

กลยุทธ์การตลาดและการแบ่งส่วนตลาดลูกค้าสำหรับผลิตภัณฑ์ถ่านขาว มูลค่าเพิ่มจากวัสดุเหลือใช้ทางการเกษตร

Marketing Strategies and Customer Segmentation for Value-Added White Charcoal Products from Agricultural Waste

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Received : August 13, 2025 Revised : October 16, 2025 Accepted : October 21, 2025

บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์หลัก 2 ประการ ได้แก่ (1) เพื่อสำรวจความพึงพอใจและความต้องการของผู้บริโภคที่มีต่อถ่านขาวและผลิตภัณฑ์มูลค่าเพิ่มที่ผลิตจากวัสดุเหลือใช้ทางการเกษตร (2) เพื่อระบุและจำแนกกลุ่มผู้บริโภคที่มีความต้องการแตกต่างกัน โดยใช้เทคโนโลยีเดาเฝ้าแบบสองห้องพร้อมระบบแกชปีเคชัน ที่ควบคุมด้วยเทคโนโลยีอินเทอร์เน็ตของทุกสรรพสิ่ง (Internet of Thing: IoT) ในพื้นที่ภาคเหนือตอนบน การศึกษานี้มุ่งแก้ไขปัญหาค่าความท้าทายในการยอมรับของตลาดสำหรับผลิตภัณฑ์ดังกล่าวจากแนวทางแก้ปัญหาในพื้นที่ที่ยั่งยืน เพื่อให้บรรลุวัตถุประสงค์ จึงได้ใช้วิธีวิจัยแบบผสมผสาน (Mixed Methodology Research) โดยการวิเคราะห์เชิงคุณภาพด้วยการวิเคราะห์ข้อมูลจากผู้ตอบแบบสอบถาม 74 คน กับข้อมูลเชิงปริมาณจากแบบสำรวจ รวมถึงการวิเคราะห์แบบ Discrete Choice Experiment (DCE) และการสร้างแบบจำลอง Latent Class Model (LCM) ผลการศึกษาตอบวัตถุประสงค์ข้อที่หนึ่ง พบว่า ความพึงพอใจโดยรวมมีค่าเฉลี่ยอยู่ที่ 4.1 ± 0.6 โดยปัจจัยด้านความปลอดภัย (4.5 ± 0.4) ประสิทธิภาพ (4.4 ± 0.5) และความสะดวกในการใช้งาน (4.3 ± 0.5) ได้รับการให้คุณค่าเป็นปัจจัยระดับสูง และเพื่อตอบวัตถุประสงค์ข้อที่สอง ผลการศึกษาพบว่ากลุ่มผู้บริโภคสำหรับผลิตภัณฑ์ถ่านขาวที่แตกต่างกัน 3 กลุ่มที่แตกต่างกัน ซึ่งแต่ละกลุ่มมีความต้องการและระดับความเต็มใจที่จะจ่าย (Willing To Pay: WTP) ที่แตกต่างกัน ผลการศึกษาเหล่านี้ให้คำแนะนำเชิงปฏิบัติสำหรับการวางตำแหน่งผลิตภัณฑ์ กลยุทธ์การตลาดแบบมุ่งเป้า และการส่งเสริมการบริโภคอย่างยั่งยืนสำหรับผลิตภัณฑ์ที่ได้จากวัสดุเหลือใช้ทางการเกษตร ซึ่งสามารถนำไปประยุกต์ใช้กับธุรกิจและการพัฒนาชุมชนที่มุ่งเน้นเศรษฐกิจสีเขียวและการจัดการของเสียในบริบทระดับภูมิภาค

คำสำคัญ : การแบ่งกลุ่มลูกค้า การมีส่วนร่วมกับลูกค้า กลยุทธ์ทางการตลาด

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Abstract

This study has two main objective: (1) to explore consumer satisfaction with white charcoal and its value-added products and its derived from agricultural waste, and (2) to identify and classify distinct consumer segments. The products are manufactured using a novel IoT-integrated dual-chamber kiln technology with gasification, in Upper Northern Thailand. This study addresses the challenge of market adoption for these sustainable, localized solutions. A mixed-methods approach was employed, combining qualitative thematic analysis (74 respondents) with quantitative survey data, including Discrete Choice Experiment (DCE) analysis and Latent Class Model (LCM). The results addressing objective 1 indicated overall satisfaction averaged 4.1 ± 0.6 , with safety (4.5 ± 0.4), effectiveness (4.4 ± 0.5), and ease of use (4.3 ± 0.5) highly valued.

The results addressing objective 2 identified three distinct consumer segments with heterogeneous preferences and varying Willingness-To-Pay (WTP) were identified for white charcoal products. These findings offer practical recommendations for product positioning, targeted marketing strategies, and promoting sustainable consumption of agricultural waste-derived products, applicable for businesses and community development focusing on green economy and waste management in regional contexts.

Keywords : Consumer Segmentation, Consumer Engagement, Marketing Strategies

1. Introduction

White charcoal (also known as Bincho-tan) is a premium bioproduct made from organic materials that have been pyrolyzed at high temperatures. Due to its distinctive properties, including high fixed carbon content, low ash and volatile matter, and high porosity, white charcoal is recognized as a clean and effective alternative biomass fuel (Chia et al., 2012). It is also gaining value as an essential ingredient in cleaning and cosmetic products. Moreover, white charcoal has potential for the soil carbon sequestration, contributing positive impacts on environmental sustainability.

Biomass fuels, such as fuelwood and charcoal, are essential to daily life throughout rural areas, especially in Upper Northern Thailand. A substantial population depends on these fuels for heating and cooking, which are fundamental aspects of their culture and the economy. This leads to a consistent demand for high-quality charcoal for both household consumption and commercial sales. However, traditional charcoal production, which primarily relies on large earthen kilns and local knowledge, severely limits the economic possibilities for these communities (Cornelissen et al., 2016). This production requires immense resources, labor, and time, which pose considerable challenges for locals who are constantly exposed to high heat, leading to unsafe and inefficient operations. As a result, the locals miss out on the opportunity to scale up their production to meet growing demands and high-value products in both domestic and international markets.

Aside from the challenges mentioned above, local communities frequently face a serious problem with agricultural waste accumulating in large amounts after harvesting. This waste consists of wood scraps, branches, bagasse, and maize cobs. Typically, these materials are burned out in the open, resulting in serious

haze and PM2.5 pollution during the dry season (Okimiji, 2024, Pongpiachan, 2015). Poor waste management has an immediate negative effect on the tourism industry and the health of the local population. Furthermore, it is a major contributor to ongoing environmental damage due to it is a major source of greenhouse gases such as methane and nitrous oxide, which are produced when organic matter does not degrade completely.

White charcoal production using a novel dual-chamber kiln technology stands out as a promising solution to address these urgent challenges and improve the quality of life for the local economy while lowering future environmental problems (Santos et al., 2017). In addition to enhancing safety and cutting resource usage by up to six times compared to traditional methods, this technology converts agricultural waste an alternative use. The resulting premium white charcoal can be used to create high-end products that appeal to consumers who are concerned about their health and the environment, such as odor absorbers and face masks (Mfokeu et al., 2023). In addition to giving locals a reliable source of income, this solution helps to strengthen local farmers and business owners, create new jobs, and distribute money locally.

Despite the clear benefits of this technology, there is a notable absence of research on consumer acceptance, and purchase intension towards these sustainable, high-value bioproducts within the Thai market context (Sriwaranun et al., 2015). This gap is critical, as the successful widespread deployment of this transformative technology critically hinges on the development of effective market adoption strategies. Without a clear understanding of consumer preferences, efforts to position products and scale up production will be ineffective. Therefore, this study is critically important as it systematically investigates real-world consumer satisfaction and purchasing decisions for both the primary charcoal product and value-added white charcoal-based products (Saija et al., 2023). The findings will not only validate the market potential of this sustainable technology but also provide practical recommendations for targeted marketing strategies necessary to facilitate the transition towards a green economy and effective waste management in the regional context.

2. Literature Review and Hypotheses development

This literature review synthesizes research on agricultural waste management, consumer preferences for sustainable products, and innovative promotional approaches. It provides the conceptual and contextual framework for understanding the market potential and success of white charcoal made from agricultural waste.

2.1 Agricultural Waste Management and Sustainability

Thai farming produces vast amounts of agricultural waste annually. This waste is commonly disposed of using an outdated practice of open-area burning, which directly causes air pollution. Particularly during the dry season, locals in Northern suffer from extreme haze and PM2.5 particles (Sirithian and Thanatrakolsri 2022; Jainontee et al., 2023). In addition, this practice lowers the value for the tourist sector while polluting air. The burning also releases greenhouse gasses i.e., nitrous oxide and methane, these gases further worsen climate change (Junpen et al., 2018). Experts consensually agree that an urgent solution is needed.

The concept of a circular economy is an ideal way to transform agricultural waste from an issue into something beneficial. The approach focuses on developing longer-lasting, recyclable, and reusable products,

frequently in nearby communities (Geissdoerfer et al., 2020; Ammaiyappan et al., 2025). The studies now demonstrate the effectiveness of converting agricultural waste into novel products. For instance, several studies examine the possibility of heating agricultural waste to produce charcoal or biochar. By doing this, materials that would otherwise be discarded are used up, and carbon is stored in the ground (Lim et al., 2024).

2.2 Consumer Behavior and Preferences for Sustainable and Green Products

Understanding the factors that influence consumer choice is crucial for the successful market adoption of new sustainable products like white charcoal and the value-added products made from it. Currently, more individuals worldwide are considering their health and the environment when making purchasing decisions, according to recent study (Nekmahmud and Fekete-Farkas, 2020). These environmentally and health-conscious consumers are frequently willing to spend more for products that align with their values. However, this only occurs when the product's advantages are convincing and obvious. For instance, consumers are more likely to purchase a product if it can be demonstrated that it reduces pollution.

According to several theories of consumer behavior, such as the Theory of Planned Behavior (TPB) and the Technology Acceptance Model (TAM), these remain useful for explaining the adoption of new, eco-friendly concepts. According to Ajzen (2020), these ideas emphasize the significance of elements such as our attitudes, other people's opinions, our sense of control, and whether or not we think something is beneficial. Based on their usefulness, ease of use, safety, and absence of hazardous substances, consumers are usually pleased with new or value-added products (Parasuraman, 2000). This suggests that products like white charcoal face masks need to feel good and be safe for consumers to want them.

2.3 Marketing Strategies for Sustainable Bio-products

For sustainable bioproducts to become accepted and used, effective market segmentation is essential. It helps in determining and focusing on particular consumer groups that are most likely to purchase white charcoal and related products. Targeting eco-friendly products can be achieved by dividing consumers based on their opinions, lifestyles, and concerns. For example, a certain group may value convenience, while another may place a higher value on minimal environmental damage.

When considering product positioning strategies, marketers usually highlight the distinct health benefits, environmental benefits, and positive social impact of innovative sustainable products (Kotler & Keller, 2021). Consumers can be actively engaged, for instance, by sharing the story of how waste is converted into something beneficial and how this strengthens the local economy. When it comes to pricing strategies, it usually makes sense to base the cost of these products on the value they offer rather than just their manufacturing expenses. This is because buyers are often willing to pay more for sustainable products (Nam et al., 2022).

Marketing strategies must carefully outline all of white charcoal's features. This involves being open and truthful about its sustainable origins, potential uses (such as odor absorption or skin benefits), and financial benefits for neighboring communities (Aroonsrimorakot, 2019). Engaging and educating environmentally concerned consumers can be accomplished through online marketing, community involvement, and an engaging story (Mangus et al., 2023). In addition, while these products are outstanding, ensuring community

acceptance is key. In order to ensure that the product lasts for a long time, it is also crucial to have clear communication that builds trust and demonstrates how everyone can benefit.

This study examines consumer preferences and purchasing behavior regarding white charcoal and its value-added products. It uses advanced analytical techniques. The aim is to identify specific market segments and the factors that influence them. The findings gathered from this analysis will be used to identify specific market segments and the factors that influence them, which is essential to acquiring evidence-based marketing strategies. The objectives are as follow:

1. To classify consumer preferences and purchasing behavior towards both white charcoal and its value-added products in order to distinct market segments and key influencing attributes.
2. To suggest evidence-based marketing strategies for product positioning, pricing, and promoting with the goal of community adoption, support local communities, appeal to environmentally and health-conscious consumers, thereby enhancing the economic feasibility and viability of the new technology.

A theoretical framework, as illustrated in Figure 1, developed by researchers. It is fundamentally built upon the principles of the Triple Bottom Line (TBL) concept integrates consumer adoption theories to model purchasing decisions and the established Marketing Mix framework (4Ps). It outlines the boarder dimensions guiding this study. It links consumer behavior and market adoption to propose marketing strategies, and these strategies anticipates the socio-economic viability and environmental impacts of the waste-to-bioproduct transition.

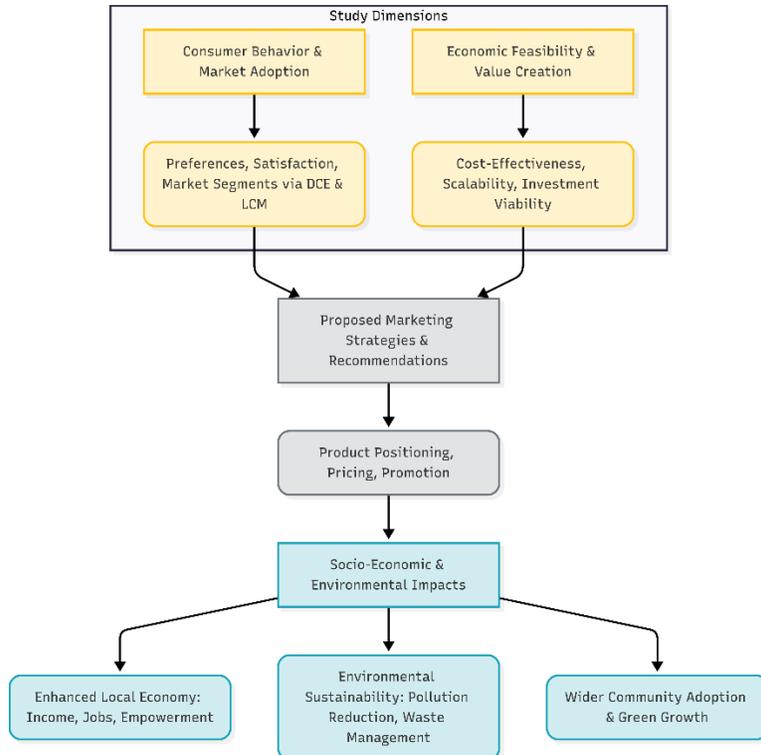


Figure 1 Market Adoption Framework for White Charcoal Solutions

3. Research Methodology

3.1 Research Type

This study adopts a mixed-method research approach, specifically using an Explanatory Sequential Design. This approach begins with a quantitative which is designed to systematically investigate consumer preferences and purchasing behaviors. Then followed by a qualitative to provide insights and contextual understanding. The results from statistical analysis of numerical data enables the distinct market segments and key influencing factors while qualitative that follows enables a more in-dept exploration of consumer motives and community dynamics. While the goal is to enhance the socio-economic status of locals through sustainable development, the core methodology involves two-phased approach of empirical data collection and rigorous analysis to achieve its objectives.

3.2 Population and Sample

3.2.1 Quantitative Phase

A non-probability purposive sample of 74 prospective customers was chosen from the provinces of Nan, Lampang, Chiang Mai, and Chiang Rai. Inclusion criteria focused on occupation, household expenditure, and interest in eco-friendly products, ensuring demographic diversity. Exclusions applied to those without household consumption decision roles, lacking eco-friendly product awareness, or residing outside study areas. While the sample size is considered below the often-recommended threshold for market surveys. It is believed to be sufficient for the Discrete Choice Experiment (DCE) based on fractional factorial D-optimal design implemented in this work, which optimizes information yield per respondent (Bliemer & Rose, 2010).

3.2.2 Qualitative Phase

15 participants were purposively sampled from Chiang Mai province for in-depth interviews. Chiang Mai was chosen as a major urban center with significant purchasing power. The interviews aimed to explore consumer motivations, community adoption dynamics, and entrepreneurial potential, with the sample size targeting data saturation for rich, non-redundant insights.

3.3 Research Instruments

3.3.1 Consumer Satisfaction Survey Questionnaire

A structured questionnaire gathered quantitative data on consumer perceptions, preferences, and satisfaction with charcoal-based products, including essential demographic and socioeconomic characteristics. It employed 5-point Likert scales and checklist-style questions across three parts, with Part 1 focusing on basic demographics (e.g., gender, age, education, income, family size, marital status, monthly expenses).

The questionnaire was divided into three main parts, primarily utilizing 5-point Likert scales and checklist-style questions to quantify responses across different dimensions of product satisfaction and consumer behavior. Each question on the Likert scale received a maximum score of 5 points and a minimum of 1 point, with each level set at equal intervals. It was adapted from consumer satisfaction and green behavior scales (Nekmahmud, M., & Fekete-Farkas, M., 2020; Luo, B., Li, L., & Sun, Y., 2022) and incorporating constructs

of readiness to adopt new solutions as proposed by Parasuraman (2000), was refined to fit the context in Thailand.

Part 1: General Demographic Information

This section used checklist-style questions to gather basic demographic data from respondents, including gender, age, marital status, occupation, family size, educational background, monthly income, and expenses.

Part 2: Charcoal Product Purchase Behavior

This part focused on eliciting specific purchasing behaviors related to three distinct white charcoal product categories: Bio Fuel, Odor-absorbing Charcoal Products, and Charcoal Face Masks. For each product group the respondent had experience with, the following aspects were explored primarily using checklist-style questions:

1. Form of purchase: What form of the [Product: Bio Fuel / Odor-absorbing Product / Charcoal Face Mask] do you typically buy/use?
2. Influence: Who most influences your decision to purchase [Product]?
3. Reasoning: What are your primary reasons for buying the [Product]?
4. Frequency of purchase: How often do you buy the [Product] in a month?
5. Location of purchase: Where do you mostly buy the [Product]?
6. Monthly expenditure: Approximately how much do you spend on [Product] per month?
7. Post-use satisfaction: How satisfied are you after trying the [Product]?
8. Recommendation likelihood: How likely are you to recommend the [Product] to others?

Part 3: Opinions on Charcoal Products

This section captured respondents' opinions on product attributes and performance using a 5-point Likert scale (1=Strongly Disagree to 5=Strongly Agree). Respondents' opinions on charcoal products were gathered, assessing (1) Bio Fuel for heat efficiency, burning duration, minimal smoke/odor, ease of use, environmental friendliness, and value for money. (2) Odor-absorbing products were evaluated based on their effectiveness in odor reduction (including duration), ease of use, safety, scent characteristics, and versatility. For (3) Charcoal Face Masks, opinions covered perceived efficacy for skin benefits (such as deep cleansing, pore reduction, acne control, detoxification, and skin tone enhancement), alongside natural/safe ingredients, and ease of application/removal. The scoring and interpretation of individual responses on the Likert scale, as show in Table 1.

Table 1 Interpretation Criteria for Average Likert Scale Scores

Average Score	Interpretation
4.21 - 5.00	Strongly Agree
3.41 - 4.20	Agree
2.61 – 3.40	Neutral
1.81 - 2.60	Disagree
1.00 – 1.80	Strongly Disagree

This detailed questionnaire and its associated scoring and interpretation guidelines for the systematic collection and quantification of consumer data, enabling a comprehensive analysis of satisfaction and behavioral patterns.

3.3.2 Discrete Choice Experiment (DCE) Design

A Discrete Choice Experiment (DCE) was used as a core instrument to quantify consumer preferences for specific product attributes and to estimate their Willingness-To-Pay (WTP). The DCE is particularly suitable for understanding consumer trade-offs between different product features and for evaluating preferences for hypothetical and/or un-marketed product adjustment. It was designed based on attributes and levels identified via triangulation of preliminary consumer survey insights, qualitative interview findings, and expert Index of Item-Objective Congruence (IOC) evaluation. A content validity was examined achieving IOC score of 0.90 (with a minimum acceptable score of 0.60).

The DCE was used as the primary tool to estimate Willingness-To-Pay (WTP) and measure consumer preferences for particular product attributes. The attributes and levels determined by preliminary surveys, qualitative interviews, and expert IOC evaluation (detailed in 3.4). The DCE results are expected to comprehend consumer trade-offs and assessing hypothetical products. Four essential characteristics were included, as shown in the Table 2.

Table 2 Selected Attributes and Levels for Discrete Choice Experiment

Attribute	Level 1	Level 2	Level 3
1. Purpose of Use	Cooking / Fuel	Order-absorption	Cosmetic Ingredient
2. Packaging Type	Basic Plastic Wrap	Resealable Pouch	Eco-Friendly
3. Price per Unit	Low	Medium	Premium
4. Label Information	Minimal	Detailed	Organic-Label

These attributes were selected based on concepts from rational choice theory and behavioral economics, with each representing a distinct facet of decision-making relevant to the charcoal market:

Purpose of Use: Differentiated utilitarian (e.g., cooking/fuel) from value-added (e.g., order-absorption and cosmetic ingredient) applications, reflecting diverse consumer needs and market segments for white charcoal products.

Packaging Type: Reflected convenience, perceived quality, and environmental consciousness, with options from basic to eco-friendly, indicating trade-offs between cost, usability, and sustainability.

Price per Unit: A fundamental economic factor with low, medium, and premium levels, allowing estimation of price sensitivity and WTP for other attributes.

Label Information: Gauged consumer importance on transparency and certifications, ranging from minimal to detailed or organic labels, reflecting demand for product origin, composition, and ethical production knowledge.

Together, these characteristics produced a complex DCE decision context that made it possible to assess consumer trade-offs between informational, ethical, environmental, and economic factors. Nine effective choice sets were produced using a fractional factorial D-optimal design. In order to replicate real-world behavior and prevent forced choice bias, each set included two fictitious product profiles along with an explicit opt-out option ("I would not buy either."), guaranteeing valid preference elicitation. Combinations were carefully examined by experts for logical consistency and realism. To illustrate the choice task presented to respondents, Table 3 provides an example of one such choice set generated by the D-optimal design. This example demonstrates how different attribute levels were combined to form distinct product alternatives for evaluation, contributing to the novel understanding of cross-category consumer preferences.

Table 3 Example of a Discrete Choice Set Presented to Respondents

Attribute	Alternative A	Alternative B
1. Purpose of Use	Cooking / Fuel	Cosmetic Ingredient
2. Packaging Type	Resealable Pouch	Basic Plastic Wrap
3. Price per Unit	Medium	Low
4. Label Information	Detailed	Minimal (Basic info)

Please choose the option you would be most likely to buy:

Alternative A
 Alternative B
 I would not buy either

After presenting choice sets, respondents selected their preferred option. The data will be analyzed using a Latent Class Model (LCM). LCM is well-suited for this study as it identifies unobserved variation in consumer preferences, segmenting consumers into distinct groups. The model will determine attribute significance and WTP for product characteristics across categories by calculating utility parameters. This approach ensures understanding of consumer preferences, guiding strategic decisions for white charcoal product development and marketing.

3.3.3 In-depth Interview Guide

For qualitative data collection, a semi-structured in-depth interview guide was employed with the goal of obtaining detailed information about participants' attitudes, driving forces, and obstacles with regard to white charcoal and its value-added products. Current charcoal usage patterns, knowledge and opinions of white

charcoal's special qualities and uses (such as face masks and odor absorbers), reasons and barriers to product adoption, opinions on product attributes, and recommendations for product development and marketing were some of the main discussion themes.

3.4 Data Collection Procedures

3.4.1 Ethical Considerations and Approvals

The Rajamangala University of Technology Lanna (RMUTL) IRB granted ethical approval for this study (RMUTL-IRB 086/2023; valid June 7, 2023 - June 6, 2025), closely following the ICH-GCP and the Declaration of Helsinki. Every participant gave their full informed consent after being fully informed about the study's goals, voluntary participation, withdrawal rights, and data confidentiality. In compliance with Thailand's Personal Data Protection Act B.E. 2562 (2019), privacy was protected by means of measures like restricted access, anonymized data collection, and unique identifiers.

3.4.2 Satisfaction Survey and the DCE Data Collection

After pilot testing, 74 respondents participated in the primary quantitative data collection for the DCE and satisfaction survey, which was carried out in the provinces of Nan, Lampang, Chiang Rai, and Chiang Mai. Data collection took place over a period of 4 weeks, from July 15, 2023 to August 11, 2023. Participants were divided into groups based on how relevant they were to particular charcoal products. Thirty respondents (who were current CocCo customers, evenly distributed by age) provided information about odor-absorbing charcoal, fourteen for white charcoal briquettes, and thirty for white charcoal face masks. All data collection was managed by trained research assistants who gave precise instructions to guarantee data quality.

3.4.3 In-depth Interview Data Collection

Qualitative data were collected through in-depth interviews with 15 potential consumers. These interviews were conducted in August 2023 immediately following the quantitative phase. It aimed to complement the quantitative data by eliciting nuanced insights into participants' perceptions, motivations, and barriers concerning white charcoal and its value-added products. Interviews were semi-structured and verbal consent was obtained before each interview, and discussions were recorded (with participant permission) and supplemented by detailed field notes.

Given the data collection was conducted via face-to-face spanned across multiple provinces and periods, non-response bias was assessed. To confirm the representativeness of the gathered sample, we analyzed the distribution of essential demographic and socioeconomic parameters such as age groups, income levels, and educational background, across the different geographic collection areas. Chi-square tests were conducted to confirm that the categorical distributions of these essential traits were consistent regardless of the location or period of data collection. The results showed no statistically significant variations (p -values > 0.05) in these critical parameters across locations and time periods.

4. Data Analysis

4.1 Qualitative Data Analysis

Data from in-depth interviews were subjected to thematic analysis (Section 4.1). This required continuous comparison, iterative coding, and verbatim transcription before being categorized into themes. The results of this manual process, which sought to fully comprehend participant perspectives (related to Section 2.2), are presented in Section 5.1.

4.2 Quantitative Data Analysis

Descriptive Statistics

Descriptive statistics summarized quantitative data, characterizing respondent features and behavioral patterns. Frequencies/percentages were computed for categorical variables (e.g., gender, age, income); means/standard deviations for scale-based satisfaction data (e.g., quality, ease of use, safety, effectiveness, environmental friendliness, innovation), providing initial consumer insights.

Discrete Choice Experiment Analysis

The LCM analyzed DCE data, understanding consumer preferences for bio-fuel/cosmetic ingredients by identifying distinct segments. The analysis estimated utility parameters, relative importance, and Willingness-To-Pay (WTP) values for each attribute level (from Table 3, Section 3.2). R statistical computing, with built-in package such as *apollo*, *gmnl*, *flexmix*, was used.

5. Results

The results of both qualitative and quantitative data analysis are presented in this section, structured to explicitly address the two main objectives of the study. Objective 1 is addressed by the Qualitative Findings and Descriptive Statistics, focusing on consumer satisfaction and influential perceptions. Objective 2 is addressed by the Latent Class Model results, which detail consumer preferences and Willingness-To-Pay for product attributes. The findings are then compared to previous research and theories.

5.1 Qualitative Findings

Significant themes influencing consumer expectations, perceptions, and choices/satisfaction with regards to white charcoal and its value-added products were identified through thematic analysis. The following four themes are highlighted.

(Theme 1) Perceived Effectiveness and Performance: Customers evaluated functional performance across uses (cooking/fuel, odor absorption, cosmetic), with positive opinions focusing on effectiveness, clean burning, or noticeable results.

Translated Quote: *"Oh wow... this white charcoal, it truly grills very evenly, and there's less smoke compared to regular charcoal. It makes the food really delicious."* (Participant 3, Age 45).

(Theme 2) Ease of Use and Convenience: Consumers valued practicality and simplicity, including ease of lighting, integration into routines, and user-friendly packaging. Straightforward products were favored.

Translated Quote: *"I like the resealable bag. It's much easier to store, and charcoal doesn't get all over the house. Very convenient indeed."* (Participant 5, Age 50).

(Theme 3) Safety and Chemical-Free: This theme emphasized consumers' desire for safe, natural, chemical-free products, particularly for body or food use. White charcoal's natural origin, reinforced by clear production info, conveyed purity.

Translated Quote: *"If it's something I put on my skin, I have to be very careful. The idea of 'chemical-free' really resonates with me. I feel much more confident with it."* (Participant 2, Age 38).

(Theme 4) Value Perception: This theme explored overall worth relative to cost and alternatives, covering distinct advantages, perceived value of higher price, and influence of eco-friendliness/specialized application on purchase intent.

Translated Quote: *"It's a bit more expensive than regular charcoal, but for grilling special meals, the consistent heat and cleaner burn... I think it's 'worth it.'" (Participant 8, Age 42).*

5.2 Quantitative Findings

5.2.1 Satisfaction and Current Perceptions

The characteristics and satisfaction levels of the respondents are detailed in Table 4 and Table 5, providing empirical data to support the findings from the qualitative phase regarding consumer perceptions. These results provide empirical support for the goals of the quantitative investigation.

Table 4 Sample Character Description (n=74)

Variable	Category	n	(%)
Gender	Male / Female	35 / 39	47.3 / 52.7
Marital Status	Single / Married/Cohabiting	25 / 49	33.8 / 66.2
Age (Years)	21–30	20	27.0
	31–40	25	33.8
	41–50	20	27.0
	51–60	9	12.2
Education Background	Bachelor's Degree / Higher than Bachelor's	40 / 34	54.1 / 45.9
Occupation	Business Owner	15	20.3
	Employee	40	54.1
	Government Official	19	25.7
Monthly Income (THB)	25,001–30,000 / Above 30,000	35 / 39	47.3 / 52.7
Family Size	1 Person	10	13.5
	2 Persons	20	27.0
	3 Persons	24	32.4
	4 or more	20	27.0

Variable	Category	n	(%)
Monthly Expenses (THB)	Below 15,000	10	13.5
	15,001–20,000	25	33.8
	20,001–25,000	25	33.8
	Above 25,001	14	18.9

Table 4 summarizes the demographic and characteristics of the 74 respondents. The primarily consisted of married females (52.7% and 66.2% respectively). Most respondents were aged 31-40 (33.8%) and employed (54.1%), with over half earnings above 30,000 THB.

Table 5 Means and Standard Deviations from Perceived Satisfaction Survey.

Statement	Mean	SD	Satisfaction Dimension
1. Overall, I am satisfied with this charcoal-based product.	4.1	0.6	Overall Satisfaction
2. The product quality meets my expectations.	4.0	0.7	Product Quality
3. This product offers good value for the price.	3.8	0.8	Value for Money
4. The product is easy to use/apply.	4.3	0.5	Ease of Use
5. I believe this product is environmentally friendly and sustainable.	4.3	0.5	Environmental
6. I consider this product to be safe and chemical free.	4.5	0.4	Safety
7. This product effectively fulfills its intended purpose.	4.4	0.5	Effectiveness
8. I would recommend this charcoal-based product to others.	3.9	0.8	Recommendation
9. This product is innovative and modern.	3.7	0.9	Innovation
10. This product contributes positively to society or the environment.	4.2	0.7	Social/Env. Impact

Both product quality (Mean = 4.0 ± 0.7) and overall satisfaction (Mean = 4.1 ± 0.6) received high ratings. Efficacy (Mean = 4.4 ± 0.5), ease of use/application (Mean = 4.3 ± 0.5), and safety/chemical-free nature (Mean = 4.5 ± 0.4) were the top attributes. Additionally, consumers placed a high value on societal/environmental contributions (Mean = 4.2 ± 0.7) and environmental friendliness/sustainability (Mean = 4.3 ± 0.5). The likelihood of consumers to recommend the product also scored positively (Mean = 3.9 ± 0.8). Value for money (Mean = 3.8 ± 0.8) and innovation (Mean = 3.7 ± 0.9) scored marginally lower but still positively.

5.2.2 Consumer Preferences and WTP

The Discrete Choice Experiment (DCE) analysis, utilizing the Latent Class Model (LCM), provides the core findings for Objective 2. This analysis quantifies consumer trade-offs and estimates WTP, directly informing strategic product development decisions.

Table 6 Estimated Beta Coefficients (β) for Product Attributes Across Latent Classes

Attribute	Level	Overall (β)	Latent #1	Latent #2	Latent #3
Purpose of Use	Bio-Fuel	0.85***	1.20***	0.50**	0.95***
	Cosmetic	1.30***	0.80**	1.80***	1.10***
Packaging Type	Eco-friendly	0.70***	1.00***	0.30*	0.60**
	Reusable	1.10***	0.60**	1.50***	0.90***
Price per Unit (THB)	50 (Baseline)	-	-	-	-
	60	-0.50***	-0.60***	-0.40**	-0.55***
	70	-1.00***	-1.20***	-0.80***	-1.10***
Label Information	Clear info. display	0.90***	1.10***	0.70**	0.80***
	Local Sourcing	0.40**	0.50**	0.20	0.30*
ASC	(Represents opting out)	-1.50***	-1.80***	-1.00**	-1.60***

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The LCM analysis identified 3-distinct consumer segments with heterogeneous preferences for white charcoal products. A 3-segment solution provided the most reliable and understandable depiction of consumer preference heterogeneity, as supported by model fit statistics. These categories are distinguished by their unique assessments of product qualities and WTP values.

As Table 6 illustrates, the positively beta coefficients preferred Cosmetic purpose of use and Reusable. Price continuously showed negative coefficients, suggesting that higher prices resulted in less utility. Clear info. display had a favorable effect on preferences as well. Further analysis revealed three distinct consumer segments based on heterogeneous preferences, a solution supported by model fit statistics (as detailed in Section 5.2.2). These categories are distinguished by their unique product quality assessments and WTP values.

Latent Class 1 (Membership Probability: approx. 35%). This market segment strongly prefer the use of bio-fuel, eco-friendly packaging, and clear information display. They value superior products, open communication, and environmental stewardship. Despite being more price sensitive than Class 2, their WTP demonstrates a strong commitment to making informed and sustainable decisions.

Latent Class 2 (Membership Probability: approx. 40%). With a positive preference for cosmetic use and reusable containers, this market segment exhibits the strongest preference for premium qualities. Notably, smaller negative coefficients for rising prices indicate that this class is the least price-sensitive.

Latent Class 3 (Membership Probability: approx. 25%). T This is the most price-sensitive market segment. Nevertheless, they continue to express favorable preferences for applications such as biofuel and cosmetics, packaging for reusable containers, and unambiguous information display. This implies that the

fundamental product value, performance, transparency, and affordable prices across a range of applications influence their decisions.

Table 7 WTP Values for Product Attributes Across Latent Classes in Baht (THB)

Attribute	Level	Overall WTP	Latent #1	Latent #2	Latent #3
Purpose of Use	Bio-Fuel	17.00	20.00	12.50	17.27
	Cosmetic	26.00	13.33	45.00	20.00
Packaging Type	Eco-friendly	14.00	16.67	7.50	10.91
	Reusable	22.00	10.00	37.50	16.36
Label Information	Clear info. display	18.00	18.33	17.50	14.55
	Local Sourcing	8.00	8.33	5.00	5.45
Purpose of Use	Bio-Fuel	17.00	20.00	12.50	17.27
	Cosmetic	26.00	13.33	45.00	20.00

Consumer preferences are quantified using estimated WTP values in Table 7. The highest WTPs were for cosmetics (THB 26.00) and reusable items (THB 22.00). Latent Class 1 prioritized eco-friendly (THB 16.67) and clear information displays (THB 18.33) within the segments as a reflection of their emphasis on the environment and health. For reusable items (THB 37.50) and cosmetics (THB 45.00). Due to their exceptionally high WTP, Latent Class 2 is a premium motivator for this least price-sensitive market segment. The need for high-performing, multipurpose products was indicated by Latent Class 3, which, despite being the most price-sensitive, gave high WTP to cosmetic use (THB 20.00) and bio-fuel (THB 17.27).

The qualitative and quantitative results demonstrate a clear convergence in consumer valuation of white charcoal products. The four major themes identified in the qualitative phase including Safety/Chemical-Free (Theme 3), Effectiveness (Theme 1), Ease of Use (Theme 2), and Value Perception (Theme 4)—serve as the contextual foundation for the high quantitative satisfaction scores recorded for Safety (Mean=4.5) and Effectiveness (Mean=4.4). Furthermore, this emphasis on premium, non-toxic attributes is empirically quantified by the Discrete Choice Experiment, which shows consumers are willing to pay the highest WTP values for Cosmetic Use (THB 26.00) and Reusable Packaging (THB 22.00). These findings collectively confirm that consumer preference is fundamentally driven by intrinsic product quality and perceived health/environmental stewardship, which transcends simple price considerations, particularly within the least price-sensitive segment (Latent Class 2).

6. Discussion and Conclusion

6.1 Key Findings

The results confirm a strong convergence between the qualitative and quantitative data. The initial positive opinions and preferences for chemical-free substitutes (Qualitative Theme 3: Safety) and functional

performance (Theme 1: Effectiveness) are consistent with the highest recorded satisfaction scores. This importance placed on natural and safe product attributes aligns with the global trend toward conscious consumerism and the demand for clean labels in food and personal care. Discussions of applications explain the high attribute for "Ease of Use" (Mean 4.3), linking it to practical elements like user-friendly packaging (Theme 2). These key findings align with the global trend toward conscious consumerism and the demand for clean labels in food and personal care (Asioli et al., 2017)

The DCE confirmed that despite high overall satisfaction, consumer preferences are highly segmented, identifying three distinct market segments: the Premium Cosmetic & Packaging Group (40%), the Eco-Conscious & Quality Group (35%), and the Price-Conscious & Performance Group (25%), accordingly. This validates the efficacy of the Latent Class Model in capturing preference heterogeneity, consistent with established DCE methodologies used to identify diverse consumer subgroups and inform policy decisions (Nicolet et al., 2024). The significant differences in Willingness-To-Pay (WTP) across these groups demonstrate that a one-size-fits-all marketing approach is ineffective in this market

6.2 Strategic Marketing

Based on the segmented preferences and WTP values derived from Objective 2, clear strategies for: Product Positioning, Pricing, and Promotion are essential for sustainable market development, particularly about the quality and advantages of green products among the younger generation (Gomes et al., 2023).

6.2.1 Product Positioning

The highest overall WTP values for Cosmetic Use and Reusable Packaging strongly suggest that the future of white charcoal lies in value-added, non-fuel applications. This application is large and least price-sensitive segment.

Hence, producers should prioritize product differentiation by expanding their beauty and personal care lines based on white charcoal. This strategy moves the product beyond the commoditized fuel market and positions it as a premium, natural ingredient, addressing the consumer focus on health and safety.

6.2.2 Pricing Strategy

Based on WTP finding, customer segmentation is divided into 3 classes, as following:

Premium Segment (Class 2): Since this group exhibits the least price sensitivity and the highest WTPs (e.g., THB 45.00 for Cosmetic Use), a premium pricing strategy is justified for products featuring cosmetic application, reusable packaging, and superior functionality.

Eco-Conscious Segment (Class 1): This group is moderately price-sensitive but willing to pay a premium for ethical and transparent attributes (THB 18.33 for Clear Info Display). Pricing for this segment should reflect the cost of sustainability certifications and clear labeling.

Price-Conscious Segment (Class 3): For this most price-sensitive group, a value-based pricing strategy should be adopted, emphasizing the cost-effectiveness and versatility of the product (e.g., dual use as biofuel and odor absorption) at competitive rates, thereby maximizing perceived value for money.

6.2.3 Promotion and Communication

Promotional strategies must focus on converting the inherent product value into observable consumer benefits, driven by the core themes of safety and sustainability.

- Marketing communication should highlight the white charcoal's origin from agricultural waste, directly

addressing regional issues of open burning and haze. Emphasizing its chemical-free, natural purification properties directly tackles the growing consumer health concern, reinforcing the high in the Safety dimension.

- For the Eco-Conscious Group, promotions should feature sustainability certifications and transparent

production processes. The strong preference for local sourcing (WTP for local sourcing) should be utilized to promote the product as contributing to the local green economy and community support, a prevalent factor in regional Thai consumer behavior.

6.3 Conclusion

The study successfully identified that the white charcoal market is driven by core values of safety, effectiveness, and convenience, but is structurally heterogeneous. By leveraging the specific preferences and WTP values of the three identified segments, producers in Upper Northern Thailand can effectively position their products, adopt flexible pricing models, and communicate the significant environmental and health benefits of utilizing agricultural waste. This provides a robust roadmap for sustainable market development and regional economic growth.

7. Limitation, Suggestion for future research and Implications

7.1 Limitation and suggestion for future research

Despite its informative results, this study has limitations. First, while the sample size ($n=74$) of the quantitative survey is sufficient for LCM, it may limit its broader generalizability in Upper Northern Thailand. Second, self-reported may introduce response bias. Third, the DCE attributes might not fully account for every aspect of client choice. Future research should consider larger, more varied sample sizes, the use of behavioral economics techniques to mitigate self-reported biases, and further attribute exploration. Additionally, investigating supply chain dynamics and producer perspectives would further enhance the comprehension of market success for agricultural waste-derived white charcoal.

This study offers valuable insights, yet its limitations pave the way for future research. First, although though the quantitative sample size was adequate for the LCM analysis, larger and more varied sample sizes should be taken into account in future research. Second, future studies could use behavioral economics techniques in addition to surveys for lower the possibility of biases in self-reported statistics. Finally, it's possible that not all of the factors impacting customer preference were covered by the DCE characteristics. Therefore, investigating supply chain dynamics and producer perspectives would further enhance comprehend of market success for agricultural waste-derived white charcoal.

7.2 Implications

The study's conclusions have important practical implications for the economy, society, and ecology, especially in Upper Northern Thailand. This study provides a clear roadmap for the region's sustainable market development by identifying discrete customer segments and their preferences for white charcoal made from agricultural waste.

From an environmental standpoint, the research directly supports the development and implementation of white charcoal production from agricultural waste, which immediately addresses the major issues of open-area burning and transboundary haze common in this region (Jainontee et al., 2023). By converting a source of pollution (agricultural residue) into a useful product, this study promotes a circular economy and measurably improves local air quality.

In terms of economics, this demonstrates how agricultural waste can be used to create local value, providing farmers additional sources of revenue and promoting the growth of regional companies. Understanding the segmented market allows local firms to implement specialized product development and marketing methods (Section 6.2), enabling them to increase sales potential and command higher prices for premium categories, thereby supporting the local green economy.

Socially, locals benefit directly from lower levels of airborne particulate matter from agricultural burning, leading to improved respiratory health. The focus on community support and local sourcing encourages community involvement and sustainable consumption patterns, aligning with dominant regional values. Additionally, promoting these goods can increase civic engagement and environmental consciousness among local producers and consumers, resulting in a healthier and more sustainable community.

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