

MODELING CONSUMER PURCHASE INTENTIONS FOR PLANT FACTORY PRODUCTS USING LOGISTIC REGRESSION (Permodelan Regresi Logistik untuk Niat Pengguna Membeli Produk Kilang Tanaman)

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ABSTRACT

A plant factory is a closed-growing system that allows farmers to control growing conditions and ensure safer vegetables without pesticides. However, to maximise the success of the plant factory, it is critical to discover the aspects regarded as relevant by consumers when purchasing vegetables and fruits. This study uses the logistic regression model to explore the market potential of curly kale and strawberries cultivated in plant factories by determining the factors influencing the consumer intention to purchase plant factory products. Data were collected through a structured face-to-face survey in two phases in 2022 (curly kale) and 2023 (strawberry). A total of $n = 558$ in phase one and $n = 438$ in phase two were randomly selected in urban areas across Malaysia. The result of this study explains that socio-demographic factors such as household income, plant factory consumers, lifestyle diets and consumer concerns about pesticide-free positively influence the consumer intention to purchase plant factory curly kale. Meanwhile, the logistic regression model also revealed that socio-demographic factors such as age and household size, selected attributes (taste and colour) and consumer knowledge of plant factories significantly influenced consumer intention to purchase plant factory strawberries. This study has practical consequences, particularly for individuals or businesses interested in introducing the notion of a plant factory in Malaysia. These models' significant factors can be employed to establish the value proposed to the client as well as the marketing strategy for plant factory producers.

Keywords: logistic regression; purchase intention; plant factory; curly kale; strawberry

ABSTRAK

Kilang tanaman ialah sistem penanaman tertutup yang membolehkan petani mengawal keadaan pertumbuhan tanaman dan memastikan sayur-sayuran yang lebih selamat tanpa penggunaan racun perosak. Walau bagaimanapun, untuk memaksimumkan keuntungan kilang tanaman, adalah penting untuk mengenal pasti aspek yang dianggap relevan oleh pengguna semasa membeli sayur-sayuran dan buah-buahan. Kajian ini menggunakan model regresi logistik untuk meneroka potensi pasaran kailan kerinting dan strawberi yang ditanam di kilang tanaman dengan menentukan faktor-faktor yang mempengaruhi niat pengguna untuk membeli produk kilang tanaman. Data dikumpul melalui tinjauan secara bersemuka dalam dua fasa pada tahun 2022 (kailan kerinting) dan 2023 (strawberi). Sebanyak $n = 558$ responden dalam fasa pertama dan $n = 438$ dalam fasa kedua telah dipilih secara rawak di kawasan bandar di seluruh Malaysia. Hasil kajian ini menunjukkan bahawa faktor sosio-demografi seperti pendapatan isi rumah, pengguna kilang tanaman, diet gaya hidup, dan keprihatinan pengguna terhadap produk bebas racun perosak secara positif mempengaruhi niat pengguna untuk membeli kailan kerinting dari kilang tanaman. Sementara itu, model regresi logistik juga menunjukkan bahawa faktor sosio-demografi seperti umur dan saiz isi rumah, atribut terpilih (rasa dan warna), serta pengetahuan pengguna tentang kilang tanaman secara signifikan mempengaruhi niat pengguna untuk membeli strawberi dari kilang tanaman. Kajian ini mempunyai implikasi praktikal, terutamanya untuk individu atau perniagaan yang berminat memperkenalkan konsep kilang tanaman di

Malaysia. Faktor signifikan daripada model ini boleh digunakan untuk menetapkan cadangan kepada pengguna serta strategi pemasaran bagi pengeluar kilang tanaman.

Kata kunci: regresi logistik; niat pembelian; kilang tanaman; kailan kerinting; strawberi

1. Introduction

There are a growing number of varieties of edible plants on the market due to consumer desire for food that is nutritious, safe, and healthy. Plant factory products are new plant products that has been introduced to Japan and certain Western countries in recent years. These products are pesticide-free and can be eaten straight out of the package without needing to be washed (Japan Plant Factory Association 2012).

A plant factory is a vegetable production system that operates throughout the year in a closed building (indoor system). This cultivation technology is one of the latest cultivation methods that is important to overcome the problem of a food shortage in the world. This technology can be used to produce food crops with the use of artificial lighting systems. In general, plant factories belong to the concept of smart farming under the scope of urban agriculture (Sayuti 2022). This concept of food production is oriented towards a commercial industrial scale implemented in urban areas. The main benefits of plant factory technology are for food security and a stable food supply. It can overcome the problems of mounting reduction of agricultural workers, the low quality of vegetables produced due to abnormal weather from the impact of global warming and food shortages due to the growing population. Plant factories that use vertical farming technology can increase the efficiency of water and nutrient use through the control of environmental factors (Benke & Tomkins 2017).

According to Kozai *et al.* (2019), a plant factory refers to a vegetable production facility inside a building that is equipped with structures such as thermal insulation and almost all factory areas are airtight. Requirements such as light, temperature, humidity and carbon dioxide are fully controlled with limited land use compared to conventional cultivation. The plant factory concept first appeared in Northern Europe and has been commercialized on a large scale in Japan. There are now more than 400 plant factories in the world and the majority are implemented in Japan (Japan Plant Factory Association 2012). Plant factories can be built in any location and building because they do not require sunlight or the use of natural land. Interestingly, the productivity of the crop does not depend on the external climate and soil fertility because it is a controlled environment concept. Plant factories play an important role in the production of nutritious and safe local vegetables for domestic consumption in big cities (Newbean Capital 2016).

A survey by Yano *et al.* (2016) on the functional and high-value-added plant factory market in the future has identified the trend of planting and producing plants in the plant factory by growing functional or high-value plants. The high-value crops for example medicinal plants and functional vegetables are trends and prospects for leading companies and academic institutions based on the global market.

However, to maximise the success of the plant factory, it is critical to discover those aspects regarded as relevant by consumers when purchasing vegetables and fruits. This study aims to explore the market potential of curly kale and strawberries cultivated through a sustainable plant factory production system by determining the factor that influences the consumer's intention to purchase plant factory products.

2. Literature Review

2.1. Plant factory products

The plant factory system based on smart agriculture is expected to be able to increase the production capacity per unit area from four to six times (Sayuti 2022). In fact, smart agriculture technology is one of the most revolutionary and interesting fields of modern technology (Khan *et al.* 2020). Selected leafy vegetables and herbs are a priority to be implemented in plant factories to strengthen the market (Liaros *et al.* 2016). Among the examples of vegetables that can be grown in the plant factory are lettuce (raddichio, wild arugula, butterhead, red green coral), baby spinach, kailan, tomatoes, strawberries and herbs (basil, chervil, curly endive and rosemary). Based on a market survey of premium products, the price of vegetables from this premium category can provide good returns to entrepreneurs and can even reach the price of RM80/kg to RM 90/kg (Ahmad *et al.* 2024). Several market players that are suppliers of plant factory products at the global level that have been identified include AeroFarms (US), BrightFarms (US), Bowery Farming (US), Gotham Greens (US), Mirai Co. Ltd. (Japan), Kalera (Norway), Farminova (Turkey), Agricol (France) and Crop One (UAE). At the local level, the leading market players are Sunway Future X Farm, Sustenir, Boomgrow and Vegetory (Sayuti 2022).

2.2. Consumer purchase intention

As mentioned earlier, the important benefits of plant factories are that the products are pesticide-free and safe to consume. Therefore, these factors may be used to advertise and could be the selling point for the plant factory products marketing. However, as mentioned in various literature other factors could influence the consumer intention to purchase the plant factory products. Vegetable consumers are the most concerned about environmental degradation and food safety. Some of them perceived plant factory vegetables as organic vegetables although they do not meet the organic requirements. Furthermore, consumers are more likely to be concerned about the impacts of using plant factory farming in the long term, such as electricity overuse, microorganism contamination, and low nutritional value (Huang 2019). Another common concern by consumers is price (Watanabe 2010). Since plant factory vegetables are more expensive than conventional, consumers are reluctant to buy unless the price is equal to the conventional. Noor *et al.* (2024) has categorized vegetable consumers into three categories: 1) quality-minded, 2) appearance focused 3) price-conscious. The quality-conscious consumers are typically safety-conscious and not particularly concerned about price. In addition, they prioritize quality by ensuring that products have certified labels. The second group of consumers is primarily preoccupied with the aesthetic aspects of the product, particularly the visual appearance of its leaves. The last category of consumers consists of the majority of those who prioritize price and actively seek the most affordable option available.

3. Research Methodology

3.1. Data collection

This study used quantitative methods and collected primary data through structured face-to-face interviews with $n = 558$ consumers between May 2022 and September 2022 (phase 1) and $n = 438$ consumers between May 2023 to September 2023 (phase 2). The consumer survey's target respondent consisted of Malaysians aged 18 and older who are responsible for their families' food purchases. Individuals were chosen by a random sampling methodology to ensure

the sample's applicability. Urban dwellers were polled in Klang Valley, Johor Bahru, Georgetown, and Kota Kinabalu. These cities were chosen based on the largest metropolitan areas and their high population in Malaysia (Department of Statistics Malaysia 2023). Meanwhile, most plant factories are also concentrated in these cities (Ahmad *et al.* 2024).

The survey method was used to collect data, which is a systematic approach to gathering data from a large number of people using questionnaires. As a result, personal interviews were conducted, utilizing questionnaires to the selected sample. The survey was conducted using street-intercept survey technique. Street-intercept surveys collect samples in areas such as marketplaces, transportation hubs, side-of-the-road vendors, shopping centres and other crowded places where people are probably to be found (Agyemang *et al.* 2023). In this study, supermarkets were chosen as the location to conduct a survey because it is easier to set up samples, less expensive and more appropriate in terms of representativeness within the intended scope of the research (Bruwer *et al.* 1996).

The participants were asked about their demographics, consumption habits, and attitudes towards fresh vegetables, as well as their thoughts and attitudes concerning vegetables cultivated in plant factories and their willingness to purchase. To assure validity and reliability, the questionnaire's instruments and measurement items were modified from previous research and models (Masdek *et al.* 2023). Furthermore, in order to make the current research easier, implementation that had proven successful in past studies was used. Participants typically completed surveys in about 10 to 15 minutes.

The ethical underpinning of any research involving human participants is built on principles that prioritise their rights, well-being, and privacy. In interview-based studies, where personal information is frequently revealed, maintaining secrecy becomes critical. At the start of the interview, a robust informed consent process was followed. This included explicitly describing to participants the nature of the study, its objectives, and specifics about data collection, storage, and data usage. The ethical issues are considered to protect the privacy and confidentiality of the data.

3.2. Data analysis

The descriptive analysis method was performed for initial analysis to understand the data and determine the purchasing behaviour of plant factory products in Malaysia. The logistic model was used in this study to discover determining characteristics such as socioeconomics and demographic factors that explain the intention to purchase plant factory curly kale and strawberry. In this study, SPSS version 26 was used to analyse the respondent's intention to purchase using binary logistic regression. Logistic regression is a type of multivariate regression that allows numerous independent variables to predict a binary dependent variable. A binary dependent variable can only take the value of 0 or 1 at each observation typically it is a coding of something qualitative. The main advantage of logistic regression is its versatility with different types of independent variables. For example, the independent variables can be continuous, discrete, or a combination of the two (Speelman 2014). Logistic regression analysis is inherently unaffected by whether the independent variables are qualitative, quantitative, or categorical. As a result, logistics regression can help researchers evaluate binary and categorical data more effectively and normal distribution assumptions are not required (Bender & Grouven 1998; Berezka *et al.* 2022).

The logit model includes a cumulative probability function that can deal with a dependent variable to determine whether an event will occur or not by predicting a binary dependent result from a set of independent variables (Starovoytova & Namango 2018). The logistic regression

model or logit model to identify consumer's intention to purchase for plant factory products can be stated as:

$$Y = \frac{1}{1 + \exp^{-Z}} \quad (1)$$

where

Y = Response of respondents' intention to purchase (Yes = 1 or No=0)

Z = summation of explanatory variables multiplied by their coefficients as stated in Eq. (2).

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k + \varepsilon_i \quad (2)$$

where

β_0 = the intercept which is constant

$\beta_1 + \dots + \beta_k$ = coefficient of the explanatory variables

$X_1 + \dots + X_k$ = set of explanatory variables

ε_i = error term

$i = 1, 2, 3, \dots, n$

n = number of observations

k = number of predictor/factor (independent variables).

The list of the factors under investigation are listed in Table 1.

Table 1: List of variables used in this study

Factor	Item
a) Socio-demographic	Gender, age, household income, household size
b) Psychological	Knowledge of plant factory
c) Lifestyle	Plant factory consumer, organic consumer, strawberry lover, lifestyle diet (vegetarian, keto diet, etc)
d) Product quality and attribute	Nutritional value, pesticide-free, taste and color of the product

4. Result and Discussion

4.1. Respondent profile

Table 2 provides sociodemographic information for the respondents in Phase 1 and Phase 2. The research was conducted in Phase 1 and involved 558 respondents. The proportion of male respondents was 41.9%, whereas female respondents constituted 58.1% of the total. Around 37.4% of the participants fell between the age range of 31 to 40. Malays constituted the largest proportion of respondents, accounting for 70.6 %, followed by Chinese at 20.6 %. Indians and other ethnicities made up the remaining 3.4 % and 5.4 %, respectively. The survey results indicate that 72.9% of the participants have a tertiary education. In addition, the proportion for secondary school was 25.1%. The majority of respondents reported a monthly income ranging from RM2,560 to RM4,310, accounting for 26.4% of the total. Approximately 18.8% of the respondents had a monthly income ranging below RM2,560.

Meanwhile, Phase 2 of the survey had 438 participants. Female respondents account for 66.2% of the total, while male respondents make up 33.8%. The majority of the respondents are below 40 years old (18-30, 32.6% and 31-40, 32.4%). Malays formed the biggest proportion of respondents, accounting for 70.1%, followed by Chinese (20.5%). Indians and other ethnicities accounted for the remaining 2.1% and 7.3%, respectively. The survey results show that 68.5% of participants have a tertiary education. Furthermore, secondary school accounted for 28.3%. Most of the respondents reported a monthly income between RM2,560 and RM4,310, accounting for 28.8% of the total. Approximately 23.5% of respondents reported a monthly income of less than RM2,560.

Table 2: Socio-demographic profile

Demographics		Category	Phase 1 (number of repondents, <i>n</i> =558)		Phase 2 (number of repondents, <i>n</i> =438)	
			<i>n</i>	%	<i>n</i>	%
a)	Gender	Male	234	41.9	148	33.8
		Female	324	58.1	290	66.2
b)	Age	18-30	155	27.9	143	32.6
		31-40	208	37.4	142	32.4
		41-50	133	23.9	84	19.2
		51-60	41	7.4	47	10.7
		61 or older	19	3.4	22	5.0
c)	Ethnicity	Malay	394	70.6	307	70.1
		Chinesse	115	20.6	90	20.5
		Indian	19	3.4	9	2.1
		Others	30	5.4	32	7.3
d)	Educational background	Primary education	8	1.4	10	2.3
		Secondary equation	140	25.1	124	28.3
		Tertiary education	407	72.9	300	68.5
		Others	3	0.6	4	0.9
e)	Household income	Below RM 2,560	101	18.8	103	23.5
		RM2,560 to RM 4,310	142	26.4	126	28.8
		RM 4,310 to RM 5,250	76	14.1	59	13.5
		RM 5,250 to RM 7,690	70	13.0	50	11.4
		RM 7,690 to RM 11,820	99	18.4	71	16.2
		RM 11,820 or more	50	9.3	29	6.6
f)	Household size	1 people	37	6.7	38	8.7
		2-3 people	176	31.6	140	32.0
		4-5 people	245	43.9	193	44.1
		More than 6 people	99	17.8	67	15.3

^aSource: Author's calculation

4.2. Factor affecting consumer purchase intention for curly kale

The binary logistic regression model shows that the omnibus test of the model coefficient was significant ($p = < 0.001$). The Hosmer-Lemeshow statistic on the other hand indicates a poor fit if the significance value is less than 0.05. Here, the model adequately fits the data. Meanwhile, the results from the Nagelkerke *R* Square test show that 26.5% of the variation in the intention to purchase plant factory curly kale can be explained by this binary logistic model.

Findings from the model showed that household income, plant factory consumers, organic consumers, and the consumers that were concerned with pesticide-free products, were significant affecting consumer purchase intention for curly kale (Table 3). Furthermore, this model also shows that the lifestyle diet also significantly affects consumer purchase intention to purchase plant factory curly kale. In the model, respondents in higher income groups were

more likely to have intent to purchase plant factory curly kale (OR: 1.00). This is because plant factory vegetables are more environmentally friendly or safer for human health compared to those produced by growing on the ground even though they are considered more expensive (Huang 2019).

The result shows respondents who were consuming plant factories and organic vegetables were more likely to purchase plant factory (OR: 1.90 and 3.93 respectively). Respondents who practice a healthy lifestyle such as keto-diet (OR: 7.32), vegetarian (OR: 3.29), are more likely to buy plant factory curly kale compared to a non-specific diet (OR: 2.92) which is due to a smaller OR value. The reason why respondents who practice a healthy life intend to buy a plant factory is because the vegetables are grown in a plant factory that does not use any pesticides, organic or chemical (Haghjou *et al.* 2020). After all, the plants are grown in a closed environment and are not harmful.

Table 3: Result of the binary logistic regression for factors affecting consumer intention to purchase plant factory curly kale

	B	Standard Errors	Wald	Sig	OR
a) Household income***	0.000	0.000	7.592	0.006	1.000
b) Plant factory consumer***	0.644	0.319	4.087	0.043	1.904
c) Organic consumer***	1.368	0.225	36.982	0.000	3.929
d) Pesticide-free product***	2.137	0.552	14.980	0.000	8.475
e) No sepcific diet**	1.071	0.507	4.462	0.035	2.918
f) Vegetarian**	1.192	0.584	4.160	0.041	3.294
g) Keto-diet**	1.990	1.007	3.908	0.048	7.317
h) Constant***	-2.476	0.552	20.146	0.000	0.084

Omnibus test: $\chi^2 = 121.856$ (df=7, p-value<0.001)

Hosmer and Lemeshow test: $\chi^2 = 6.559$ (df=8, p-value > 0.05)

-2log likelihood = 636.237, Nagelkerke R Square = 0.265

,* significance at $\alpha = 0.05, 0.01$

Source: Author's calculation

4.3. Factor affecting consumer purchase intention for strawberry

The analysis of the factors influencing consumer purchase intention for strawberries uses binary logistic regression analysis. The omnibus test of the model coefficient was significant ($p = < 0.001$). Moreover, The Hosmer-Lemeshow statistic also indicates the model adequately fits the data. Meanwhile, the results from the Nagelkerke R Square test show that 13.8% of the variation in the intention to purchase plant factory strawberries can be explained by this binary logistic model.

The logistic regression model showed that age, household size, the taste of the strawberry, the color of the strawberry, and knowledge of the plant factory were significant and independent affecting consumer purchase intention for strawberries (Table 4). In the model, the more age of the respondents the more likely was the intention to purchase plant factory strawberries (OR: 1.02). The size of the household is one of the important factors, the more family members the less the respondent's intention to buy a strawberry plant factory taking into account that probability the price of strawberries is quite expensive if bought in large quantities (OR: 0.86). The taste of strawberry sweetness was an important factor for the respondents to consider purchasing or not the strawberry. Respondents who consider the taste of strawberries that are grown in a plant factory will less likely intend to buy a strawberry factory plant (OR: 0.483). In terms of the color of the strawberry, the respondents are most likely to buy strawberry factory plants because the plants' factory products were perceived as having a good appearance, fresher

or higher quality (OR: 1.66) (Huang 2019). Respondents who have knowledge about plant factories will more likely intent to buy plant factory strawberry (OR: 2.03).

Table 4: Result of the binary logistic regression for factors affecting consumer intention to purchase plant factory strawberry

	B	Standard Errors	Wald	Sig	OR
a) Age**	0.022	0.009	5.990	0.014	1.022
b) Household size***	-0.151	0.061	6.061	0.014	0.860
c) The taste of the strawberry	-0.729	0.262	7.743	0.005	0.483
d) The color of the strawberry	0.508	0.210	5.885	0.015	1.663
e) Knowledge of plant factory	0.706	0.153	21.184	0.000	2.026
f) Constant	-2.997	0.754	15.794	0.000	0.050

Omnibus test: $\chi^2 = 47.529$ ($df=7$, $p\text{-value} < 0.001$)

Hosmer and Lemeshow test: $\chi^2 = 9.040$ ($df=8$, $p\text{-value} > 0.05$)

-2log likelihood = 550.238, Nagelkerke R Square = 0.138

,* significance at $\alpha = 0.05, 0.01$

Source: Author's calculation

5. Conclusion

The result of this study demonstrates that, socio-demographic factors such as household income, plant factory consumers, lifestyle habits, and consumer concerns about pesticide-free have a favorable influence on consumer intention to purchase plant factory curly kale. Meanwhile, the logistic regression model demonstrated that socio-demographic parameters such as age and household size, selected features (taste and colour), and consumer understanding of plant factory strawberries all had a significant influence on consumer intention to buy plant factory strawberries. This study has practical implications, particularly for people or businesses looking to introduce the concept of a plant factory in Malaysia. The main components in these models can be used to determine the value proposition to the client as well as the marketing strategy for plant factory producers.

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