

Article

## Consumers' Willingness to Pay for Cabbage with Minimized Pesticide Residues in Southern Benin

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**Abstract:** Cabbage (Brassicaceae) is one of the most frequently consumed exotic vegetables in Benin and also the most affected by insects. To meet growing food demand, farmers rely heavily on synthetic pesticides that are harmful for themselves, consumers and the environment. Integrated pest management has been proposed as the means to improve vegetable productivity and quality in many developing countries. One approach is to substitute pesticides with physical barriers to insects, like nets. Here, we assess consumers'

perceptions about cabbage and their purchasing behavior towards cabbage that was produced using these nets in two major cities in Benin. Results indicate that consumers are aware of the health risks associated with intensive use of pesticides but were not able to recognize the quality difference between cabbage produced under nets from those using pesticides. All consumers were willing to pay a price premium for cabbage with minimized pesticides residues compared with conventionally produced cabbage, the average premium being 38%. Women, older, highly educated consumers and those able to distinguish cabbage qualities were willing to pay the most. We suggest that farmers will obtain higher prices if their production of cabbage with preferred characteristics is accompanied by an improved marketing strategy.

**Keywords:** contingent valuation; eco-friendly production; healthy food; IPM; premium price; purchasing decision; West Africa

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## 1. Introduction

In a world of 9.5 billion people, global demand for food has to be met with minimal increases in land, water, fossil fuels and impact on the environment [1,2]. It is estimated that 60% of the world population will reside in cities by 2030. Sub-Saharan Africa (SSA), previously considered the least urbanized zone in the world, is urbanizing rapidly [3] with an urban population growth of 600% in the last 35 years. The boom in urbanization has resulted in a steep increase in demand for food, especially high value crops such as fruits, vegetables and other horticultural crops [4]. Food production is no longer seen simply as providing nutrition for a growing population but also as contributing to poverty reduction, better health outcomes and conservation of natural resources [5–7].

Over the past couple of decades, urban agriculture has gained increasing importance as a viable strategy for resource-limited people to generate additional income and to reduce their reliance on cash income for food by growing their own [8,9]. However, because of demand driven pressure of a growing urban population demanding fresh food, food production, and urban agriculture in particular, are inevitably linked to indiscriminate use of pesticides. These both harm the environment [10] and expose many people to toxic pesticides [11–13]. Vegetable production in Africa is now highly dependent on insecticides, not only in places dominated by large-scale cash crops, but also in small-holder production systems [11,13–15]. Inappropriate application and handling of often banned pesticides can damage the environment [10] and impinge on the health of both those applying the pesticides and the consumers buying crops and vegetables [11–13,16–20]. Nearly 75% of the 200,000 deaths associated with pesticide poisoning occur in developing countries even though they use only 15% of global pesticide supply [21,22].

In developed countries, both environmental awareness and consumer awareness of healthy and safe food has increased in the last three decades, leading to a significant increase in the demand for safe organic [23–27] products, including those that are pesticide-free, or pesticide residue-reduced [28–33] as well as products from a particular origin [34–37]. While consumer awareness has received considerable research attention in Asia [26,38–41], little has occurred in African countries, with just a

few case studies from either consumer [42–47] or producer perspectives [20,48]. Most consumer preference studies in African countries relate to bio-fortified foods [49–51].

However, with greater purchasing power, consumers in Africa are consuming more food outside the home [46] and have become more apprehensive about food quality and safety [43]. This creates a market for high quality, safe food produced by urban farmers. One way to increase food productivity with minimized pesticide use is to deploy nets (referred to as eco-friendly nets—EFNs) as a physical barrier to insects. These nets have been trialed in Benin and Kenya through the USAID funded project “Low cost pest exclusion and microclimate modification technologies for small-scale vegetable growers in East and West Africa”. The nets are increasingly replacing foliar insecticide spraying in these two countries with the prospect of being adopted in other African countries [11,52–54]. EFNs can reduce pesticide use by at least 70%, sometimes by even 100% [11,55,56], hence the term “eco-friendly”. While the EFNs showed promising results in term of productivity in France [57], Kenya [58,59] and Benin [11,55,56], and also acceptance by farmers [54], nobody has studied consumers’ attitudes towards the vegetables and their attributes that can be produced using the nets, *i.e.*, without heavy use of pesticides.

A recent survey carried out in Benin [60] has shown that the cost of producing cabbages (*Brassica oleracea* L. var. *capitata*) using EFNs is about 10% more than without. Understanding consumer behavior will thus help design market incentives for urban farmers, without which sustainable and economically viable production of safe vegetables using EFNs will be challenging. Our study aims to assess (i) consumers’ concerns about the use of pesticides in cabbage production, (ii) their preferences for cabbage qualities, and (iii) their willingness-to-pay (WTP) for pesticide-free cabbage produced using EFNs.

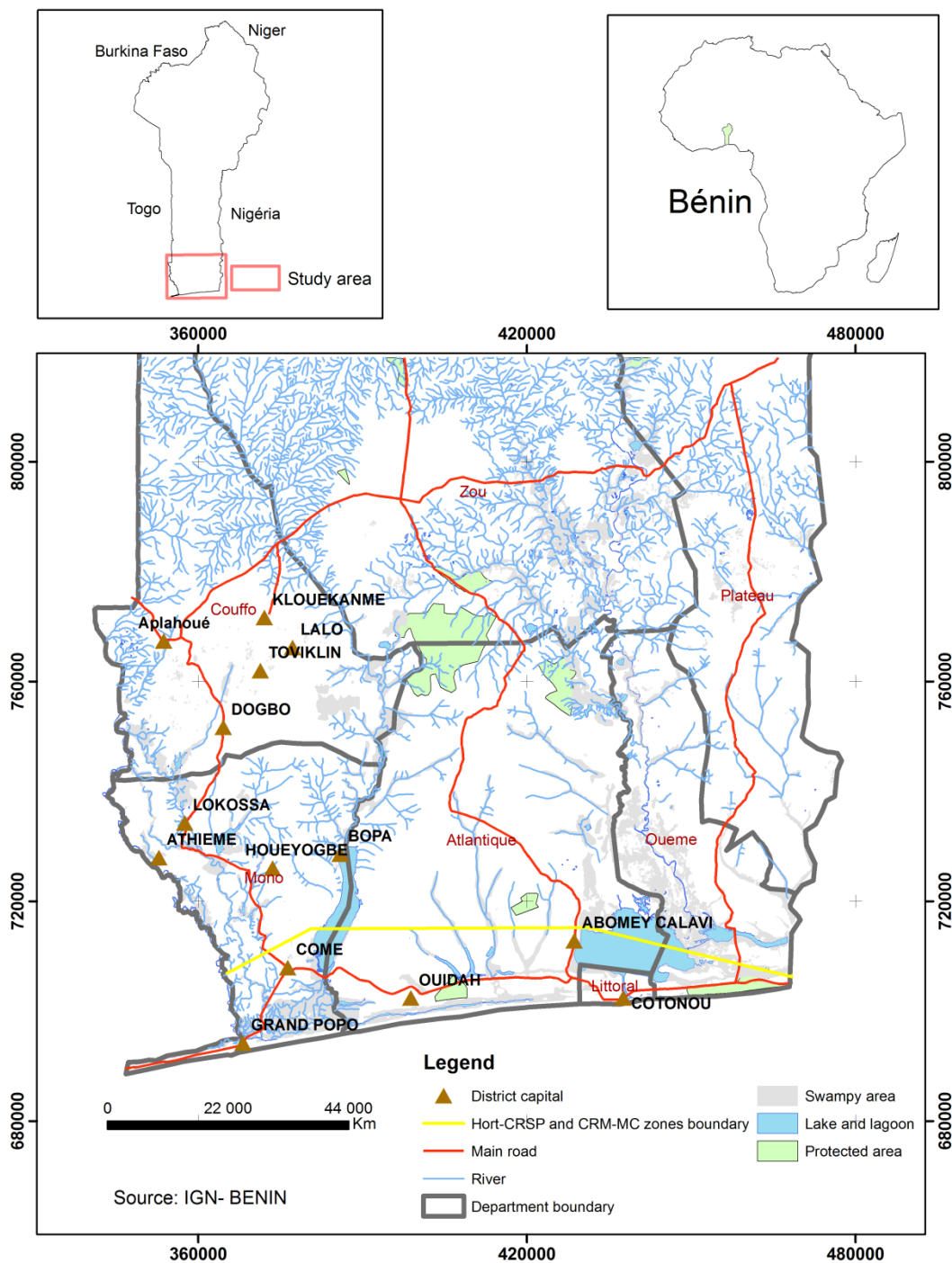
We carried out a survey including a contingent valuation (CV), a stated preference elicitation method. Stated preference methods such as CV and choice experiments (CE) rely on peoples’ WTP for goods or services whose value is not readily apparent at markets and has become an important evaluation tool for project developers, designers and planners wishing to introduce a new technology such as EFNs [61,62]. The CV, as applied here, can reveal the tradeoff consumers make between paying a higher price and consuming pesticide-free cabbages that had been produced using EFNs instead of cabbages with high pesticide residues. Besides having the potential to provide information to decision-makers about promoting EFNs for vegetable production in urban areas of Benin, our study also contributes to a growing but still relatively small body of literature on consumer preferences for high quality and safe fresh food products in very poor countries.

## 2. Materials and Methods

### 2.1. Research Area

The study was carried out in two major cities in southern Benin, Cotonou and Abomey-Calavi. Cotonou is Benin’s largest city and its economic capital, hosting the biggest business centers and almost all public services. Abomey-Calavi is also densely populated and is the education center of Benin with the largest university in the country and many secondary schools (Figure 1). The two cities are roughly the same size with populations of about 700,000 people whilst the total population of Benin is approximately 10 million [63]. Both cities are supplied by urban farmers who grow a large range of exotic vegetables such as lettuce, eggplant, carrot, cabbage, and indigenous vegetables such as chilli pepper,

sweet pepper, tomato, amaranths, gboma and basilica. Consumers mainly purchase locally produced vegetables from one of the formal markets (there is one per district) or numerous informal markets.



**Figure 1.** Location of the two survey sites in southern Benin (Cotonou and Abomey Calavi).

The EFNs are cut to cover an iron or wooden frame over a small plot. They are generally made of recyclable polyethylene or, more recently, from starch. The mesh size recommended depends on climate and the size of the pests to be excluded. In tropical Benin both fine mesh nets (0.4 mm) and larger mesh (0.9 mm) are used to protect cabbage from major lepidopteran pests (*Plutella xylostella*, *Hellula undalis*, *Helicoverpa armigera* and *Spodoptera littoralis*) and aphids (*Lipaphis erysimi*). EFNs are usually removed during daylight hours, when pests specializing in cabbage are inactive, to enable regulation of

aphids populations by their natural enemies (predators and parasitoids) and to prevent overheating and excessive shade [11,52,53,55,56]. While nets should be removed every day, most farmers remove them just three times a week to minimize labor costs [56].

## 2.2. Sampling Strategy

Two enumerators were employed and trained to assist with the interviews that took place between August and September 2013. Face-to-face interviews were implemented in ten urban districts (the lowest administrative entities of a town in Benin). In each district, the sampling process for random sampling of residents was initiated at a crossroads. First, three crossroads were randomly selected per district. The direction of the street segment connecting the starting point to the next crossroad was also chosen randomly. The second starting point was the crossroad situated just below the terminal point of the first segment with the third at the end of the second segment. Each street segment was composed of a set of houses, all of which were assigned a number. Finally, three houses were selected per street segment for household interviews (one respondent per house). This sampling procedure has been successfully applied by others [64] in southern Benin to analyze satisfaction across urban consumers of smallholder-produced teak (*Tectona grandis*).

A total of 303 sampled houses were selected, 180 in Abomey-Calavi and 123 Cotonou, a sample size similar to other consumer WTP studies [31,65,66]. Households not purchasing and consuming cabbage (*Brassica oleracea* L. var. *capitata*) were not interviewed. Ninety households (32 in Abomey-Calavi and 58 in Cotonou) in which cabbage was frequently bought for home consumption were finally interviewed for this study.

## 2.3. Questionnaire

We used a structured questionnaire, which, additional to the CV questions, contained various questions eliciting respondents' socio-demographic characteristics and issues relevant to cabbage consumption. We collected information on annual income but also recorded house quality, the main means of transport, and the means of preserving fresh food (see Tables S1.1–S1.3 in supplementary materials) in order to create an indicator of wealth [67]. These complementary indicators were recorded because respondents are often reluctant to reveal their income. When asked about cabbage consumption, respondents were invited to show how cabbage ranked among the vegetables they consumed; whether they distinguish cabbage qualities at the market place; and the criteria they use to guide their choices. Information was also collected on respondents' awareness of farmers' use of nets to replace pesticides.

## 2.4. The Contingent Valuation

Analysis of the change in utility for consumers induced by a change in cabbage quality and the level of payment associated with these qualities is based on McFadden's random utility models [68] which assume utility is comprised of both a deterministic component, which is stated by a consumer or can be observed by a consumer's actions or choices, and a random, unobservable component. The random utility model provides estimates of the probability of a consumer choosing a policy alternative, or in our study, to purchase cabbage of a certain quality at a certain price. The consumer will select pesticide-reduced

cabbage at a higher price if he or she receives higher utility from it than from conventional cheaper cabbage, *i.e.*, the utility is a function of the cabbage attributes, including its price and consumers' characteristics, including their budget constraints [69]. The tradeoffs consumers make is reflected in their WTP.

The WTP can be revealed through CV. In a CV, hypothetical markets are set up in which consumers' WTP for products (cabbage) are revealed by asking them directly how much more they would pay for a given change in the product's attributes or qualities [70]. Here, we used a modified double-bounded dichotomous choice framework (see [69]).

Given that the cost of producing cabbages using EFNs is about 10% more than without [60], a 10% premium was adopted as the lowest bid. Those who were willing to pay at least 10% more than the prevailing market value were presented with payment card questions to choose from: 11%–30%, 31%–50%, 51%–70% and more than 70%. Those respondents who declined the initial bid of 10%, were asked if they would pay something lower than 10%. The assumption of a double-bounded dichotomous approach is that the respondents' answers to both bids are driven by the same underlying WTP value and therefore the second bid can increase the information about respondents' true WTP [71]. The CV question was phrased as follows:

“Are you willing to purchase and consume cabbage if an increase of FCFA 20 (~10% of its current price) is required to support a policy that contributes to a continuous supply of cabbages with minimized pesticide residues?”

A negative response triggered the presentation of a lower bid while a positive response was followed by the presentation of a higher bid. Thus, following [72], possible combinations of responses were “no-no”, “no-yes”, “yes-no” and “yes-yes”.

We acknowledge the ongoing debate on the validity of stated preference methods such as the CV approach. Particularly the potential of a hypothetical response bias (potential difference between real and hypothetical payments) can lead to an overestimation of the WTP results [73–75]. While particularly true for public goods, the effect is much smaller for private goods [73,74] and hence this bias should be reduced in our case as respondents state their WTP for a private good (cabbage). When stating their WTP for private goods, respondents are not misguided by free-riding problems and positive sentiments [73,75]. For private goods, it has even been found that respondents understate their WTP to avoid higher payments in real settings [76]. Biases in stating the “true” WTP can also happen if respondents do not have complete knowledge about the good [74], a bias we reduced here by only including people who had previously purchased cabbage. Another factor leading to hypothetical bias is an apparent lack of consequences associated with a respondent's response [73,77]. This hypothetical bias was minimized in our study because the issues are consequential to respondents' own health and well-being and therefore no hypothetical bias should occur (see [78,79]). We did not apply approaches aimed at reducing hypothetical bias, such as cheap talk scripts and certainty adjustments for calibration of WTP estimates [75], because we were confident that bias was already minimized for the reasons noted above. We also reduced hypothetical bias by applying a double-bounded dichotomous choice question format [80].

### 2.5. Data Processing and Analysis

To determine the WTP and the factors that might influence these, we applied an ordered probit model. The dependent variable WTP was categorical and coded 0 to 3: 0 when the respondent declined to pay a premium (no-no), (1) when the WTP was positive and lower than 10% (no-yes), (2) when the WTP was 10%, the starting bid (yes-no), and (3) when the WTP was higher than 10% (yes-yes). In this study, no one was unwilling to pay a premium, even if less than 10%, and, consequently, the WTP was not censored (as opposed to, for instance, [47]). Because the dependent variable was ordered, we employed an ordered probit model.

The WTP model can be formulated as [73]  $WTP^* = \mathbf{X}'\boldsymbol{\beta} + \varepsilon$ , where  $WTP^*$  is the consumer's latent (unobserved) WTP for safe cabbage,  $\mathbf{X}$  is a vector of variables affecting the WTP,  $\boldsymbol{\beta}$  is a vector of parameters reflecting the relationship between WTP and variables in  $\mathbf{X}$ , and  $\varepsilon$  is the error term, normally distributed with mean of zero and a variance of one. If a consumer's unobserved WTP ( $WTP^*$ ) falls within a predetermined range, their WTP is assigned a numerical value that reflects the category within which lies their unobserved WTP.

If  $\gamma_{j-1} < WTP \leq \gamma_j$ , then  $WTP = j - 1$  for all  $j = 1, \dots, J$ , where  $j$  is the WTP category selected by the respondent and  $\gamma_k$  are category threshold parameters. As the dependent variable had five categories, four unobserved thresholds were expected:

$WTP = 0$  if a respondent is willing to pay a very low premium [ $WTP^* \leq \gamma_1$ ]

$WTP = 1$  if a respondent is willing to pay a low premium [ $\gamma_1 < WTP^* \leq \gamma_2$ ]

$WTP = 2$  if a respondent is willing to pay a medium premium [ $\gamma_2 < WTP^* \leq \gamma_3$ ]

$WTP = 3$  if a respondent is willing to pay a high premium [ $\gamma_3 < WTP^* \leq \gamma_4$ ]

$WTP = 4$  if a respondent is willing to pay a very high premium [ $WTP^* > \gamma_4$ ]

The probability (P) of a WTP being in one of the five finite categories can be written as:

$$P(WTP = j - 1) = \Phi(\gamma_j - \mathbf{X}'\boldsymbol{\beta}) - \Phi(\gamma_{j-1} - \mathbf{X}'\boldsymbol{\beta}) \quad \forall j \in J$$

where  $\Phi$  is the cumulative density function measuring the probability of WTP being less than the respective threshold level.

## 3. Results

### 3.1. Respondents' Socio-Demographic Characteristics

Eight interviews out of a total of 90 were incomplete because respondents did not fully understand the questionnaire and CV question, usually failing to complete the interview. These were not used in the analysis, leaving a final sample of 82 (Table 1).

**Table 1.** Sample description and explanatory model variables.

Explanatory Variable	Criterion	Criteria and Coding if Included in Model	Percentage of Respondents
Location	Residential location and level of urbanization	Cotonou-urban (1)	66
		Abomey-Calavi-regional (0)	34
Gender	Respondent's gender	Male (1)	45
		Female (0)	55
Age	Respondent's age	20–40 (1)	74
		41–60 (2)	26
		>60 (3)	0
Education	Respondent's level of education	No education (0)	10
		School in local languages (1)	25
		Conventional schooling (2)	65
Household size	Number of people in one household, all depending on one household-keeper	1 person (0)	21
		2–3 persons (1)	29
		4–5 persons (2)	18
		6–7 persons (3)	19
		8–9 persons (4)	7
		10 persons (5)	5
Income	Total annual income (in thousands) = Cash annually earned from all activities of the household members)	More than 10 persons (6)	1
		< FCFA 380 or < € 580 (1)	17
		between FCFA 380 and 1200 (2)	27
Wealth	Wealth class <sup>1</sup> (Financial and asset capitals owned)	> FCFA 1200 or > € 1830 (3)	56
		Poor (1)	32
		Middle (2)	44
Purchase frequency	Frequency of cabbage purchasing	Rich (3)	24
		At most twice a week (0)	87
Timeframe	The time at which respondent think they will be able to adjust their budget to pay a price premium for cabbage with minimized pesticides residues	More than twice a week (1)	13
		Immediately (1)	95
Budget allocation	Percentage of household vegetable budget allocated to cabbage	Later (0)	5
		< 25% (1)	57
		25% (2)	38
Place of purchase	Place where respondents buy cabbage	Between 26% and 50% (3)	5
		Farm gate	9
		Wholesalers	5
		Retailers	85
Recognize pesticide use	Respondents recognizing cabbage produced using pesticides	Others	1
		Yes	38
Attributes for recognition	Main attributes from which consumers recognize cabbage produced using pesticides	No	62
		Absence of damaged leaves	18
Net use awareness	Respondents are aware of farmers using nets to protect cabbage	Smell of pesticides or smell of rapid rotting	94
		Aware (1)	32
Pesticide use knowledge	Respondents knowing that farmers use pesticides when producing cabbage, even when protected by EFNs	Not aware (0)	68
		Yes (1)	79
Quantity	Respondents meeting required quantity of cabbage	No (0)	21
		Yes	98
Quality	Respondents meeting required quality of cabbage.	No	2
		Yes	11
Public policy opinion	Respondents' opinions about public policy of pesticides use in agriculture	No	89
		Agree	17
		Indifferent	15
		Disagree	68

Note: <sup>1</sup> Wealth was measured by four indicators; Poor = annual income less than € 580, low quality of housing, limited means of transport, few means to preserve fresh foods; Middle = annual income of between € 580 and € 1830, moderate quality of housing, improved means of transport, some means to preserve fresh foods; Rich = annual income greater than € 1830, modern housing, good means of transport, fresh foods readily preserved.

The sample was slightly biased towards women (55%). Respondents' age ranged between 20 and 60 years with a high share (74%) being between 20 and 40 years. The majority (65%) of respondents were educated at a formal school where French is the official language. Only 10% never attended a formal school, while the remainder were schooled in local languages. Household size ranged from 1 to 10 with



a relatively high share of respondents (21%) living alone. Half of the remainder lived in households of at most five members (the average national household size according to the Bureau of Statistics [63]) while the other half lived in large households with more than five members.

Seventeen percent of respondents said they had an annual income of at most € 80, for 27% it was between € 580 and € 1830, and the remaining 56% had an annual income of more than € 1830. Despite this income frame, 76% of the respondents described themselves as poor and 24% thought they belonged to the middle class. Almost all respondents (95%) devoted less than 25% of their vegetable budget to cabbage while the remainder estimated this proportion to be between 26% and 50%. Thirty-eight percent of the respondents said that they were aware of the use of EFNs in vegetable production.

### 3.2. Consumer Knowledge about Cabbage Quality

Only a few consumers (38%) were able to recognize cabbage that was treated with large amounts of synthetic pesticides (Table 1). They distinguished this cabbage by the smell of synthetic pesticides and the degree of leaf alteration. Consumers did not distinguish between smell and damage/spoilage and cabbage without spoilage was said to have a particular and unique smell. Cabbage leaves without holes were also associated with being treated heavily with pesticides. More than 80% of the consumers (Table 1) were aware of the health risk associated with intensive pesticide use in cabbage production.

### 3.3. Access to Cabbage and Purchase Decisions

Most consumers (88%) purchased cabbage at most twice a week for home consumption. The retailers were the main suppliers of the 85% of those consumers who allocated at most 25% of their food expenditure on cabbage (Table 1). Almost all respondents (98%) were satisfied with the quantity of cabbage they could buy but their satisfaction with cabbage quality was much lower, with 89% of respondents dissatisfied. Almost all consumers (94%) preferred safe cabbage, indicating a strong concern about health. A third were aware of EFN use to protect cabbage.

More than 80% of the consumers reported that freshness, number of holes in the leaves, price, size and color influenced their decision to purchase cabbage. Weight was also important to 78%, while smell, taste, texture, and origin were mentioned by 8%–26% of consumer (Table 2).

**Table 2.** Cabbage attributes influencing consumer purchase decisions (N = 82).

Explanatory variable	Criterion	Criteria and Coding	Percentage
Size	Size of cabbage is a differential criterion in cabbage choice	Yes (1)	84
		No (0)	16
Color	Color of cabbage is a differential criterion in cabbage choice	Yes (1)	94
		No (0)	6
Hole-free	Number of holes in cabbage is a differential criterion in cabbage choice	Yes (1)	95
		No (0)	5
Harmless	Respondents are aware of health risk associated with heavy use of synthetic pesticides	Yes (1)	18
		No (0)	82
Smell	Smell of cabbage is a differential criterion in cabbage choice	Yes (1)	91
		No (0)	9

**Table 2.** *Cont.*

Explanatory variable	Criterion	Criteria and Coding	Percentage
TaTaste	Taste of cabbage is a differential criterion in cabbage choice	Yes (1)	8
		No (0)	92
Freshness	Freshness of cabbage is a differential criterion in cabbage choice	Yes (1)	98
		No (0)	2
Spoilage	Level of spoilage is a differential criterion in cabbage choice	Yes (1)	87
		No (0)	13
Origin	Origin of cabbage is a differential criterion in cabbage choice	Yes (1)	74
		No (0)	27

### 3.4. Willingness to Pay for Cabbage with Minimized Pesticide Residues

On average, consumers were willing to pay a premium of 38% ( $\pm 30\%$ ) or € 0.44 for an average sized residue-reduced cabbage, with a range from 4% to 129% (Table 3). Almost half of the consumers (47%) were willing to pay a premium higher than 10% of the conventional price of cabbage (which is FCFA 233 or € 0.36 per head), 16% were willing to pay a premium of 10% (the threshold WTP) and the remaining 37% were willing to pay a premium of less than 10%.

**Table 3.** Respondents' mean and median willingness to pay (WTP) a premium for pesticide residues reduced cabbage (the current average price of cabbage is FCFA 233 or € 0.36) (N = 82).

	FCFA	Euro	% of Current Cabbage Price
Mean	89	0.14	38
Median	76	0.12	33
Std. Deviation	70	0.11	30
Minimum	9	0.01	4
Maximum	301	0.46	129

Note: € 1 = FCFA 656.

### 3.5. Factors Influencing Respondents' Willingness to Pay

Consumers' WTP for cabbage with minimized pesticide residues was affected by consumers' characteristics and awareness, household expenditure decisions, and cabbage characteristics (Table 4).

**Table 4.** Results of the ordered probit model (N = 82).

Variable	Coefficient	Stand Error	$p > Z$
Cotonou	1.32 **	0.63	0.035
Female	2.72 ***	0.80	0.001
Age	1.79 *	0.97	0.064
Education	1.24 **	0.52	0.017
Household size	-0.15	0.26	0.575
Income	0.19	0.43	0.656
Wealth	0.54	0.43	0.208
Pesticide awareness	-1.43 **	0.63	0.022

Table 4. Cont.

Variable	Coefficient	Stand Error	$p > Z$
Net use awareness	1.71 **	0.78	0.029
Budget allocation for cabbage	1.22 **	0.57	0.031
Purchase frequency	-0.15	0.24	0.542
Immediate availability	5.55 ***	1.86	0.003
Size	-1.80 *	1.01	0.075
Color	1.48	1.32	0.261
Hole-free	-1.11	1.65	0.499
Harmless	0.68	0.86	0.432
Taste	-3.57 ***	1.34	0.008
Freshness	1.87 **	0.83	0.024
Spoilage/Smell	-3.09 ***	0.98	0.002
Origin	0.84	0.69	0.221
$\gamma_1$	9.73	3.36	
$\gamma_2$	14.10	3.68	
$\gamma_3$	15.29	3.76	
$\gamma_4$	15.61	3.77	
R <sup>2</sup>		0.28	
Log likelihood		-77.2	

Note: \*\*\*: significant at 1 % ( $p < 0.01$ ); \*\*: significant at 5 % ( $p < 0.05$ ); \* significant at 10 % ( $p < 0.1$ ).

Age ( $p < 0.1$ ), being a woman ( $p < 0.01$ ), having a high level of education ( $p < 0.05$ ) and living in Cotonou ( $p < 0.05$ ) positively affected the WTP. Consumers' awareness of farmers using nets to protect cabbage also positively influenced their WTP ( $p < 0.05$ ) whereas pesticide awareness and WTP were negatively correlated ( $p < 0.05$ ). The more budget consumers allocated to purchasing cabbage, the higher their WTP ( $p < 0.01$ ). They were also willing to pay more for safe-to-eat cabbage that was immediately available ( $p < 0.01$ ).

Cabbage characteristics with a significant impact on the WTP were health-related variables such as taste ( $p < 0.01$ ), spoilage ( $p < 0.01$ ), freshness ( $p < 0.05$ ) and size ( $p < 0.1$ ). Whereas taste, spoilage and cabbage size had a negative influence on consumer WTP a premium, freshness had a positive effect. As respondents said that spoilage and smell were highly correlated, we only included spoilage as an explanatory variable in the model.

## 4. Discussion

### 4.1. Consumers' Willingness to Pay

We found that consumers in southern Benin are willing to pay, on average, a 38% premium for cabbage (that is 38% of the current market price of cabbage) with minimized pesticides residues. This WTP is high relative to values reported in developed countries. In the USA, 87% of consumers are reluctant to pay a price premium of more than 10% of the conventional price for pesticide-free fresh products [28]. Similarly, 68% of consumers in Italy are unwilling to pay a price premium higher than 10% for pesticide-free fresh fruits and vegetables [30] and consumer WTP a premium for organic products in Spain was  $< 25\%$  [23]. Moreover, these studies showed only 1% of American consumers [28] and 11%

of Italian consumers [30] would pay a premium price of more than 20% for pesticide-free fresh produce. Here, we found that 47% of Beninese consumers would pay a premium of more than 20%.

Our study is more in line with findings from similar studies in Benin and other developing countries. Two studies in Benin found that consumers are willing to pay an average premium of more than 50% for pesticide-free vegetables: for cabbage in the coastal regions of Porto-Novo, Cotonou, Ouidah, Lokossa and Grand-Popo [42] and for pesticide-free vegetables in Cotonou and Grand-Popo [65]. A study from Ghana [47] reported a mean WTP of a 30% premium for organic watermelons (€ 0.35 per kg for organic vs. € 0.27 for conventional watermelons) and about 560% for organic lettuce (€ 0.79 per kg for organic vs. € 0.12 for conventional). Other studies showed a WTP ranging from a 34% to a 66% premium for safe kale in Kenya [81] and a WTP a 70% premium for organic vegetables in Vietnam [66]. Results of a meta-analysis across 25 studies from developed countries and eight from China also demonstrated a higher WTP for organic food products [82].

This higher WTP among consumers in developing countries may be explained by the urge to purchase healthy and safe fresh food, with non-regulated abuse of pesticide use being a more severe problem there than in developed countries. In Benin, repeated and increasing poisoning from fresh food produced in cotton production areas is often reported in local mass media. This publicity and associated concerns over health has probably helped raise awareness among consumers and raised their high WTP for safe food.

#### 4.2. Demographic Effects

The coefficient for gender was highly significant ( $p < 0.01$ ) with women being more likely to pay a premium. In Benin, as in many other countries, women buy most groceries for their households [33,44] and, while men tend to provide the income, women tend to manage household health issues [83]. Results from other studies are mixed. Some found no gender differences in WTP for healthy or organic fresh food [46,47] while others reported that women would pay more than men, e.g., for organic apples in the USA [24] and Europe [33] and for organic chicken meat in the USA [27].

Age was also significant, indicating that older consumers would pay more, a finding consistent with one study [27] but not others who found that age was not a significant determinant of WTP for premium fresh foods [33,38,46,47]. The positive relationship between age and WTP for healthy fresh food could be because older people were more concerned about health [75].

We also found that better educated consumers were willing to pay higher premiums, consistent with studies from Taiwan for vegetables with minimal pesticide residues [38] and from Vietnam for organic vegetables [66].

While, as reported elsewhere [33,42], household size was not significant, the lack of significant impact of income and wealth class on consumers' WTP (Table 4) was more surprising. While our results did not match those of [65], who concluded that income negatively influences Beninese WTP for pesticide-free cabbage, they do suggest that demand for healthy cabbage extends to all households, not only the richer ones. Given that studies from both developed [27,28,30] and less developed [43,45] countries have found that WTP for organic and "safe" foods is significantly and positively related to income, the lack of relationship in Benin suggests that either the health risk from cabbages is thought to be higher in Benin or concerns about health are greater than in other countries where such studies have been undertaken.

### 4.3. Effect of Location

Respondents from the more urbanized Cotonou were willing to pay more than those from less urbanized Abomey-Calavi. This finding could be the result of increasing sensitization of the Beninese population concerning the impacts of pesticides on health that is taking place in Cotonou through various advertising and campaigns conducted by NGOs and the government. These initiatives include household visits, strategic groups meetings and communication via mass media.

### 4.4. Effects of Cabbage Purchase Behavior

Demand for cabbage in general, and even more so for healthy cabbage, can be expressed through the frequency with which it is purchased, the quality of the cabbage attributes and the price the consumers are willing to pay for cabbage of the desired quality. Although the frequency of cabbage consumption was not found to be a significant indicator of consumers' WTP, this can be because the frequency of purchasing cabbage is highly dependent on the supply of cabbage of desirable quality. While cabbage is an exotic vegetable that has only recently been introduced to many parts of Africa [84], demand is believed to be increasing [84,85]. Thus, consumer demand for cabbage that is healthy and safe to eat may be much higher than is currently the case with respondents saying that, while they could get enough cabbage, it was often not of the quality they desired (Table 2). Indeed, the strong influence of "Immediate availability" on the WTP suggests that consumers would probably already be paying price premiums if safe fresh produce was more readily available.

### 4.5. Effects of Cabbage Attributes

For at least 90% of the consumers, the decision to purchase a cabbage is guided by its freshness, extent of spoilage, color and smell (Table 2), in line with other studies [44,65,86–88]. Cleanliness and being pleasant to the eye have been reported as the main attributes guiding consumers' decisions in purchasing vegetables [86]. In terms of WTP, three of the four important attributes related to sensory appearance characteristics: spoilage, cabbage size and freshness (Table 4), in line with other studies [42,47], with freshness being particularly important [47,65]. The negative sign for cabbage size, although also reported elsewhere [47], was surprising. One reason could be that consumers associate bigger cabbage size with the use of pesticides, and not with cabbage locally produced by farmers using EFNs, *i.e.*, consumers may not believe that large cabbages of bigger size can be produced without excessive use of pesticides.

The fourth attribute that highly influenced consumers WTP was taste. Sensory attributes such as smell and taste are important determinants for respondents to identify healthy and safe to eat cabbage. Bad taste and smell are indicators of contamination with pesticide residues or that the cabbage is starting to rot. Judging the extent of pesticide residue in cabbage by its taste and smell is important for consumers because most farmers in Benin ignore the re-entry and withholding periods after spraying of pesticides [11], harvesting their cabbage so soon after spraying that the smell can be detected by consumers. When farmers comply with the withholding period, however, the smell may no longer be detectable, making it difficult for the consumers to assess whether pesticides have been applied inappropriately.

The origin of cabbage was not a criterion for paying a premium for fresh foods, unlike in many developed countries in which the origin, if labelled appropriately, can indicate a particular taste,

production method or ethnocentrism associated with a region. Consumers in developed countries prefer products from their home country or region [89,90], as shown by their higher WTP [35,36,91,92]. Consumers in Tanzania, on the other hand, would not pay more for food that is from Tanzania compared to other countries [43], which is in line with our results. This difference between developed and developing countries could be because of labelling and awareness for regional products.

#### 4.6. *Effects of Awareness and Knowledge*

Awareness frequently determines preference and WTP for premium fresh foods. This includes awareness of chemical residues and health risks [42,65] and concern about a healthy diet and environmental degradation [28]. Here, we found that consumers who were aware that EFNs had been used by farmers as an alternative to excessive pesticide use were more likely to pay a premium.

Given this positive relationship between awareness and WTP, there is merit in increasing awareness that farmers using EFNs use less pesticide to grow their cabbages and that consumers may avoid health problems by purchasing such cabbages. For instance, consumer behavior and WTP may be affected by taking samples of pesticide residues in vegetables just before harvest and making these results publicly available, as was done recently in southern Benin [93]. This could also overcome a lack of trust among consumers, which is evident from our study in the lower WTP among consumers who know that farmers producing cabbages under EFNs do still use small quantities of pesticide to control small insects such as aphids that pass through the net mesh. We think that the lower WTP was because consumers did not believe that the farmers who use EFNs also do not use a lot of pesticides. A similar study [47] also found that consumers who are aware of chemical residues in conventional vegetables are willing to pay less for organic lettuce and watermelons in Ghana, also possibly for lack of trust.

Despite the increasing sensitization of consumers to the use of pesticide, particularly in the urban center of Cotonou, our results show there is a lack of knowledge about the impacts of pesticide and pesticide residues in fresh foods. As a result, while consumers may prefer pesticide free cabbage, they may not have the skills needed to recognize the pesticide residue status of cabbage—indeed they may not be recognizable without chemical analysis that will be beyond the capacity of household consumers. This points to a role for government or NGOs in analyzing and publicizing the pesticide status of the EFN and non-EFN cabbages.

#### 4.7. *Policy Implications*

Cabbage is an exotic vegetable and not yet widely consumed in Benin (~30% of the households). Our results indicate that consumers are not satisfied with the current quality of the cabbage, which is likely to hamper higher levels of consumption. One efficient policy could be to apply minimum quality/safety standards on markets in Benin and enforce a ban on all vegetables that do not meet these standards [87]. While this intervention could be costly for society, as it increases the cost of production and prohibits consumer choice [94], this may be balanced by lower health costs and increased economic productivity from healthy workers.

We discovered a relatively high WTP for health-related attributes. Health concerns from pesticide residues in vegetables in developing countries are growing and should be supported by government subsidies or, integrated into markets by higher premium prices generated through appropriate labelling

and marketing. We also showed that not all consumers could distinguish between cabbage contaminated by pesticides and those not. Labelling healthy fresh food would therefore help those who wish to buy healthy food. Setting up and marketing using certified labels will require government support, as would the setting up of niche markets. Initially these could be in the form of special zones in conventional markets where only healthy fresh products are sold, although the cost of establishing a labelling system would need external subsidies until costs can be covered by sales. This could be through credits to vegetable farmers' cooperatives from government, NGOs or international donors.

In addition to a need for appropriate labeling and the absence of niche markets, farmers need to be better educated about alternative sustainable gardening practices and the right way to apply pesticides. Farmers who used EFNs were part of a broader project, but once this project has finished, there is no ongoing support and service for farmers to increase awareness of the negative use of pesticides for themselves and consumers, and to learn new practices. Again, government, private or NGOs will need to continue promulgation of new sustainable practices such as EFNs. Currently the information conveyed to farmers is that good yields and vegetables without heavy damage can only be produced by using pesticides. Thus, most farmers will continue to use pesticides with little regard for regulations recommended by the CNAC in application of Rotterdam and Stockholm conventions [95,96]. Another sustainable alternative, botanical pesticides, of which a few are registered and were traditionally produced from local raw materials, is no longer possible in peri-urban environments because they have already been over-exploited [20].

Once there is a market for healthy cabbage, farmers should be able to make a living by selling cabbage produced using EFNs at a price at least 10% higher than the current price for conventional cabbage. Almost half of the consumers (47%) are willing to pay a premium higher than 10% of the conventional price of cabbage, suggesting there is a market opportunity for farmers, as the additional costs for farmers to produce cabbage using nets is assumed to be 10% higher [60]. However, while this premium should be enough for farmers to produce cabbage with the attributes desired by consumers, it also highlights a role for outside agencies in ensuring compliance with any labelling that occurs. If a premium is indeed generated by EFN cabbages, consumers may only trust labelling, and pay the premium, if they are confident that non-EFN cabbages are not being fraudulently mislabelled to benefit from the EFN premium. The actual premium paid by consumers will thus be a trade-off between their desire for a healthier product and the level of trust that the more expensive product they are purchasing does indeed comply with its label.

## 5. Conclusions

This study assessed consumers' perceptions of and purchasing behavior towards "healthy" and "eco-friendly" cabbage in southern Benin. Smell, freshness, and taste were the main factors affecting a decision to purchase. All interviewed consumers are willing to pay a price premium of at least 10% and, in most cases, 20%–70% on top of the actual cabbage prices if the cabbage was produced with minimized pesticide use. Those consumers who detect the impacts of pesticides on cabbage (pesticide-related spoilage and alterations in taste/smell) are willing to pay less whereas highly educated women and older consumers are willing to pay the highest premiums. Consumers in the capital of Benin would also pay more than those in the more regional areas of the country because they are increasingly sensitized to the

impacts of pesticides on their health. Similar to studies on organic food and food labelling from developed countries, we recommend the establishment of niche markets and eco/organic labelling for vegetables that are produced without or minimal pesticide use. This will increase the amount of information and knowledge for pesticide-free food and help those consumers who cannot distinguish “pesticide-free” from conventional vegetables. In turn, higher prices for vegetables will allow urban farmers to invest more in sustainable farming technologies such as nets used as physical barriers to insecticides.

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### Author Contributions

Faustin Vidogbéna had the original idea for the study and, with all co-authors carried out the design with the help of Anselme Adégbidi, Laurent Parrot, Serge Simon, Thibaut Martin and Rigobert Tossou. Faustin Vidogbéna, Anselme Adégbidi, Mathieu Ngouajio, Françoise Assogba-Komlan and Laurent Parrot were responsible for carrying out the field work. Faustin Vidogbéna was responsible for data cleaning and analyses. Faustin Vidogbéna, Laurent Parrot and Kerstin K. Zander drafted the manuscript, which was revised by all authors. All authors read and approved the final manuscript.

### Conflicts of Interest

The authors declare no conflict of interest.

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