcement through testing, but allowing the firm autonomy over its production process. Process standards specify procedures required to produce output of the desired quality – the prior approval previously referred to. High levels of intervention create the potential for firms to 'capture' the regulatory process and thereby attempt to co-opt the regulatory system to gain competitive advantage. This phenomenon, together with the enforcement problems that arise from a heavy regulatory approach - evident, for example, in the case of India below (Harriss-White, 1995) – suggest that where the institutional framework is weak, regulation must be approached with caution.

3.2 The public-private balance in theory

In advanced economies, there are increasing concerns about the costs to the industry of regulatory compliance. The costs to the authorities are those of the enforcement of performance measures through product testing, and to firms are the costs of conforming to industry-wide standards that may not be appropriate. Whether or not food chain stakeholders engage in private QA activities depends in part on the mix of incentives. Incentives may be positive, resulting in voluntary adoption of appropriate QA mechanisms. They may be negative, either purposive (in the form of policy-mediated sanctions for non-compliance such as fines), or consequential (in the form of declining market share and exclusion from the market).

Consensus is growing that both public and private sector initiatives are necessary in enhancing the integrity of food systems (Fearne and García, 1999; Segerson, 1999). Regulatory initiatives to impose 'due diligence' requirements and legal liability cannot work alone. Nor can the task to secure the integrity of the supply chain be left to individual or firm initiatives in response to market forces.

Drèze and Sen argue that the contrast between market-based and government-based economic decision making, particularly in India, requires a clear understanding of the context (1995). As Basu argues, "In reality, an effective market is one which operates freely, but *within* a structure of norms

and legal institutions" (Basu, 1992: 341). At the state level in India, Drèze and Sen (1995) note *inter alia* the essential role of three factors for successful public policy implementation. There must be:

- well-functioning public (ie state-provided) services;
- public (ie democratic and participative) action; and
- a particular type of public action – the political organization of deprived sections of the society.

In the context of food safety, advocacy and consumer pressure are forms of public action expected to play a role in bringing about improved QA. "Public action can also affect outcomes without having to work through swaying government policy" (Drèze and Sen, 1995: 89). These assertions are consistent with the climate of economic adjustment that seeks to find an efficient and effective balance between intervention and regulation by the state, and private sector activity in response to incentives created by the market (World Bank, 1997).

Efficient and effective transmission of private information and incentives is an important constituent of the mechanisms for QA. Information and incentives are likely to play a part in food QA mechanisms at least as important as policy, especially where the regulatory environment is weak. Even in advanced food systems, deficiencies in the flow of information through market systems have been found to be a source of market imperfection in matching market intermediaries' perceptions of quality to consumers' preferences and demand characteristics (Poole and Baron, 1996; Poole, 1997).

Thus there is a range of factors that will determine the feasibility of different approaches to QA, and hence the appropriate blend of market-mediated mechanisms and public intervention. In summary, efficient, effective and relevant food QA mechanisms in developing countries are likely to involve improved scientific knowledge, accompanied by technical and institutional responses through both regulatory and market mechanisms, and commercially propitious business attitudes. Information and incentives are likely to play a part in QA mechanisms at least as important as policy, especially where the regulatory environment is weak.

3.3 Public sector opportunities for food QA

Regarding incentives that may arise from within the state sector system, some, but not all agricultural wholesale markets in India, are governed by the regulated market acts that date from 1886. It was the Royal Commission on Agriculture in 1928 that laid down the operational details of regulated markets and the functions of the Agricultural Produce Market Committees (APMCs):

- specification of management of the physical infrastructure, selling methods, payment regimes, classifications and licensing of market functionaries and their activities, marketing charges, commodities regulated, etc;

- the regulation of market practices, grading and standardisation, good infrastructure, proper weighing systems, payment arrangements.

The focus of the regulated markets policy is primarily to reduce inequities at the first point of sale and ensure remunerative prices to otherwise exploited producers (Agriknowledge, 2001b; Agriknowledge, 2001a). However, by no means all of Indian markets are regulated. According to Bhupal, who researched regulated markets in Rajasthan in the 1970s, regulations are not always fully observed, but compared with the operation of unregulated markets, regulation has served to 'help to remove the darkness of the centuries-old custom-ridden agrarian society' (1979). He concluded that in Rajasthan, notwithstanding imperfections, the institution of regulated markets had created a new economic atmosphere in the agrarian sector. In contrast, in Varanasi, in Uttar Pradesh, three of the four major wholesale markets are unregulated, while the fourth (Sarnath) is only 'regulated' in a nominal sense.

The weight of evidence about the public sector intervention in food markets suggests that although there are regulatory instruments that could serve as mechanisms of improved quality control (Poole, Bell, te Lintelo, Marshall and Poole, 2000), it would be wrong to entrust food quality assurance to strong regulatory control through Central or State governments. Private initiatives must form part of the framework of incentives and controls.

3.4 The potential for commercial QA initiatives

Sivamohan (1997) has undertaken a study of the evolving commercial arrangements in high value horticultural marketing in India. Traditionally, private wholesale merchants, retailers and street vendors have been the mechanism linking producers and consumers. The development of cooperative societies in states such as Gujarat and Maharashtra since Independence has opened up alternative marketing channels. Latterly, newer marketing arrangements[1] have evolved in response to the rapid rate of population growth, urbanisation and the consequent increased dependence on formal transport systems from rural to urban areas, and also growing export opportunities.

[1] The commercial organisation 'Mother Dairy' is well known in Delhi, and has its roots in the public sector National Dairy Development Board (NDDB). Latterly there has been extension into fruit and vegetable marketing and the creation of a private limited company. The Fruit and Vegetable Project (F&VP) was set up in 1986 by the NDDB, initially as a pilot project to market fruit and vegetable products to consumers in Delhi. The organisation is now a sophisticated business enterprise, retailing through 250+ outlets under the brand name of Safal in Delhi and to markets elsewhere in India.

Procurement occurs preferably through formal or informal producer organisations at rural procurement centres. Important functions that are integrated within the organisation are technical support to producers, transport, cold storage and ripening, product grading, some processing (washing and freezing) and quality control functions. Storage, processing and distribution are centred in Delhi. Incentives are paid to suppliers of produce above specified standards. Sivamohan attributes the success of F&VP to the farmer-support system and the integrated nature of the handling and distribution system.

In a recent interview, the chairman of the Azadpur (Delhi) APMC stressed the dynamic nature of the fruit and vegetable industry (Sharma, 2001). As many as seven purely private food marketing initiatives have arisen recently in response to the liberalising economic environment and wealthy consumers' expressed quality preferences. Although evidence is largely anecdotal at this stage, these new private enterprises were said to surpass Safal in quality and efficiency.

That new quality-conscious enterprises should be developing is significant. Together with the decommoditising of the fruit and vegetable sector into branded, packaged, labelled produce lines, the evolution of market supply and demand is creating opportunities for quality initiatives that can serve as models for the mass market. It is in this context that the system of regulated markets offers public-private partnership opportunities to improve market coordination. The management of the wholesale markets provides the most immediate entry point to improve post-harvest quality control. The next section contains results from an exploratory investigation of the potential of wholesale market system for improving QA, focusing on the Azadpur market for vegetables in Delhi.

4 Market system coordination: exploratory research and potential for QA

Exploratory studies of the market system for selected vegetables were conducted in two stages. During November 2000 interviews were conducted in the Delhi Azadpur market among 54 market intermediaries in order to gain an understanding of the market system with respect to sourcing patterns for vegetables, transport methods, value addition and pricing methods (4.2). A further study of quality attributes and transaction characteristics in the cauliflower trade was conducted in among 242 market participants in January 2001 (4.3). In brief, the objective of the studies was to uncover any evidence of awareness of provenance, information flows on supply and demand conditions, quality incentives, clientisation and non-price contractual terms that might suggest closer vertical coordination – and hence potential for better flows of information and incentives - other than simply through the price mechanism.

4.1 Azadpur *mandi*

Azadpur fruit and vegetable *mandi* (market) is one of the regulated markets in Delhi. It is the largest fresh produce wholesale market in India, and in terms of volumes handled is said to be the largest in Asia. It was constructed in 1977 by the Delhi Development Authority and is managed by the Azadpur APMC, an autonomous body of Government of Delhi National Capital Territory. The market covers an area of more than 30 hectares, and the operations of the 3800 commission agents and wholesalers are regulated in order to 'ensure orderly marketing to safeguard the interests of both producers, sellers and consumers by eliminating various mal-practices… and indulgence of too many intermediaries' (Agricultural Produce Market Committee (Azadpur), 2001). A total of 50-60 different vegetables are traded daily, depending on seasonality, and total annual arrivals exceed 1.5 million tonnes. Produce is

received throughout the year not only from local producers but also from areas from Jammu and Kashmir in the North to Kerala in the South, and from Mizoram–Manipur in the East to Rajasthan-Gujarat in the West. Both fruit and vegetables are re-transported to other parts of the country.

4.2 Marketing system

Three important vegetables were selected on the basis of their perishability, seasonality and physical characteristics: spinach beet (*palak*), okra (*bhindi*) and cauliflower (*gobi*). Interviewees were the three main categories of wholesale market actors prior to distribution through the myriad small retailers and hawkers:

- assembly wholesalers: assemble vegetables after buying from other markets (within the NCT, peri-urban areas and from outside areas) and/or directly from the producer sellers, and sell in Azadpur market. 15 assembly wholesalers in all were selected.
- commission agents: negotiate transactions between buyers and sellers for a commission fixed at 6%; but in reality less is charged because of competitive pressures in the market. 15 assembly wholesalers in all were selected.
- mashakhore is a local term used for a functionary between the wholesaler and the retailer, only in Azadpur *mandi*. He is a small wholesaler or a big retailer, buying in quantity and selling in smaller units to the retailers, vendors and consumers. They are numerous, so 8 mashakhores were selected for each vegetable, totalling 24.

Three interviewers were deployed in the *mandi* for a week from 6-11 November 2000 to conduct interviews using a structured questionnaire. Interviews were conducted from morning to evening depending upon the availability of the respondents.

Responses

Responses to questions about produce origins, value-adding and prices were markedly homogeneous and are summarised in Table 3 below:

Table 3 Vegetable trading and sourcing: findings from Azadpur traders

			% sourcing			Prices: Rs received per unit sale	
			Urban	Peri-urban	Other	Peak season	Off-season
	Repeat dealing	Value addition	Peak / off-season	Peak / off-season	Peak / off-season	Low / high quality	Low / high quality
Cauliflower	Frequent / always	Limited	58 / -	35 / -	7 / 100	2.1 / 5.2	19.9 / 34.8
Spinach	Frequent	None	56 / 35	44 / 65	- / -	3.3 / 5.7	5.0 / 8.4
Okra	Frequent / always	Limited	17 / -	82 / -	- / 100	8.0 / 12.0	22.6 / 33.8

Table 4 Quality characteristics affecting pricing for three vegetables, Azadpur

	% of respondents citing factor					
	Variety	Freshness	Physical damage	Colour	Shape	Size
Cauliflower	33	94	50	94	54	100
Spinach	63	98	80	76	0	74
Okra	74	98	0	82	67	100

Table 4 shows the percentage of respondents citing particular quality characteristics as important. All categories emphasised equally the importance of freshness; the importance of other characteristics depends on vegetable type. Size and colour were important for cauliflower and okra, but less so for spinach. Variety, shape and physical damage were of lesser overall importance.

4.3 Cauliflower trade: quality and transaction characteristics

January is the peak season for cauliflower in Delhi, during which month further interviews were conducted among 150 producer-sellers arriving at Azadpur to elicit baseline information on quality attributes and transaction characteristics.

Responses

Regarding non-price transaction characteristics, responses showed that more than half of producer-sellers (55%) sometimes sold their produce on credit and almost half (45%) secured loans from their buyers. More than half (57%) of producer-sellers said that quality was never a factor in price negotiation, and only 18% said that familiarity with the buyer was sometimes a means of negotiating higher prices. A high proportion of producer-sellers (79%) exchanged information about consumer preferences, and more still (86%) acknowledged that they trimmed and cleaned the product to make it more presentable.

Responses confirmed earlier results that freshness was the most important quality attribute (Table 5). This was followed by variety and colour. This is significant inasmuch as gaseous air pollution effects include discolouration for which inspection can serve as an assurance mechanism. However, quality assurance for cauliflower, selected for research as a vegetable most likely to trap heavy metal contaminants, cannot be entrusted to inspection alone, as indicated in Table 2.

Table 5 Perceived importance of factors determining prices of cauliflower*

Factors	**Not important = 0 Slightly important = 1 Moderately important = 2 Very important = 3**
Variety	2.53
Stage of maturity	<0.02
Freshness	2.89
Visible blemishes	1.86
Colour	2.09
Shape	0.11
Size	1.69

* mean of 150 producer-sellers

On disaggregating the data by production area, scale-of-production effects were noted. Smaller producers (1-5 ha) tended to achieve higher output per hectare, sold all their produce earlier in the day and thereby secured higher prices than large-scale producers (10-20+ ha). On the other hand, it was the producer-sellers of intermediate scale (5-10 ha) who were more likely to receive credit and to negotiate prices on the basis of quality and familiarity with the buyer. This suggests a researchable hypothesis that it is the medium sized growers for whom merchandising output is a significant activity, whereas small and large-scale growers either sell at the first opportunity to return to their farms, or are relatively unconcerned with the intricacies of commercial activity vis-à-vis production.

4.4 Summary of exploratory results

Product sourcing patterns varied with season and product perishability. Overall, UPU areas accounted for a high proportion of marketed produce. Transportation methods varied according to distance, from cycle rickshaws to lorries. Little was done in the market to add value to any of the produce beyond limited grading and trimming of vegetables. (It is worth noting that trimming of cauliflower leaves has the effect of exposing the vegetable to atmospheric contaminants). Repeat dealing and credit relations were not uncommon phenomena, suggesting the existence of backward linkages to producers. Price levels within the market were homogeneous within the day, but there was evidence of strong premia for product quality and seasonality effects; freshness was regarded as the paramount quality attribute, and the importance of other attributes varied with the type of vegetable.

That perceived quality attributes should vary between vegetables is not surprising. Spinach is sold in bunches, such that the leaf shape and presence of blemishes on individual leaves is not easily observable. Physical damage certainly does matter for spinach: leafy vegetables are known to show imperfections when exposed to gaseous contaminants (and agrochemical abuse). 'Search' methods cannot serve as a QA mechanism for such attributes that are hidden, at the wholesale marketing stage. The variety of each of the three vegetables was cited less frequently as a quality characteristic, and was perceived by traders to be less important for cauliflower than other characteristics, whereas there is evidence that important varietal differences do indeed exist for some vegetables concerning ease of contamination by heavy metals, and susceptibility to gaseous damage.

Interviews of 127 assembly wholesalers, commission agents and mashakhores in the cauliflower trade were also conducted. An overview of responses from the total of 277 producers and traders interviewed highlights the following issues of potential significance in creating stronger quality assurance throughout the supply chain:

- there is evidence that vertical relationships exist throughout the supply chain due to credit and loan arrangements;
- however, trading relationships are not characterised by trust, but by pure commercial considerations;
- there is also evidence that the level of awareness of consumer preferences increases progressively through the market chain from producers to wholesaler-retailers.

4.5 Regulated wholesale markets as a QA entry point

Interesting hypotheses emerge from these exploratory studies. Most importantly, there is potential to use the market system to increase flows of quality information and price-quality incentives. In Azadpur, considerable emphasis is placed on improved handling practices to reduce physical and economic losses. In an interview in May 2001, the Chairman of the APMC commented on the expansion plans to reduce congestion, increase land area, improve facilities and infrastructure for traders, and upgrade technologies and human skills (Agricultural Produce Market Committee (Azadpur), 2001; Sharma, 2001). The provision of handling infrastructure and facilities for traders is the primary task of the APMC, in order to expedite the flow of produce with minimum delays and losses due to poor handling.

However, improving forward and backward linkages in the market chain is also considered to be a responsibility of the APMC. This issue has three elements involving extension to farmers providing training on best practice pre- and post-harvest techniques; similarly, education of traders (commission agents and wholesalers) in handling technologies; and thirdly, consumer-friendly packaging to reduce

losses and maintain quality. What is notably absent from the aims and objectives of market regulation is any concern with the food safety attributes of quality, which was said to be the function of the Ministry of Agriculture (Sharma, 2001).

However, the proposed removal of the Azadpur *mandi* to a larger site with the possibility of better physical facilities, and the stated objective of improving forward and backward market coordination is an opportunity for the APMC to extend their educational mandate to initiate quality control improvements that embrace the food safety attributes of quality (Table 2).

Investment by the APMC in new physical marketplace infrastructure will provide a signal to producers and traders that quality matters not just for economic reasons but also for safety reasons. Creation of awareness about post-harvest contamination can be linked to measures to reduce peri-harvest contamination. Better practices to protect the integrity of produce at the level of production, assembling, wholesale and retail can be promoted to the whole range of market participants. At the same time, disseminating evidence that quality characteristics carry market premia will create an incentive framework for entrepreneurial producers and traders to develop quality signalling mechanisms such as reputation, packaging, branding and labelling. The advantages of concentrating supplies through cooperative organisations will be evident to producers. Similarly, establishing vertical market linkages between producer or village associations and traders will prove advantageous to both parties as the provenance and traceability are linked to desirable reputation effects. While further work needs to be conducted on retailing, handling and packaging practices by retailers are likely also to respond to an enhanced incentive framework.

Quality controls must also be part of the public sector response. Limited product quality testing at all levels of the market chain is necessary to support the incentive framework, and creates an opportunity to use of public interest litigation against suppliers of contaminated produce. This is a feasible approach, but the legal framework is only partly developed to this end, and the necessary changes are beyond the scope of this article.

Together with heightened public awareness, these changes have the potential to provide incentives for institutional innovation by improving market-place organisation and adopting best practice technologies throughout the horticultural chain.

5 An integrated framework for horticultural QA in UPU India

The foregoing discussion of QA issues and the policy environment serves to highlight areas that must be considered in tackling critical food safety hazards associated with air pollution in Delhi and other UPU areas. The vastness of the ‘ecological footprints’ of cities such as Delhi, the atomistic structure

of agricultural and industrial production in UPU areas, and sectoral interactions such as the need for urban employment may prevent the elimination of sources of contaminants.

The complexity of enhancing food safety and quality in India – as anywhere else - requires a multifaceted and integrated approach. Taking advantage of the regulated market system as a QA entry point is a necessary but not sufficient food safety and quality strategy. This concluding section suggests a framework for identifying other necessary measures to reduce food system health hazards of which the market system initiatives constitute one element.

Initiatives to improve food quality assurance can be expected to operate at three levels in India, and will range from strong intervention to implement controls on emissions and industry location, through actions facilitating improved market coordination, to information dissemination and creation of awareness:

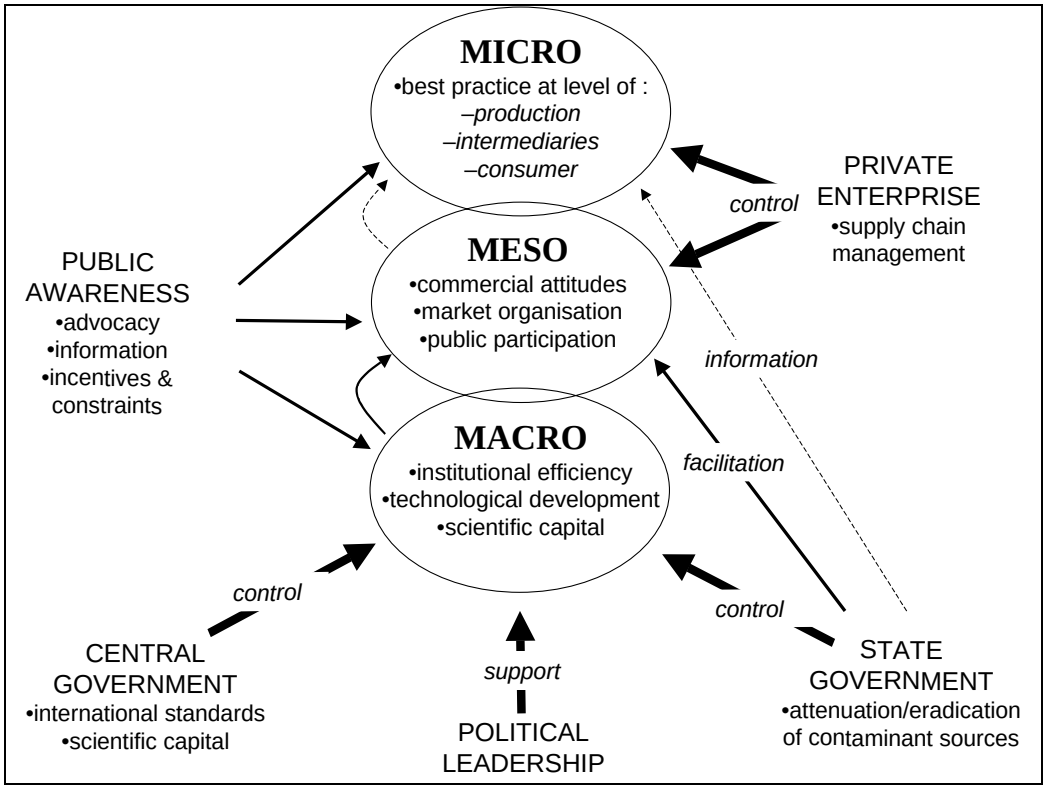
- macro level: national or Central government/State/city;
- meso level: market system from input supply and production through wholesale and retail to consumption;
- micro level: individual producers, traders and consumers.

Following the literature cited above and reviewed elsewhere (Poole et al., 2000), it is arguable that for India, enhanced food QA will be associated with strategies at each level:

- development of scientific capital: knowledge and techniques of hazard analysis and control;
- an enhanced legislative framework: food and environmental standards and regulation, and implementation methods;
- commercial initiatives: supply chain restructuring including increasing concentration, and institutional innovations such as branding, labelling, and self-regulation.

High level political and judicial support and heightened public awareness through advocacy information dissemination are likely to be important prerequisites for achieving improvements to the integrity of the food chain both in India and other countries. A summary view of the different stakeholders and initiatives for assuring food quality are presented in Figure 2.

Figure 2 Regulatory and incentive framework for UPU horticulture in India



The challenge of achieving fruitful public sector coordination can only be highlighted here, however: among the constraints affecting healthy city initiatives generally are significant difficulties in implementing an integrated approach, and also securing political leadership by Central backing of local decision-makers. Consistent information should be provided through the range of different government entities involved in horticultural production and extension, market regulation, food policy initiatives and consumer organisations. This highlights the need for cooperative public-private initiatives.

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