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Food Safety Concerns of Consumers: A Case Study of Pesticide Residues on Vegetables in Delhi

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Abstract

The study has examined the consumers' concerns regarding the presence of chemical pesticide residues on vegetables marketed in Delhi, their willingness to pay a higher amount for pesticide-residue safe vegetables and factors that affect their willingness to pay. The consumer survey has indicated that more than two-thirds of the consumers believe that fresh vegetables contain pesticide residues, and close to 80 per cent apprehend that the pesticide residues would have serious health implications. Using principal component analysis, the study has identified three dimensions of consumers' perception: (i) implications of pesticide residues and better ways of pesticide application; (ii) essentiality of pesticide application for vegetable production and price impacts; and (iii) ethical standing on pesticide application. The perception of a general consumer was that pesticide application is essential for profitable vegetable cultivation, and vegetables produced without pesticide would be costlier. The study has found that about 85 per cent of the consumers are willing to pay more for residue-safe vegetables and the important determinants of WTP were perception regarding presence of pesticide residues, its health implications, and economic status of the consumers.

Key words: Food safety, pesticide residue, consumer perception, willingness to pay, vegetables, Delhi

JEL Classification: Q1, Q510, Q570

Introduction

The issues related to food safety are being debated intensively in agribusiness and policy sectors world over. These issues have assumed paramount importance notably in the context of WTO agreements, on account of the sanitary and phyto-sanitory (SPS) measures therein. Besides the export sector, the domestic sector also views food safety issues more seriously now than before. The case of putting a ban on the sale of a processed food product, Maggi noodles, manufactured and marketed by Nesle India, in many states of India consequent to the reported presence of some additives in excess of the permitted limits is a recent example (Hindustan Times, 2015). In the case of vegetables, the presence of pesticide residues in amounts more than the permissible limits is a widely reported food safety issue. The vegetables being susceptible to a large number of pests and diseases, the farmers have to resort to chemicals. They consider application of plant protection as a fast and cheaper way to save the produce and get unblemished fruits and vegetables, which would fetch better prices in the market. There are many studies reporting that that the pesticide application is indiscriminate and has crossed the safe limits in India as well as in many developing countries (Kumari *et al.*, 2004; Mandal and Singh, 2010; Chen *et al.*, 2011). The implications of exposure to higher levels of

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pesticide residues include accidental poisoning, several health hazards, environmental pollution and increased presence of toxic residues (Pimentel *et al.,* 1992). The pesticide-related hazards may affect the overall performance and the productivity of the farm family (Antle and Pingali, 1994; Wilson, 2002; Ntow *et al*., 2006; Mathews, 2008; Devi, 2009).

The farmers largely use a pesticide without complete understanding of its safe handling and impact on human health and environment, particularly in the developing countries (Wesseling *et al*., 1997; Ngowi *et al*., 2007; Mathews, 2008). Over the years, a large segment of the consumers has become sceptical about the increased usage of agro-chemicals world over (Grunert, 2005). A direct off-shoot of this issue is the increasing demand for organic farming (Ramesh *et al*., 2010). Agricultural commodities, certified to be organically produced, fetch higher prices. However the spread of organic farming has been limited in terms of scale. Though there are some studies reporting positive impact of organic farming in boosting farm income, a recent survey of literature has indicated that the profitability of organic farming depends on the premium price on account of the certification, and without premium price, the farming would not be profitable (Ramesh *et al*., 2010). It suggests that, to feed a large section of the society in a populous country like India, the conventional farming practices have to be continued at least in the short-to-medium term. In this context, the pesticide residues are likely to continue as important food safety concerns (Wilson and Tisdell, 2001).

Delhi is a major urban consumer centre of vegetables in India and a large number of villages in its periphery cultivate vegetables to cater to the needs of consumers of the city, mostly sold fresh. There are some reports on the presence of pesticide residues in the fresh vegetables sold in Delhi (Mukherjee, 2007; Indian Express, 2015).

Under this backdrop, the present study has examined the perception of consumers on pesticide residues in fresh vegetables in Delhi. The study has also attempted to find whether the consumers are willing to pay a higher price for fresh vegetables having pesticide residues within the safe limits (residue-safe vegetables). We had hypothesized that that there are food safety concerns among the consumers regarding pesticide residues in vegetables; and they are willing to pay more for the residue-safe vegetables, and, the major determinants of the willingness to pay are economic status and level of concern.

Data and Methodology

The study is based on the primary data collected from 142 respondents of central district of Delhi through survey conducted in October 2014, using a structured schedule containing both close and open-ended questions. The survey instrument was divided into three sections: the first section comprised questions on personal and economic background of the respondents such as age, gender, education, family size, employment status, food expenditure, and source of vegetable purchase. The second section was on consumers' perception regarding the presence of pesticide residues in vegetables. The third section dealt with the consumers' perception about the potential impacts of pesticide residues and their willingness to pay (WTP) more for residue-safe vegetables.

Statistical and Econometric Methods

Firstly, descriptive analysis was conducted to find the perception of the consumers towards pesticide residues in vegetables. Then, factor analysis was carried out to bring out the major dimensions of the attitude towards pesticides application in vegetables cultivation. The Logit model (Gujarati, 1999) was used to identify the factors that influence the willingness to pay for residue-safe vegetables.

Principal Component Analysis (PCA)

The main aim of the PCA is to obtain a compact and accurate representation of the data that reduces or eliminates statistically redundant components or dimensions. Factor analysis by principal components is the most widely used dimensionality reduction technique. In this study PCA has been carried out to find the key dimensions concerning consumers' perception on the pesticide residues on fresh vegetables.

Contingent Valuation Approach

To examine the factors that affect consumers' WTP higher for safe vegetables, contingent valuation technique was employed (Bromley, 1995; Mathis, 2003). At first, the perceptions of consumers with

respect to pesticide residues in vegetables, and their potential implications were sought. Then, they were asked whether they would be willing to pay some extra amount for vegetables having pesticide residues within the safe limits. The consumers who were willing to pay an extra amount were asked "how much they would be willing to pay more?". The respondents were asked to choose any option out of five options, viz. up to 10 per cent, 11-20 per cent, 21-30 per cent, 30-50 per cent and above 50 per cent, using a bargaining approach.

Logit Model

For examining the factors that affect the WTP higher for safe vegetables, logit model was specified as:

$$\ln [P(v) / \{1-P(v)\}] = Zi = Xi'\beta + E \qquad \ldots(1)$$

where, P(v) is the probability of WTP, Xi′ is the vector of explanatory variables, β is the vector of response coefficients, and E is the vector of random disturbance.

Model Specification

This analysis considered variables pertaining to the following realms as the determinants of the WTP: (1) consumers' household characteristics; (2) consumers' perception on pesticide residues and their impacts on health; (3) economic status; and (4) current purchase practices. The major consumers' characteristics considered in the analysis were: age, gender and education level. It was hypothesized that the age of consumer would negatively affect the WTP, as the younger consumers would have higher degree of WTP for safe vegetables.

The education level of the consumers can have different impacts. The consumers with higher education level may be more aware about the consequences of pesticide residues on health, and therefore, higher WTP. On the other hand, the higher education might provide knowledge regarding safe handling practices of vegetables. Therefore, the sign of the variable would depend upon the relative strength of these two dimensions. The education level of consumers was classified into three broad groups: illiterate and upto primary level; middle and high school level and higher than high school level. Two dummy variables were used to depict the same, with the middle and high school levels as the base dummy.

Another important household characteristic was the family size. It was anticipated that higher family size would negatively affect the WTP. Two variables put forward to elicit the perception of consumers were: perception regarding presence of pesticide residues; and, perceived health impacts. For recording these variables Lykert scale was used. The higher the perceived presence of pesticide residues and the severer the perceived health implications, the stronger was the positive influence of these variables on WTP. The economic status of the consumers was captured by using two set of variables, viz. the average monthly per capita food expenditure and nature of employment of family-head. The per capita consumption expenditure would proxy the household income.

The nature of employment of the family-head was classified into three categories, viz. unemployed and casual labourers; self- employed and employed in the organized sector (both private and government). Two separate dummy variables were used to capture the same with the base dummy of 'organized sector'. Consumers purchase vegetables from both organized and unorganized sources. The major unorganized source is the street vendors, whereas the major organised sources are outlets of *Safal, Reliance Fresh*, *More*, etc. A dummy variable was used to capture the same with unorganized sector assigned a value of zero.

Results and Discussion

Consumers' Perceptions about Pesticide Residues on Vegetables

Table 1 presents the summary of consumers' perceptions about pesticide residues on vegetables. About 62 per cent consumers believed that there were high and very high levels of pesticide residues on vegetables, 32 per cent believed that the pesticide residues were of low level and 6 per cent believed that fresh vegetables were free from pesticide residues. More than 75 per cent consumers believed that the presence of pesticide residues was highly unsafe for health. Three-fourths of the consumers reported about thorough washing of vegetables before cooking, but 46 per cent consumers felt that washing removes pesticide residues only to a limited extent.

Table 2 depicts consumers' perception regarding the impact of pesticide residues on vegetables and the management practices that need to be followed based

Table 1. Consumers' perception about presence of pesticide residues on fresh vegetables

(in per cent)

Factor description	Level of pesticide residues			
	Very high	High	Low	Nil
Fresh vegetables contain pesticide residues	20	42	32	6
Pesticide residues are unsafe for health	40	39	15	6
Practice thorough washing of vegetables before cooking	75	18	6	1
Believe that washing will remove pesticide residues completely	17	32	46	4

Source: Field survey

Table 2. Consumers' perception about impact of pesticide residues in vegetables and management options

(in per cent)

Statement	Consumers' perception				
	Strongly agree	Mostly agree	Don't know	Disagree	Mostly disagree
Pesticide residue causes health risk (X_1)	56	32	11	1	0
Pesticide residue induced health risk is costly to treat (X_2)	44	37	18	1	0
Pesticide induced health risks are difficult to cure (X_3)	23	42	27	8	0
Pesticides application contaminates drinking water (X_4)	42	38	18	1	0
Vegetable cultivation without pesticide is not profitable (X_5)	18	46	22	14	1
Chemical pesticides are necessary to control crop-damage(X_6)	29	32	18	20	1
Vegetables cultivation without pesticide application would be costlier (X_7)	36	34	25	6	0
Educating farmer would help to reduce pesticide residues (X_8)	44	44	12	1	0
Stringent regulations are needed for pesticide use (X_9)	49	35	15	1	0
Selling of certified residue-free vegetables would reduce pesticide residues in vegetables (X_{10})	46	37	17	1	0
Only biological/ organic materials be used as pesticides (X_{11})	30	32	16	20	1
Application of chemical pesticides is unethical (X_{12})	8	46	30	15	1

on 12 statements. More than 80 per cent respondents concurred (either 'strongly agree' or 'mostly agree') with the statement that there is high health risk in intake of vegetables with pesticide residues. Most of the consumers believed that such health problems are difficult to manage, and the treatment cost would be very high. Also, 80 per cent consumers believed that pesticides contaminate drinking water sources.

The consumers' opinion regarding the necessity of pesticide-use for cultivation is quite noteworthy. Close to 60 per cent consumers believed that application of chemical pesticides was necessary to control the pests-induced crop damage. And about 65 per cent consumers believed that vegetable cultivation would be less profitable without pesticides application. Further, vegetables without pesticides application would be costlier.

The consumers also expressed their perception on the management tools that can be used for ensuring residue-safe vegetables. Educating the farmers was believed to be an effective tool by close to 90 per cent consumers. About 80-90 per cent consumers agreed that stringent regulations would help in reducing pesticide residues. Opening of outlets for selling certified residue-free vegetable was considered to be an effective measure by close to 80 per cent of consumers. About 60 per cent consumers believed that only pesticides with organic/ biological base should

be used. Often such opinion might be rooted in the ethical standing of the consumer. A statement in this regard indicated that only 8 per cent consumers 'strongly agreed' that chemical pesticide application was unethical.

Dimensions of Consumers' Perception: Principal Component Analysis

The principal component analysis was carried out to identify the dimensionality of consumer perception. A total of three principal components were retained, explaining close to 70 per cent of variations. The pattern of the three extracted components with varimax rotation using PCA is shown in Table 3. Table 4 presents the factor loadings retained by the components.

The first retained principal component could explain 34.7 per cent of the total variance. The perceptions of pesticide residues in vegetables is a health risk, treatment of pesticides-induced health problems is costly, application of pesticides contaminates drinking water resources, and various options for management of pesticide residues including educating the farmers, regulating pesticides-use through legislation and opening up of outlets for selling certified organic vegetables contributed significantly to the first principal component. Broadly this component reflected the health implications and the tools to manage the pesticide-residue problems.

Table 3. Eigen values of components and proportion of variance explained by them

Component	Eigen values of rotated components		
	Total	Percentage of variance explained	Cumulative percentage
1	4.16	34.69	34.69
2	2.24	18.65	53.34
3	2.02	16.82	70.15

The second component had positive loadings on the statements which suggested that cultivation of vegetables would not be profitable without application of pesticides, application of pesticides is essential for controlling crop damages, and vegetables produced without pesticides application would be costlier. The variables broadly reflected consumers' perception on the essentiality of chemical pesticide application and its price impacts. This principal component explained about 18.7 per cent of the total variance.

The last component retained from the analysis explained 16.8 per cent of the total variance. This component had positive loadings on promoting biologic/ organic farming, and ethical standing of consumers on pesticide application. Therefore, this component to a great extent represented the ethical standing on chemical pesticide application.

Table 4. Factor loadings of retained components on original variables after orthogonal (varimax) rotation

Variable	Component 1	Component 2	Component 3
Pesticide residue causes health risk (X_1)	0.83*	0.23	0.23
Pesticide residue induced health risk is costly to treat (X_2)	0.71*	0.21	0.27
Pesticide induced health risks are difficult to cure (X_3)	0.37	0.53*	0.36
Pesticide application contaminates drinking water (X_4)	0.71*	0.11	0.23
Vegetable cultivation without pesticides is not profitable (X_5)	0.10	0.89*	-0.01
Pesticides are necessary to control crop damage (X_6)	0.05	0.85*	-0.02
Vegetables without pesticides application would be costlier (X_7)	0.49	0.53*	0.28
Educating farmer would help to reduce pesticide residues (X_8)	0.78*	0.07	0.26
Stringent regulations are needed for pesticide use (X_9)	0.80*	0.12	0.15
Selling of certified residues-free vegetables would reduce pesticide residues in vegetables (X_{10})	0.82*	0.08	0.08
Only biological/ organic materials be used as pesticides (X_{11})	0.34	-0.06	0.86*
Application of chemical pesticides is unethical (X_{12})	0.22	0.16	0.89*

Note: The factor loadings were multiplied by 100 and rounded off to the nearest integer. The values greater than 0.5 are flagged by an ' *' mark.

Table 5. The summary statistics of variables across willingness to pay (WTP)

Variable	WTP		Test statistic	Value of statistic	Inference
	No	Yes			
Age of consumer (years)	40.4	40.8	t-test	-0.20	Insignificant
Family size (No.)	3.6	3.4	t test	0.50	Insignificant
Gender (Mean of dummy values)	0.68	0.77	Chi-square	0.72	Insignificant
Per capita monthly food expenditure (₹)	2586	4028	t-test	-1.51	Insignificant*
Education (Mean of category values)	1.4	2.5	Chi-square	30.38	Significant
Consumers' attitude towards pesticide residue (Mean of category values)	1.05	1.88	Chi-square	32.01	Significant
Source of purchase of vegetables (Mean of dummy variable)	0.31	0.40	Chi- square	0.63	Insignificant
Health concern of consumers (Mean of attitude values)	1.04	1.34	Chi-square	52.9	Significant
Source of employment (Mean of category values)	0.77	1.08	Chi-square	33.94	Significant

*When equal variance was assumed

Factors Affecting Willingness to Pay of Consumers: Logit Analysis

A large majority of the respondents were (85 %) willing to pay (WTP) more for safe vegetables. The statistical difference of the variables that affect the WTP classified across the groups that were willing to pay and otherwise was examined by the appropriate statistical method (t-test or chi-square test) (Table 5). It was noted that the age of consumer, family size and gender did not differ significantly between these two groups. The per-capita food expenditure differed significantly (when unequal variance of two groups was assumed). On the other hand, the perceptions on the presence of pesticide residues, health implications of pesticide residues, employment of the family-head, and education level of family-head differed significantly between these two groups. The group which was willing to pay viewed the health implications of pesticide residues more seriously than the other group.

The results of logit analysis presented in Table 6, depicts the anticipated signs of variables, regression coefficients, standard errors, probability and odd's ratio. The statistically significant variables were the source of purchase of vegetables, employment status family-head, and consumers' perception regarding presence of pesticide residues and their health implications. Among all the variables, the odd's ratio was the highest for consumer perceptions on health impacts of pesticide residues, followed by the presence of pesticide residues. The more concerned the consumers were about the pesticide residues, the higher the odds that they turned out to be willing to pay higher for residues-free vegetables.

Another set of variables that affect the consumer WTP was the economic status as reflected by the employment status of family-head. The family-heads who were largely labourers had significantly lower odds for WTP. Another important variable was the source of purchase of vegetables. The consumers mainly depend on two sources — organized retail outlets and unorganized local street vendors. Of the total respondents, 61 per cent purchased vegetables 'most often' from street vendors and the rest from organised outlets. The variable representing organised vendors was negative. This could be because such consumers were already paying higher prices compared to the small street vendors. It is also believed that organized retail outlets sell vegetables with pesticide residues within the safe limits.

Conclusions

The presence of pesticide residues is a serious issue from food safety aspects. The study has identified the broader dimensions of consumers' perceptions on the presence of pesticide residues on vegetables. It has also examined the consumers' willingness to pay for the vegetables which are safe with respect to pesticide residues. It has emerged that the majority of consumers believed that vegetables have pesticide residues and

Table 6. Estimates of logit model for willingness to pay for residue-safe vegetables

Variable	Anticipated sign	Coefficient	Standard error	P >|z|	Odds ratio
Constant		0.75	2.65	0.77	
Age of consumer	-ve	-0.04	0.47	0.36	0.96
Gender (dummy, male 1, female 0)	+/-	1.10	0.91	0.27	3.00
Family size (No. of members)	-ve	-1.75	0.94	0.06	0.17
Education_ upto primary (Dummy, =1, and 0, otherwise)	-ve	-1.69	1.22	0.17	0.96
Education_above high school (Dummy, =1, and 0, otherwise)	+ve	-0.19	1.23	0.88	0.83
Source of purchase (dummy, =1, if purchased from organized retailers, and otherwise 0)	-ve	-2.15	1.02	0.04	0.12
Unemployed (Dummy, 0 if unemployed and 0 otherwise)	-ve	-3.07	1.33	0.02	0.05
Self-employed (Dummy, 1 if self- employed, and 0 otherwise)	+/-	-0.67	1.03	0.51	0.51
Per-capita food expenditure (₹/ month)	+ve	-0.00002	0.0002	0.90	0.99
Consumer attitude towards pesticide- residues	+ve	1.23	0.56	0.03	3.40
Health concern of consumers	+ve	1.76	0.56	0.002	5.82
No. of observations		142			
log likelihood ratio		-26.82			
Probability		0.00			
Pseudo R^2		0.56			

they viewed the negative consequences of pesticide residues as a serious matter. Using principal component analysis, the study has identified three dimensions of consumers' perception: (i) implications of pesticide residues and better ways of pesticide application; (ii) essentiality of pesticide application for vegetables production and its impact on price; and (iii) ethical standing on pesticide application. The perception of a general consumer was that application of pesticide was essential for profitable vegetable cultivation, and vegetables produced without pesticide would be costlier. It has also emerged that farmers need to be educated on good management practices for pesticides application.

Most of the consumers (86%) have been found willing to pay a higher price for pesticide-safe vegetables. The major determinants for it were consumers' perception regarding presence of pesticide residues and its health implications, followed by the economic status of consumers. The major strategies could be evolving a legal mechanism to prevent excessive use of pesticides and institutional facilities for quality checking of vegetables. Educating the farmers on judicious and scientific use of pesticides would help the producers, consumers and the ecosystems at large.

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