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Willingness to Pay for Pesticide-free Vegetables: A Trade-off between Appearance and Pesticide Use

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Abstract

Most Japanese consumers focus on the appearance of vegetables, for example, their shape, color, or size. However, giving consumers precise information about the growing process of vegetables may change their preferences. Therefore, in order to reduce food loss, it is important to change consumers' preferences for vegetables and for producers to understand consumers' preferences, and select vegetable production methods. Japanese supermarkets sell vegetables containing legally permissible amounts of pesticides and chemical fertilizers, and chemical-free vegetables are generally hard to find. Therefore, in this study, pesticide-free vegetables were cultivated from scratch to analyze whether consumers are willing to pay a premium when presented with pesticide-free vegetables. The contingent valuation method and double-bound dichotomous choice were used for analysis. The results revealed that consumers' willingness to pay was not related to the appearance of the pesticide-free vegetables. In other words, they cared neither about the color nor about the shape of the vegetables so long as they were pesticide-free. In Japan, some farmers continue to grow organic or pesticide-free vegetables, although they are few. Therefore, if producers know the actual needs of consumers' vegetables, they may reduce their dependence on pesticides and chemical fertilizers and expand the market for environmentally friendly and healthy vegetables. Such a change could, in turn, reduce food loss.

Keywords: contingent valuation method, pesticide-free, food loss, vegetables' appearance, discarded vegetables

JEL codes: D12, Q13, Q18, Q50

1 Introduction

In recent years, the problem of food loss has been severe worldwide, with an annual waste of 1.3 billion tons of food. Meanwhile, Japan's annual food loss in 2020 was approximately 5.2 million tons. Although Japan, with a low food self-sufficiency rate on a calorie basis (37% in 2020), imports numerous food items from foreign countries, most of them are discarded (Ministry of Agriculture, Forestry and Fisheries of Japan, 2022a (hereafter, MAFF)). The breakdown of food loss is as follows: business food loss (2.75 million tons) and household food loss (2.47 million tons). Taking a serious

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view of this situation, the Japanese government enacted the "Law for Promotion of Food Loss Reduction" in October 2019, aiming to halve business-related food loss by 2030 compared to the 2000 level. In fact, however, this standard will be met if business food loss is reduced by another 20,000 tons to 2.73 million tons by 2030. On the other hand, the household food loss needs to be significantly reduced from 2.47 million tons to more than 300,000 tons. According to MAFF (2022a), since 330,000 tons of household food loss is due to excessive removal of edible parts, vegetables grown in healthy soil without pesticides and guaranteed to be safe and secure may contribute to reducing this portion of the food loss. As evidence of this, when asked in the same survey about their image of organic food, safe was the most common response (86.0%), with 60.0% of respondents saying that they can eat organic food without peeling it because they do not have to worry about pesticide residues. Careful consideration will be required to determine whether organically grown vegetables in Japan are truly safe and free of pesticide residues.

Most of the vegetables shipped are grown by conventional cultivation in Japan. This means that even if conventionally grown vegetables are within the legally permitted standards, they are treated with pesticides and chemical fertilizers to keep eliminate pests away and avoid malnutrition. For example, pesticides commonly used as fungicides on cucumbers and tomatoes include isofetamide, iprodione, and ametoctradin. Isofetamide has been found to have adverse effects on the liver and thyroid gland in animal studies, according to Cabinet office Japan (2016). Similarly, according to Cabinet office Japan (2016, 2021), iprodione has been found to be carcinogenic, and ametoctradin has been found to cause weight loss. Furthermore, comparing the Japanese and global standards for tomato production based on Pesticide Residue Limit Values by Product calculated by MAFF (2022b), the Japanese standard for isofetamide is 6 mg/kg, which is four times higher than that permitted in the European Union (EU) and the United Kingdom (UK) and 60 times higher than that permitted in Canada (it has not been detected in the United States (US)). The Japanese standard for iprodione and ametoctradin is 5.0 mg/kg for both, but the first is 10 times the Canadian standard, and the second is approximately 3.3 times the US and Canadian standards. The fact that the standard values for pesticide use in Japan are higher than those in the rest of the world may be attributed to Japan's hot and humid climate, which makes this unavoidable.

In Japan, organic agricultural products with the Japanese Agricultural Standards (JAS) mark are sold in the market. However, the MAFF defines organic agricultural products as those that have not been treated with agricultural chemicals or chemical fertilizers for at least two years before sowing or planting (https://www.maff.go.jp/j/seisan/kankyo/yuuki/). This means that if pesticides or chemical fertilizers were used two years previously, the product can be sold as organic products in the market even if the soil contains residual pesticides. In fact, field experiments on isofetamide at the legal application frequency showed that 1.44 mg of the 6 mg remained in the soil after one year (MAFF, 2018). According to the MAFF (2018), only 3.7% of respondents correctly understood the term organic. In other words, consumers may mistakenly believe that organic vegetables do not include any pesticides.

Table 1 Comparison of the ratio of organic land in developed countries

Country	Agricultural Land(ha)	Organic land(ha)	Ratio
Australia	358,895,000	35,687,799	9.944
Germany	16,645,000	1,613,785	9.695
France	28,660,100	2,240,797	7.819
Canada	58,199,000	1,321,072	2.270
United States	405,810,400	2,326,551	0.573
Japan	4,420,000	10,792	0.244

Source: Trávníček et al. (2021)

Now, what about vegetables grown without pesticides, which are less likely to have pesticide residues in the soil? It seems that the national character of Japan seems to become a barrier to expanding these vegetables. Japanese citizens tend to strongly prefer color, shape, and blemish-free vegetables and fruits, leading farmers to discard substandard vegetables even before they reach the market. According to MAFF (2020), the percentage of people who care about the appearance of vegetables is 36.7%, but on the flip side, this is evidence that due to the efforts of farmers and a system that prevents substandard vegetables from being distributed, stores are stocked with vegetables that look good. The incidence of substandard vegetable products is uncertain, and the amount of waste is also unclear. However, according to MAFF (2022c), while the overall vegetable harvest in 2020 was 12,876,000 tons, 11,104,000 tons were shipped, with 1,772,000 tons not shipped (approximately 14%). Not all of this amount is considered substandard vegetables, and some of them are used for processing, such as juice. However, some vegetables are discarded before they are counted in the harvest, so if these are included, the amount discarded as substandard vegetables may be higher than 1.78 million tons. Vegetables grown without pesticides are generally inferior in appearance to conventionally grown vegetables. However, it cannot be said that Japanese consumers have a correct understanding of the pesticides that remain on vegetables. Thus, there is room to verify whether a correct understanding of pesticides has the potential to expand the market for pesticide-free vegetables.

According to Willer et al. (2021), the Japanese consume very little organic produce per capita per year compared to other developed countries: one-third that of the UK, one-twelfth that of France, one-fifteenth that of the US, and one-third that of Switzerland. In addition, although global sales of organic food products are increasing yearly, the percentage of arable land in Japan that is cultivated organically is minuscule compared to that in the developed countries (see Table 1). Underlying the lack of increase in organic vegetable cultivation is the farmers' reluctance to produce organic and pesticide-free vegetables because of the costs and effort involved in organic and pesticide-free cultivation, in addition to consumers' strong preference for vegetables that appear good and their lack of interest in environmental issues (MAFF, 2019).

This study aimed to analyze whether consumers are willing to pay a premium for pesticide-free

vegetables, regardless of their appearance, when given information about the possibility of pesticide residues not only on conventionally grown vegetables but also on organic vegetables. In other words, this study will clarify whether consumers still value appearance when informed of the pesticides used on conventionally grown or organic vegetables or whether they do not care about the appearance of vegetables that do not use pesticides. In the strictest sense of the word, as pesticide-free vegetables are not commercially available in Japan, for the purpose of this study, pesticide-free vegetables were grown by the author and my seminar students and were presented to the respondents of the study to examine their willingness to pay (WTP). [1]To the best of my knowledge, this is the first study to reduce the inherent bias in the contingent valuation method (CVM) by offering respondents pesticide-free vegetables that are inferior in appearance to commercially available vegetables and analyzing whether the vegetables' appearance can be disregarded so long as they are pesticide-free and contribute to food loss reduction. Furthermore, this study will provide knowledge that will contribute to the reduction of food loss by improving the Japanese inherent tendency to be extremely particular about the appearance of vegetables through the acquisition of correct knowledge about the use of pesticides.

The rest of this paper is structured as follows. Section 2 presents a review of previous studies, and Section 3 describes the experimental design and data collection. Section 4 presents the empirical specification of this analysis, and Section 5 provides the conclusions and implications of this study for future research.

2 Previous research

There have been several studies that have mentioned the relationship between the appearance of vegetables and the use of pesticides (Hoi et al., 2009; Zhou and Jin, 2009; Rahman et al., 2021). However, while those studies mention the relationship between consumers' concern about the appearance of vegetables and pesticide use, they do not analyze the relationship from an economic perspective. On the other hand, some studies have focused on the value of organic foods and analyzed them from an economic perspective, but most of them have examined the effect of organic labels or the relationship between individual attributes and WTP (e.g., Chakrabarti et al., 2019; Dettmann and Dimitri, 2010; Huang and Lin, 2007; Krystallis et al., 2006; Lin et al., 2008; McFadden and Huffman, 2017). This section focuses on previous studies that have analyzed consumer preferences for organic vegetables, with an emphasis on the problematic use of pesticides and chemical fertilizers. Katt and Meixner (2020) and Li and Kallas (2021) conducted a comprehensive review of the WTP for organic foods.

Using a hedonic pricing model, Coulibaly et al. (2011) evaluate the potential market for organically grown vegetables in West Africa and analyze consumer attitudes toward and perceptions about chemical pesticide residues on vegetables. The results indicate that the misuse of chemical

[1] In Japan, as part of local production for local consumption, there are supermarkets and direct sales outlets that sell locally grown vegetables, but these vegetables are never inspected and often do not indicate to consumers whether they are grown without pesticides.

pesticides sprayed during vegetable production can cause serious health problems. Their analysis also reveals that consumers prefer vegetables that are undamaged, fresh, large, and well-colored, indicating the potential demand for synthetic pesticide-free vegetables. Nandi et al. (2017) provide a detailed analysis of consumers' WTP for organic fruits and vegetables in India and related factors affecting consumers' WTP. They find that approximately 90% of consumers are willing to pay premium prices ranging from 5% to more than 100% to obtain better quality vegetables and fruits. On the contrary, the high price of organic vegetables is one of the barriers for consumers purchasing organic vegetables. Khan et al. (2018) analyze the factors affecting WTP for pesticide-free fruits in Pakistan and demonstrate that more than 90% of the respondents have higher WTP. In particular, demographic and socioeconomic variables such as age, income, and health status are significantly associated with higher WTP. Furthermore, Ha et al. (2019) focus on regional differences in the determinants of WTP for organic vegetables in Vietnam and find that consumer perception of organic vegetables, trust in labels, and disposable family income increase WTP for organic vegetables in both urban and rural areas. Suanmali (2020) analyzes the factors influencing consumers' WTP for organic products (vegetables and fruits) in Thailand to show that the most significant factor is the experience of having once purchased organic products. Liang et al. (2021) conduct a survey in Macau and find that more than 80% of the people consider food waste a serious problem. In addition, they show that vegetables and fruits are the most common food waste from households, and income level and age have a significant impact on WTP for efficient food waste collection and management. Thus, many previous studies have analyzed WTP for organic and pesticide-free vegetables and the factors affecting WTP in developing countries.

Studies in developed countries include the following: Bernard and Bernard (2010) conduct experimental auctions on subjects selected from several states in the US, including Delaware and Maryland. In their experiment, they estimate consumers' WTP for potatoes and sweet corn for four different types: conventional, organic, pesticide-free, and non-genetically modified organisms. As fresh produce grown without the use of pesticides can capture substantial premiums, they argue that small farmers, in particular, should consider the profitability of not using pesticides rather than the cost incurred in obtaining the organic certification label. Gilmour et al. (2019) use a choice experiment to estimate consumers' WTP for hydroponic versus conventional lettuce. Although there was no WTP premium for hydroponics with or without organic certification, the study is very significant because it points out that providing consumers with a variety of information about hydroponics can change their preferences. In a pioneering laboratory experiment using eye tracking in Arizona in the US, Grebitus and Loo (2022) show that consumers' cognitive and affective processes are related to WTP. In particular, they find that WTP for pesticide-free labeling increased by an average of $0.10 per second increase in attention, indicating that consumers are more concerned about pesticide residues than about genetically modified foods.

On the contrary, in Japan, few studies have estimated and compared the values of organic and conventionally grown vegetables from an economic perspective. Such studies have limited themselves

to clarifying that consumers highly value organic vegetables and proposing the expansion of organic vegetable markets. Sawaragi et al. (2002) conduct a sales experiment as well as a questionnaire survey using CVM to extract consumers' WTP for organic agricultural products (tomato and spinach). Their results show that consumers' WTP for organic products is +26.6% and +14.9%, respectively, compared to marketed products, indicating a considerable discrepancy between their awareness and their behavior. Sato et al. (2005) estimate the value of locally and organically grown vegetables. Assuming that a bunch of spinach produced by conventional farming methods costs 160 yen, four higher amounts are presented (170, 175, 180, and 190 yen, respectively), and the WTP is estimated using the double-bounded dichotomous choice contingent valuation. Their estimation results show that the WTP for spinach produced by organic farming is 19 yen higher than that of conventionally grown spinach. Tsuge (2004) also uses the CVM to estimate the value of organic vegetables and explores measures to promote environmentally friendly agriculture by estimating the added value of vegetables produced by such farming methods. A comparison of tomatoes from conventional farming methods (4 packs) priced at 200 yen and tomatoes from environmentally friendly farming methods (4 packs) priced slightly higher reveals that WTP for tomatoes from environmentally friendly farming methods is 60 yen higher than that for tomatoes from conventional farming methods. In a recent study, Yang et al. (2022) show that Japanese consumers earn the trust of environmentally friendly food products when they get information from friends and family. Their study applies a choice experiment by gathering samples through an internet survey.

As described above, many of the studies that have evaluated organic vegetables from an economic perspective have been conducted in developing countries, where pesticide residue in vegetables is a greater problem than in Japan. However, even in developed countries, consumers may not feel fully secure and assured of their safety regarding the use of pesticides in production when purchasing vegetables. In Japan, although some studies pay attention to organic products in terms of economics, they concentrate on the value of organic ones, not pesticide-free ones.

3 Methods

3.1 Experimental design

A preliminary (pre-) survey of residents in Sapporo, Japan, ranging from university students in their 20s to residents in their 70s, was conducted between June–July 2018, and 50 samples were collected. We asked students attending Hokusei Gakuen University[2] and their families and acquaintances to cooperate in the pre-survey. Respondents were asked about their WTP for cucumbers and tomatoes in an open-ended manner to avoid range bias. However, at the time of the pre-survey, because the average market price for a pack of three conventionally grown cucumbers at four stores we had been scheduled to be surveyed was 180 yen (approximately US$ 1.64, considering the exchange rate at that time), we showed that value as a reference price. Based on the results of the pre-survey, the first bid prices in

[2] This research was undertaken in part while the author worked at the Hokusei Gakuen University, Japan.

Table 2 Comparison of each type of farming

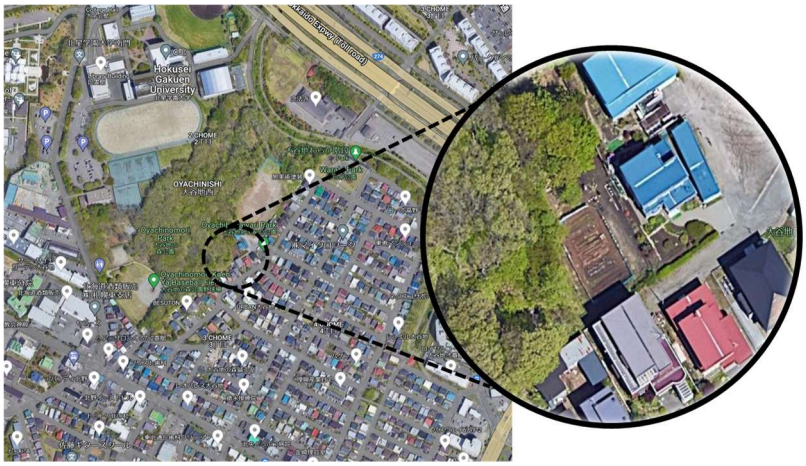
Type of farming	Pesticide use and its residue	
	Use of pesticide	Pesticide residue in the soil
Conventional	Dependent on each prefecture's standard*	No stipulations
Specially cultivated	Uses less than half the amount of chemical fertilizers and pesticides compared to conventional farming methods	No stipulations
Organic	Avoids the use of chemical fertilizers and pesticides as much as possible	No use of prohibited pesticides or chemical fertilizers for at least two years before sowing or planting
Pesticide-free	Avoids the use of chemical fertilizers and pesticides as much as possible	Highly unlikely

*For example, according to the Hokkaido prefectural government (2022), the nitrogen compositions of the chemical fertilizers used for cucumbers and cherry tomatoes are 42kg/10a and 28kg/10a, respectively. The number of pesticide applications during cultivation ranges from 33 to 49 times for cucumbers and 23 times for tomatoes. Both of these counts are the highest among fruit and vegetable crops.

this survey were set at 190, 200, 210, 220, and 250 yen, in addition to the market price of 180 yen. Similarly, for cherry tomatoes, in addition to the market price of 210 yen at the time (approximately US$ 1.91), the first bid amounts of 230, 240, 250, 260, and 280 yen were set based on the results of the pre-survey. [3] Only the fifth bid was set higher for both cucumbers and cherry tomatoes because the highest amount from multiple individuals' pre-survey responses was extracted. In the pre-survey, only 5% of the respondents indicated that the WTP for cucumbers was between 220 yen and 250 yen, whereas no one mentioned that the WTP for cherry tomatoes was 270 yen. As pesticide-free vegetables are generally 50% more expensive than conventionally grown vegetables in the market (National Agriculture and Research Organization of Japan, 1997), it is reasonable to set a higher price for such vegetables. According to the MAFF (2016), the price of cucumbers was, on average, 1.6 times higher and that of cherry tomatoes was 1.35 times higher in the 2015-2016 survey for domestic organically grown vegetables compared to standard domestic products. For both vegetables, the smallest price differences between standard and organically grown products were observed in summer (September), when prices were 1.04 and 1.13 times higher for cucumbers and cherry tomatoes, respectively.

The pesticide-free vegetables used in this study were cultivated by ourselves from scratch. According to the MAFF's "Outline of Labeling of Organic Agricultural Products," special cultivation agricultural products refer to agricultural products grown with less than half the use of pesticides and chemical fertilizers, but labeling them "no pesticides" or "no chemical fertilizers," respectively, is prohibited because it is misleading when sold in the market (see Table 2). This is because consumers

[3] Usually, prices of summer vegetables such as cucumbers and tomatoes gradually decrease from June to August, but in 2018, the prices of these vegetables rose in August to the same level as they were in June (see MAFF(2018) https://www.maff.go.jp/j/seisan/ryutu/yasai_zyukyu/y_sapporo/attach/pdf/index-26.pdf.).



Source: Google map

Fig.1 The location of the farmland

Fig.2 Farmland and compost (Photographed in April 2018).

tend to misinterpret pesticide-free vegetables to mean the absence of residual pesticides in the soil and pesticide dispersal from neighboring fields. In April 2016, unused land on the grounds of Hokusei Gakuen University was cultivated (see Figs. 1 and 2 (left)). Compost and leaf litter generated exclusively from food waste from the student cafeteria were used to cultivate the vegetables (see Fig. 2 (right)). Considering the possibility that food waste from the cafeteria (e.g., vegetable scraps) may contain pesticides, we verified the suppliers and harvesting process. Although most of the vegetables used in the student cafeteria are domestically produced, they may contain trace amounts of pesticides. Despite negligible pesticide traces, the possibility that small amounts remain in the soil during composting cannot be ruled out. Therefore, we explained to the respondents during the survey that the vegetables presented were close to being pesticide-free and significantly less likely to contain pesticides. After planting seeds and seedlings, we did not use any chemical fertilizers, herbicides, insect repellents, or other pesticides but only wood vinegar, which has insect repellent effects and fertilizer made from food waste. There were also no fields in the neighborhood where pesticides may have been applied. As explained earlier, pesticide-free vegetables as defined in this study are

Fig.3 Comparison with commercial (top) and pesticide-free vegetables (bottom)
(Photographed in August 2018)

different from organic or special cultivation agricultural products as defined by the MAFF because we deliberately avoided the use of pesticides and chemical fertilizers.

We explained to the respondents that the pesticide-free vegetables shown in this study were different from commercially available organic produce and showed them the actual products that we had grown (see Fig. 3). We also carefully explained to the consumers why the actual products were somewhat inferior in terms of color and appearance. To avoid an evaluation bias, we did not inform them that we had grown the vegetables ourselves. Cucumbers and cherry tomatoes were used in this study because 1) they are commonly consumed by Japanese people according to a survey conducted by the Ministry of Health, Labour and Welfare of Japan (2015); 2) they can be grown efficiently in a small area and can thus be widely cultivated across Japan; 3) they are not directly affected by factors other than pesticides, such as soil hardness. According to MAFF (2022c), the yield of cucumbers and tomatoes in 2021 was 5,500 and 6,360 tons per 10are, respectively, much more than that of other vegetables such as peppers (4,660 tons) and eggplants (3,600 tons). The top three prefectures for cucumber production are Miyazaki, Gunma, and Saitama, respectively, whereas the top three prefectures for tomato production are Kumamoto, Hokkaido, and Aichi, respectively, all of which cultivate these crops over a wide area. Both are summer vegetables but are grown in the warmer south during the cold season, making them available throughout the year.

In general, cucumbers are susceptible to various diseases and require treatment using fungicides and insecticides, failing which they exhibit poor growth, deformities, and discoloration (Takii & Co., Ltd; 2022). The most commonly used pesticides in Japan are neonicotinoid pesticides, which may have adverse effects on the human body. In the case of cherry tomatoes, although they appear to be similar in color to market tomatoes, they comprise a mixture of well-colored and not-so-well-colored

tomatoes and are small in size. According to the Ministry of Health, Labour and Welfare of Japan (2009), phytohormones (4-Chlorophenoxyacetic Acid), which are often used to promote tomato growth, improve the gloss, and produce large fruit, have been linked to adverse effects on the fetus and possible internal organ diseases. Before and after cultivating land, we interviewed farmers from cities and towns in the suburbs of Sapporo city (Yoichi, Rankoshi, Namporo, and Yuni town and Bibai city) who were growing vegetables without agricultural chemicals or organically to understand the process of growing chemical-free vegetables.

To select supermarkets for the survey, we first randomly selected companies that sell organically grown vegetables from among those operating several supermarkets in Sapporo. Next, we contacted the stores owned by companies that agreed to allow us to conduct our survey. Among the stores that agreed to cooperate with us, four stores that were as far away from other stores as possible were chosen considering not only distance but also the availability of sufficient space to conduct the survey. Of the four stores, we chose two, (A) Coop Sapporo Hondori store and (B) Aeon Asabu store, to show the pesticide-free vegetables to the respondents and two others, (C) Coop Sapporo Kawashimo store and (D) Aeon Shinkotoni store, where we did not show the pesticide-free vegetables. Owing to the long survey period, there was a possibility that the same person would visit the different stores, thereby informing their neighbors about the survey. To prevent this, we took precautions to choose stores as far apart as possible. The closest store to the Coop Sapporo Hondori store is the Coop Sapporo Kawashimo store, which is approximately 3.1 km away by the shortest route. The closest store to Aeon Asabu is Aeon Shinkotoni, which is approximately 7.6 km away by the shortest route. None of the stores sold cucumbers and cherry tomatoes at least 5 yen lower or higher compared to the average market prices at the time of the survey. The survey was conducted from 9:00 am to 3:00 pm on weekdays from August 16-24, 2018, at these four supermarkets. We distributed questionnaires to 100 shoppers at each store. There were a few days when the survey could be conducted until the evening crowd came, but usually, the survey ended at 3:00 p.m. because conducting the survey during rush hours would disturb shoppers. It is undeniable that the time constraints of the survey may have affected the representativeness of the sample.

The survey method is described as follows.[4] Shoppers who had paid for their purchases and were putting their items in their bags were asked to cooperate and answer the questionnaire at a response booth provided by the store. Depending on the store, the survey location could be a booth or just a desk and chair in a corner of the store. Before answering, shoppers were asked whether they had recently responded to any survey with similar content, and those who said “yes” were not asked to complete the survey. Both conventional and pesticide-free vegetable cultivation methods were also explained before stating answer. In particular, we explained that the conventional farming method, which is usual for vegetables that are generally available in the market, allows the use of pesticides

[4] All surveys conducted in this study were subject to research ethics review by Hokusei Gakuen University in advance. In addition, survey respondents were fully briefed on the purpose of the survey and the handling of post-survey data before responding to the survey.

Table 3 Number of respondents for different initial bids

Initial bid (Cucumbers/ Tomatoes)	Higher bid	Lower bid	Number (%)
190/230	200/240	180/210	89(26.2%)
200/240	210/250	190/230	79(23.1%)
210/250	220/260	200/240	86(25.15%)
220/260	250/280	210/250	88(25.73%)
Total			342

and chemical fertilizers within government-determined standards. In addition, to make the respondents aware of the current status of food waste in Japan, data related to food imports and the amount of food waste in Japan were presented and explained. The survey instrument covered personal attributes such as gender, age, occupation, family structure, and household income. Next, using the information obtained from the pre-survey, respondents were asked to check all applicable boxes regarding environmental issues of concern (global warming, acid rain, water pollution, air pollution, waste problems, ozone depletion, deforestation, invasive alien species problems, and others). Finally, respondents were asked about their WTP for pesticide-free cucumbers and cherry tomatoes.[5] The study uses a double-bounded dichotomous choice (DBDC) format to estimate WTP, which is in accordance with Hanemann et al. (1991). Each respondent was offered a random amount of money. First, a specific amount was offered; if the respondent was willing to pay that amount, a higher amount was offered; if the respondent was not willing to pay the first amount, a lower amount was offered. Those who were not willing to pay the amount offered both times were asked the reason for their unwillingness, and respondents who checked the option corresponding to the protest responses were excluded. After completing the questionnaire, respondents were given chopsticks as a reward. Table 3 shows the different initial bid values and the bid value setting after each initial bid value. The initial bid values are 190, 200, 210, and 220 yen for cucumbers and 230, 240, 250, and 260 yen for cherry tomatoes, and the proportion of shoppers who were shown each initial bid is approximately 25% for each store.

3.2 Data and descriptive statistics

The number of valid responses obtained from each store varied somewhat but could be estimated using approximately equal numbers of observations (Table 4). Table 5 shows the descriptive statistics. Of the 342 responses, 278 were women and 64 were men, with women accounting for 81% of the total. More than half of the respondents were in their 60s or older (58.8% of the total), and by occupation, most respondents were homemakers (44.2%), followed by unemployed individuals (22.8%). The fact that most of the shoppers were women who were full-time homemakers could be attributed to the time of day when the survey was conducted. The most common family composition was a two-person household, accounting for 44.7% of the total. From the above, it can be assumed that most shoppers

[5] The full survey questionnaire is available from the author upon request.

Table 4 Number of valid responses collected at each store

Store	Freq.	Percent
A	73	21.35
B	87	25.44
C	88	25.73
D	94	27.49
Total	342	100.0

Table 5 Definitions and sample statistics of the variables

Variable	Description	Mean	Std. Dev.	Min	Max
Gender	1 if the respondent is a woman, 0 for a man	0.791	0.406	0	1
Age	Age of the respondent	61.36	16.57	15	85
Family size	Number of family members living with the respondent (including the respondent)	2.556	1.217	1	8
Income	Household income, in 10,000 yen	413.8	222.1	200	1,000
Show	1 if the pesticide-free cucumbers and tomatoes were shown to the respondent, 0 otherwise	0.468	0.027	0	1
Environment	The number of environmental issues that concerned the respondent	3.181	1.951	0	9

were older adult couples. As for household income, the largest number of respondents reported household incomes between 2 and 4 million yen (36.8% of the total), followed by those who reported incomes between 4 and 6 million yen (23.7% of the total). The average annual income of shoppers was 4.243 million yen, slightly higher than the average annual income in Sapporo in 2018, which was 3.149 million yen. Finally, shoppers were asked to select all of their concerns from a list of nine different environmental issues, including others. The average number circled was 3.2, with global warming being the most selected and acid rain being the least selected. Table 6 summarizes DBDC's WTP answer patterns and environmental issues of interest. In the case of cucumbers, the approval rates for those offered 190, 200, 210, and 220 yen at the first bid were 85.4%, 77.2%, 72.1%, and 69.3%, respectively. In the case of cherry tomatoes, the approval rates for those who were offered 230, 240, 250, and 260 yen at the first bid were 78.7%, 75.9%, 73.3%, and 55.7%. Respondents who agreed to pay even once were asked why they accepted the rate. The most common response was “feels safe and secure,” at approximately 56% for cucumbers and 48% for cherry tomatoes. The next most common response was “seems good for my health,” at approximately 12% for cucumbers and 13% for tomatoes. Six respondents who chose “concerned about the farming methods of the pesticide-free vegetables” were considered protest responses because they did not have any WTP. In addition, there were 20 non-responsive individuals and 32 incomplete (partially blank) responses, resulting in a final

Table 6 Means of the variables by the distribution of responses

Variable	No-No	No-Yes	Yes-No	Yes-Yes
Global warming	40	36	61	183
Acid rain	5	3	15	43
Water pollution	11	6	25	83
Air pollution	22	17	29	108
Waste	18	22	35	123
Ozone layer	10	11	9	60
Deforestation	11	6	18	67
Alien species	13	9	20	62
Other	0	1	0	4

total of 342 responses used in the estimation.

Owing to the limited space, had the survey been conducted with and without the display of vegetables at the same store, respondents who were classified as having not been shown the pesticide-free vegetables may have seen them unintentionally. There are other adverse effects of simultaneously surveying respondents in the same store with and without a display of pesticide-free vegetables. For example, because the survey was conducted in an open space that was visible to shoppers, if there were customers who came to shop every day, there was a possibility that they would see the pesticide-free vegetables even if they declined the survey. Accordingly, if they participated at a later date and were classified as not having seen the pesticide-free vegetables, their WTP would include bias. To eliminate these possibilities, we separated the stores that showed the vegetables to the respondents from those that did not. However, in such cases, a difference in the population of respondents is likely. Therefore, we conducted a Welch's t-test focusing on age and household income, which are most likely to affect WTP between the samples in the “show” and “no-show” cases. The t-value for age was -0.8955 and that for household income was 0.8838. The P-value for age was 0.3712 and that for household income was 0.3774, indicating that the null hypothesis could not be rejected and that the mean values of age and household income were not statistically significantly different between the two groups.

4 Empirical specification

The double-bounded model was developed by Hanemann et al. (1991). Since then, many studies have applied the model to assess the value of an environmental amenity. Assuming that the WTP function is linear, respondent i’s WTP is expressed by the following equation:

$$WTP_i(x_i, u_i) = x_i^{'}\alpha + u_i,$$

where x_i is the vector of explanatory variables, α is a vector of parameters, and u_i is an error term assumed to be normally distributed with mean 0 and standard deviation σ. Respondents are asked two questions about whether they accept the first bid Bid_1 as well as the follow-up Bid_2. Based on these two questions, four possible intervals can be constructed for WTP as follows.

1. If a respondent i answers Yes to the first bid and No to the second bid, then $Bid_1 \leq WTP_i < Bid_2$.
2. If a respondent i answers Yes to both first and second bids, then $Bid_2 \leq WTP_i < \infty$.
3. If a respondent i answers No to the first bid and Yes to the second bid, then $Bid_2 \leq WTP_i < Bid_1$.
4. If a respondent i answers No to the first and second bids, then $0 < WTP_i < Bid_2$.

The probability of each of the four cases is given as follows (Haab and McConnell, 2002; Hanemann et al., 1991):

$$Pr(Bid_1 = yes, Bid_2 = no) = Pr(Bid_1 \leq WTP \leq Bid_2) = G(Bid_2; \alpha) - G(Bid_1; \alpha) \quad (1)$$

$$Pr(Bid_1 = yes, Bid_2 = yes) = Pr(WTP \geq Bid_2) = 1 - G(Bid_2; \alpha) \quad (2)$$

$$Pr(Bid_1 = no, Bid_2 = yes) = Pr(Bid_2 \leq WTP < Bid_1) = G(Bid_1; \alpha) - G(Bid_2; \alpha) \quad (3)$$

$$Pr(Bid_1 = no, Bid_2 = no) = Pr(WTP \leq Bid_2) = G(Bid_2; \alpha), \quad (4)$$

where $G(Bid, \alpha)$ represents the cumulative density function. If there are N respondents, the log-likelihood function takes the form

where $G(Bid, \alpha)$ represents the cumulative density function. If there are N respondents, the log-likelihood function takes the form

$$ln\, L = \sum_{i=1}^{N} \{d_i^{YY}\, ln\big(1 - G(Bid_2; \alpha)\big) + d_i^{NN} \cdot G(Bid_2; \alpha)$$

$$+ d_i^{YN}\big(G(Bid_2; \alpha) - G(Bid_1; \alpha)\big) + d_i^{NY}\big(G(Bid_1; \alpha) - G(Bid_2; \alpha)\big)\},$$

where, d_i^{YY},d_i^{NN},d_i^{YN}, and d_i^{NY} are indicator variables that take the value of 1 or 0 corresponding to the response probabilities given by Equations (1)-(4).

The estimation results are as shown in Table 7. The coefficients for age are positive and significant at the 1% level for both cucumbers and cherry tomatoes. This indicates that older people have higher WTP. The coefficients for gender and income are not significant for both cucumbers and cherry tomatoes. The coefficients for the dummy variable (Show), which takes a value of 1 for the vegetables being shown, are likewise not significant. This means that showing pesticide-free vegetables that were not colored or shaped well did not affect respondents' WTP. In other words, the respondents were not particular about the appearance of the vegetables so long as they were pesticide-

Table 7 Estimation results

	Cucumbers			Cherry tomatoes		
Variables	Coefficient	S.E.	p values	Coefficient	S.E.	p values
Age	0.567***	0.138	0.000	0.815***	0.203	0.000
Gender	2.745	5.429	0.613	6.076	7.667	0.428
Income	0.009	0.010	0.399	-0.002	0.014	0.864
Show	-3.518	4.396	0.423	-8.271	6.120	0.177
Environment	2.194*	1.217	0.071	3.616**	1.690	0.032
Constant	184.635***	11.593	0.000	208.653***	16.763	0.000
Mean WTP (Japanese yen)		226.58***			270.38***	
Log-likelihood		-361.339			-334.944	
Wald statistic		22.08			23.54	
Sample size		342			342	

The estimated coefficient is significant ∗at the 10% level; ∗∗at the 5% level; ∗∗∗at the 1% level.

free. This is a very important result derived from consumer preferences for reconsidering the use of pesticides on agricultural products in Japan. Finally, the coefficients for concern regarding environmental issues are significant at the 10% level for cucumbers and 5% level for cherry tomatoes. This indicates that knowledge about environmental issues positively affected respondents' WTP. In addition, the WTP was 227 yen for cucumbers and 270 yen for cherry tomatoes, only 47 yen and 60 yen higher, respectively, than the prices of conventionally grown vegetables sold in the market. This result is similar to that of Tsuge (2004), who found that the price of organically grown tomatoes was 60 yen higher than the market price. On the contrary, the results of this study showed that the prices of cucumbers and cherry tomatoes are 26% and 29% higher, respectively, than conventionally grown vegetables, which is lower than the 50% higher price of organic vegetables compared to conventionally grown vegetables, as indicated by the National Agriculture and Research Organization of Japan (1997) results mentioned earlier.

5 Concluding remarks

This study uses a DBDC method to examine WTP for vegetables grown without pesticides; two stores displayed pesticide-free vegetables to shoppers, whereas the other two did not. The results showed that shoppers were willing to pay more for pesticide-free vegetables, regardless of whether they were shown the slightly inferior shape and color of the pesticide-free vegetables compared to cucumbers and cherry tomatoes produced using conventional farming methods. Although it has been pointed out that Japanese people tend to be overly concerned about the appearance of vegetables, which has led to substandard vegetables being discarded and food loss problems, the results of this study indicate that shoppers are not concerned about the appearance of pesticide-free vegetables. Given that consumers

are willing to pay a premium of approximately 30% of the price of conventionally grown vegetables for pesticide-free vegetables, the WTP for organic vegetables could be less than that. Furthermore, the results of this study also revealed that those who are more concerned about environmental issues have a higher WTP. It has long been asserted that consumers in Japan are less environmentally conscious than consumers in other countries, and this trend has not changed to this day (Boston Consulting Group, 2022). If consumers become more concerned about environmental issues and focus on food loss, they may choose pesticide-free vegetables more than they do now. Indeed, according to the Consumer Affairs Agency of Japan (2020), the most common reasons given for purchasing substandard vegetables are low prices and not caring about appearance. However, these are substandard vegetables from among the conventionally grown vegetables, which contain pesticide residues but are substandard because of their poor appearance and are hence sold at low prices. The key is to understand how to distribute pesticide-free vegetables, which are grown without the use of pesticides or chemical fertilizers and therefore appear inferior compared to conventionally grown vegetables but are more expensive because of the time and effort required.

This study's findings indicate that enhancing consumers' awareness of environmental issues can be an effective measure for the distribution of pesticide-free vegetables. Consumers must be made aware that pesticides and chemical fertilizers are used on conventionally grown vegetables to make them look good. In addition, they should know the importance of carbon farming, which involves fixing atmospheric carbon dioxide and maximizing the use of fungi and microorganisms in the soil and does not rely on pesticides and chemical fertilizers. Hokkaido is the most agriculturally active region in Japan, but most of the soil in Hokkaido is black soil, a type of volcanic ash, which requires chemical fertilizers. However, it has been demonstrated in Hokkaido that nutrients in the soil can be secured without the use of chemical fertilizers (Onodera and Nakamoto, 2007), and there may be some value in experimenting with cultivation methods that do not affect the environment or the human body. Even now, the number of farmers growing organic and pesticide-free vegetables in Japan is minuscule. As Britwum and Yiannaka (2019) point out, producers should understand the demographic composition of their target consumers and reflect these preferences in their vegetable production methods. Such attempts will expand the market of vegetables that less affect the environment or human health and reduce their dependence on pesticides and chemical fertilizers. As a result, those changes could decline out-of-specification vegetables and consumers' food loss that is occurred discarding edible parts of vegetables.

It is important for the government to focus not only on reducing the physical amount of food loss but also on motivating consumers to choose more environmental friendly products and reduce substandard vegetable waste by understanding their preferences and raising their environmental awareness. Furthermore, more efforts are needed to expand the market for pesticide-free vegetables by encouraging producers to shift to production methods that do not use pesticides and chemical fertilizers and providing subsidies to help lower production costs. For example, the Japanese government should immediately consider measures to support the purchase of more expensive but

safer vegetables for low-income consumers in Japan, by referring to the Supplemental Nutrition Assistance Program (SNAP) that allows low-income households in the US to buy organic food.

Although the study findings provide substantial evidence of consumers' WTP for pesticide-free vegetables, they are subject to certain limitations. The first is that the sample is not representative of the Japanese population, and the respondents of this study are, on average, older citizens. To insist on the importance of expanding the pesticide-free vegetable market, it would be necessary to conduct a survey questionnaire nationwide in Japan. Another limitation is the hypothetical nature of the experiment, which can raise concerns about hypothetical bias, that is, the concern that WTP may be overestimated. In particular, the respondents who were concerned about pesticides or chemical fertilizers may have chosen "Yes" in response to the price shown in the questionnaire but may opt for conventionally grown vegetables that are cheaper, especially when facing budget constraints. This can potentially bias results. However, as we explained the differences between conventionally grown, organic, and pesticide-free vegetables and elaborated on pesticide use before distributing the questionnaires to the respondents, the hypothetical bias is expected to be minimal. Regardless, as mentioned by Meyer (2020), applying virtual reality technology to eliminate various constraints in on-site surveys can help avoid the biases inherent in the CVM. These issues should be the subject of future research.

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