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## **An Investigation into Food Safety Culture and Producers' Knowledge within the Vegetable Supply Chain**

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### **Abstract**

Food safety is increasingly recognized as a crucial determinant of food safety effectiveness, especially in agricultural food systems in developing countries, where production is often fragmented and practices inconsistent. This study aimed to assess the knowledge of farmers or those working in vegetable supply chain professions in Hung Yen, Bac Ninh, and Hanoi. A total of 300 respondents were surveyed and categorized into four age groups (19–34, 35–49, 50–59, and 60–70) to facilitate comparative analysis. The results showed that in the age group over 50, the results indicate that respondents aged over 50 demonstrated a higher level of knowledge, with 79% providing correct responses, suggesting that accumulated practical experience plays a significant role in enhancing food safety awareness and understanding. In contrast, respondents under the age of 49 exhibited a lower correct response rate of 56%, which

may be attributed to limited hands-on experience or reliance primarily on indirect sources of information, such as public communication campaigns. These findings underscore the critical role of food safety management systems, particularly in terms of knowledge in improving compliance with safe agricultural practices. Effective management not only ensures hazard control throughout the production process but also strengthens the capacity of producers to apply food safety principles in real-world contexts. This study provides practical implications by emphasizing the need to design targeted interventions, such as age-specific training programs and knowledge transfer initiatives. Such strategies are essential for enhancing the sustainability and overall effectiveness of food safety practices within the fruit and vegetable supply chain in Vietnam.

**Keywords:** Food Safety Knowledge, Vegetable Supply Chain, Farmers, Food Safety Management, Vietnam, Agricultural Practices

### **1. Introduction**

Food safety is a critical global issue due to its direct impact on public health, economic development, and consumer trust [1]. In developing countries, ensuring food safety at the primary production level remains challenging due to fragmented farming systems, weak regulatory enforcement, and varying levels of producer capacity. Among the various determinants of food safety performance, knowledge has been consistently identified as a fundamental factor influencing how individuals perceive and manage food safety risks [2]. This is particularly important in vegetable production, where fresh products are highly susceptible to contamination from chemical residues, microorganisms, and environmental factors [3-7]. In Vietnam, vegetables play a vital role in daily consumption and urban food supply systems. The Red River Delta, particularly areas such as Hanoi, Hung Yen, and Bac Ninh, represents one of the most important vegetable production hubs in the country due to favorable climatic conditions and proximity to major consumption markets. Hanoi alone has approximately 29,000 hectares of vegetable cultivation annually, with key crops such as cabbage, mustard greens, and water spinach accounting for nearly 50–70% of total production [8]. In terms of supply, locally produced vegetables from Hanoi and surrounding areas contribute significantly to urban consumption. Studies estimate that vegetables produced in and around Hanoi account for approximately 43.6% to 46.3% of the city's total demand, and up to 49.6% for household consumption [8]. However, the remaining supply over 50% is sourced from other provinces or external regions, highlighting the complexity and fragmentation of the vegetable supply chain. Hung Yen and Bac Ninh play important complementary roles in supplying vegetables to Hanoi, supported by their geographic proximity and established agricultural linkages [9]. At the provincial level, Bac Ninh alone has developed

approximately 31,000 hectares of vegetable cultivation, producing around 626,000 tons annually, reflecting its role as a major supplier within the northern vegetable network [10]. Meanwhile, specific production zones such as Me Linh district (Hanoi) contribute about 98,000 tons of vegetables per year, supplying not only Hanoi but also neighboring provinces. These figures illustrate both the scale and the regional interdependence of vegetable production in northern Vietnam. Within this supply chain, producers play a critical role as the first point of control in food production. Their decisions regarding pesticide use, hygiene practices, and post-harvest handling directly influence the safety and quality of the final products. However, in many cases, producers rely on limited or unclear knowledge of food safety hazards, and agricultural chemicals are often applied improperly or without adequate technical guidance [3-7]. While positive attitudes toward food safety are important, they must be reinforced through proper education and practical training [11, 12]. These challenges further emphasize the importance of knowledge in shaping food safety outcomes [13]. Knowledge can be understood as a combination of experience, skills, and structured information that influences human behavior and decision-making [14]. It enables individuals to identify hazards, assess risks, and implement appropriate control measures. According to Benjamin Bloom [15], knowledge forms the foundation of the cognitive domain, supporting higher-order thinking processes such as analysis and evaluation. Studies have shown that safety culture is influenced by interconnected dimensions such as management commitment, communication, and training, all of which are closely linked to knowledge [16]. Similarly, research in technical sectors such as railway maintenance highlights that insufficient knowledge and weak safety culture can directly lead to unsafe practices and increased risk exposure [17]. Despite the implementation of food safety standards such as VietGAP, unsafe practices—such as improper pesticide use

and poor hygiene—remain prevalent in Vietnam’s smallholder-based production systems [3-7]. Given this context, research focusing specifically on food safety knowledge at the primary production level remains limited, particularly in key vegetable-producing regions of northern Vietnam. Therefore, this study aims to systematically assess the level of food safety knowledge among farmers and agricultural workers in Hung Yen, Bac Ninh, and Hanoi—three strategically important regions that collectively supply a substantial proportion of vegetables to urban markets. The study further seeks to identify knowledge gaps across different demographic groups and generate empirical evidence to support targeted training programs and knowledge dissemination strategies, thereby enhancing food safety performance and ensuring the sustainable supply of safe vegetables.

**2. Materials and Methods**

**2.1 Study Area and Sampling**

The study was conducted in several provinces in Northern Vietnam, Hanoi, Hung Yen, and Bac Ninh, which are characterized by intensive vegetable production and diverse vegetable supply chain structures. This area was selected for its representativeness in terms of production scale, farming methods, and food safety challenges.

A stratified multi-stage sampling method was applied to ensure representativeness. Bac Ninh with a typical vegetable supply chain was selected. Subsequently, cooperatives or production groups within the selected districts were identified, and farming households were randomly chosen from these groups.

A total of 300 vegetable-producing households participated in the quantitative survey.

**2.2 Measurement Design**

The study focused on primary constructs: Knowledge (K) along with control variables.

**Table 1:** Tools, scales, and analytical methods

Ingredient	Number of questions	Scale type	Key measurement content	Scoring/Standardization
Knowledge (K)	18 multiple-choice questions (including multiple-choice questions)	Objective questions (true/false, select one or more answers)	Pesticides, withdrawal periods, fertilizers, irrigation water, hygiene during processing, and traceability.	+1 point for each correct answer; 0 points for blanks; -0.25 points for each incorrect answer (for multi-select questions). Standardized to a 0–10 scale.
Demographic and socio-economic information & production characteristics	8 sentences	Quantitative-Neutral Questions	Gender, age, educational level, experience, production scale, type of certification, participation in training.	Descriptive statistics

Control variables included demographic and farm characteristics such as age, education level, farming experience, farm size, labor availability, and participation in training programs.

**3. Results and Discussion**

**3.1 Status of food safety knowledge among the research subjects**

**3.1.1 Level of knowledge about food safety**

Out of a total of 300 participants in the study, the level of knowledge regarding food safety was categorized into three levels: low (50–69.9 points), medium (70–85.9 points), and high (86–100 points). The results presented in Table 2 show that the proportion of participants with a high level of

knowledge was 59.7% (179/300), while the proportions at the medium and low levels were 18.3% (55/300) and 22.0% (66/300), respectively.

**Table 2:** Distribution of food safety knowledge by overall status, education level, and job position (n = 300)

Category	Sub-category	Low	Medium	High	Total
Overall	All participants	66	55	179	300
Education level	Elementary	2	0	1	3
	Junior high school	22	3	16	41
	High school	23	13	35	71
	Vocational/Associate	17	33	70	120
Job position	University	2	6	57	65
	Farmer	65	54	121	240
	Manager/Representative	1	1	58	60

Thus, although the majority of producers have achieved a fairly good level of knowledge about food safety, nearly a quarter (1/4) of them still have low levels of knowledge. This indicates an unevenness in awareness of food safety and reflects a certain gap in accessing and acquiring related knowledge.

To further clarify the factors influencing knowledge levels, the study continues to analyze the relationship between food safety knowledge and several characteristics of the subjects such as educational level, position, and age.

**3.1.2 The relationship between knowledge and educational attainment**

The results of the analysis of the relationship between educational level and food safety knowledge are presented in Table 2. The data shows a clear difference in the distribution of knowledge levels among different educational level groups.

Specifically, in the intermediate/college level group, the percentage of subjects achieving a high level of knowledge was 58.3% (70/120), while in the university level group, this percentage increased significantly to 87.7% (57/65). Conversely, in the lower-level groups, especially junior and senior high school students, the percentage of subjects with low knowledge was relatively high, at 53.7% (22/41) and 32.4% (23/71) respectively. This result shows a clear disparity in knowledge levels between educational groups, especially between those with vocational or university education and those with general education.

The Chi-square test results showed a highly statistically significant association between educational level and food safety knowledge ( $\chi^2 = 92.5$ ;  $df = 8$ ;  $p < 0.001$ ). This confirms that educational level has a clear influence on food safety knowledge among producers.

This difference can be explained by the fact that those with higher levels of education generally have better access to information and are more capable of understanding and applying technical knowledge in production effectively. Conversely, those with lower levels of education tend to rely more on practical experience, thus limiting their access to systematic and up-to-date knowledge.

**3.1.3 The relationship between knowledge and job position in production**

The results of the positional analysis show a significant difference in food safety knowledge levels between the farmer group and the management/representative group, as presented in Table 2, with a total of 240 farmers and 60 managers/representatives.

Specifically, in the management/representative group, the proportion of respondents with a high level of knowledge was very high, reaching 96.7% (58/60). Meanwhile, in the farmer group, this proportion was only 50.4% (121/240), and 27.1% (65/240) still had low levels of knowledge.

The Chi-square test results showed a statistically significant relationship between job position and level of food safety knowledge ( $\chi^2 = 62.6$ ;  $df = 2$ ;  $p < 0.001$ ). This indicates that position within the production system significantly influences access to and accumulation of food safety knowledge.

This difference can be explained by the differing roles and responsibilities among the groups. Those in managerial positions generally have more opportunities to participate in training programs, access technical documents, and understand food safety regulations. Meanwhile, the farmer group is primarily involved directly in the production

process and often relies on experience or short-term training courses, leading to uneven levels of knowledge.

**3.1.4 The relationship between age and level of knowledge in food safety.**

In this study, age groups were divided into four categories: 19–34, 35–49, 50–59, and 60–70. This division was based on the characteristics of labor stages in agricultural production, differences in production experience, and the ability of different age groups to access and update information. Specifically:

- **19–34 years old:** a young workforce with high access to information.
- **35–49 years old:** the main workforce, combining experience and learning.
- **50–59 years old:** the group with many years of experience.
- **60–70 years old:** the older age group, primarily based on experience.

The results of the age-based analysis are presented in Table 3.

**Table 3:** Knowledge levels by age group

Age	Level of knowledge		
	Low	Medium	High
19 – 34	29	45	94
35 - 49	27	10	48
50 - 59	7	0	26
60 - 70	3	0	11

The analysis results showed that the proportion of subjects achieving a high level of knowledge was 56.0% (94/168) in the 19–34 age group and 56.5% (48/85) in the 35–49 age group. In older age groups, this proportion increased significantly, reaching 78.8% (26/33) in the 50–59 age group and 78.6% (11/14) in the 60–70 age group. At the same time, younger age groups had a higher proportion of subjects with an average level of knowledge (26.8%), while in older age groups, almost no subjects at this level were recorded.

This result reveals a notable trend: food safety knowledge levels do not decrease with age but rather tend to remain high in older age groups. This is somewhat different from the common assumption that younger groups with better access to information will have higher levels of knowledge.

This difference can be explained from several perspectives. Firstly, older age groups generally have longer periods of involvement in production, thus accumulating more practical experience related to food safety. This experience can serve as an equivalent to, or even replace, theoretical knowledge in some cases. Secondly, in the context of agricultural production, older individuals often hold key roles or have a voice in the production process and therefore tend to participate more in training activities or access information from technical assistance programs.

It is important to note that the younger age group (19–34) exhibits greater variability in knowledge levels, with respondents distributed across low, medium, and high categories. This pattern suggests that, although younger individuals may have better access to information, their level of knowledge acquisition and practical application is influenced by additional factors, such as educational attainment and the extent of their involvement in agricultural production activities.

In addition, the sample size for the older age groups is relatively limited; therefore, the findings should be interpreted with caution when attempting to generalize them to the broader population.

### 3.2 Discussion

The study results show that out of a total of 300 subjects, 59.7% (179/300) achieved a high level of knowledge about food safety, while 22.0% (66/300) had low levels of knowledge. This reflects that although the overall level of food safety knowledge is relatively positive, there is still significant inequality among the different groups of subjects.

Analysis of related factors showed that educational level was strongly and statistically significantly associated with the level of food safety knowledge ( $\chi^2 = 92.5$ ;  $df = 8$ ;  $p < 0.001$ ). Specifically, the proportion of subjects with high knowledge increased significantly with educational level, especially in the university group (87.7%) and vocational/college level (58.3%), while the group with lower education had a significantly higher proportion of low knowledge. This confirms the fundamental role of education in raising awareness and understanding of food safety.

Furthermore, position in production also significantly influenced the level of knowledge ( $\chi^2 = 62.6$ ;  $df = 2$ ;  $p < 0.001$ ). The management/representative group had a very high rate of knowledge attainment (96.7%), significantly higher than the farmer group (50.4%), indicating the role of position in the production system in accessing information and participating in training.

Regarding age, the results show differences in the distribution of knowledge levels among the groups, with a higher proportion of knowledge tending to increase in older age groups (78.8% in the 50–59 age group and 78.6% in the 60–70 age group compared to approximately 56% in the under-50 age group). However, this association is indirect and needs to be considered in the context of interaction with other factors such as educational level and occupation. Although younger groups have better access to information, they exhibit a more pronounced differentiation in knowledge, while older groups tend to be more stable due to accumulated experience in the production process.

Thus, food safety knowledge among producers is not the result of a single factor but is influenced by a combination of many factors, most notably educational level and position in the production system, while age plays a moderating role through experience and access to information.

### 4. Conclusion

Based on the present findings, food safety knowledge among vegetable producers in Northern Vietnam remains uneven, despite a relatively high overall level. Key demographic and occupational factors, particularly educational attainment and job position, play a decisive role in shaping knowledge levels, while age contributes indirectly through accumulated experience.

Given these disparities, interventions must not only improve access to information but also ensure effective knowledge acquisition and application among producers, especially those directly involved in farming activities, thereby contributing to a more sustainable and reliable vegetable supply system.

### 5. Conflicts of Interest

The authors declare no conflicts of interest.

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