

Article

Ideating A Sustainable Swine Feed Prototype: A Qualitative Approach in Farmers' Pain Point Identification and Product Development

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Abstract: There is a growing interest and trend in new product development (NPD) from food waste. However, most qualitative approaches rarely use the lean entrepreneur concept in the context of new product development (NPD), which allows for understanding customer insight rather than the traditional qualitative approach. Therefore, this study aims to (1) explore the swine farmer behaviors, desired outcomes, and pain points in using swine feedstuffs, (2) select three representative segments and identify high-value customers of swine feeds, and (3) develop a sustainable swine feed prototype from the fermented fish industrial residues. The target users, 24 pig farmers from 11 provinces across the Northeastern Region of Thailand, were recruited to participate in this research. Qualitative in-depth semi-structured interviews and thematic analysis were conducted to analyze their behaviors, desired outcomes, and pain points towards pig feed usages. The framework was combined with in-depth qualitative interviews and the customer, problem, and solution zoom tools. The results revealed that household farmers were the target customer segment of swine feed made from fermented fish industrial wastes. In addition, the findings showed that the household farmers typically fed their pigs with instant feeds and alternative feeds. Moreover, their desired outcomes were the pellet feed with nutrients. Furthermore, the pain points of the household farmers were the expensive cost of feeds and mold in feeds. Therefore, this segment needs to minimize the cost of feeds by using other sustainable alternatives.

Keywords: food waste; fermented fish industrial residue; animal feed; sustainability



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1. Introduction

Food waste is a concern on ecological, economic, and societal levels. Global attention is being paid to the loss of embedded resources since nearly one-third of food intended for human consumption is thrown away in the food supply chain [1]. An estimated 1.3 billion metric tons of food are thrown away each year [2]. Food waste wastes many resources, most notably the nutrients included in the food [3]. Food waste refers to nutrients that are discarded from food intended for human consumption and, hence, have a high nutritional value [4,5]. Food that has not been consumed accounts for 46% of approximately over 10,000 tons of solid waste collected daily in Thailand's largest cities. Bangkok, Nakhon Ratchasima, Chiang Mai, Phuket, and Chon Buri are included [6]. Food waste has traditionally been disposed of in landfills. However, a circular economy can reduce food waste issues sustainably. Moreover, food waste has enormous potential to be transformed into high value-added products, including foods, feeds, energy, and natural nutrients [7].

Fermented fish or Plara is a well-known Thai seasoning widely used in Southeast Asian countries, including Cambodia, Laos, Vietnam, and Thailand. With an annual output of 52,000 tons, Thailand's fermented fish sector is worth USD 34 million. However, it is estimated that 1500 tons of fish bones scales and other waste items are dumped into

landfills each year without any treatment or processing. This has a detrimental effect on the environment and the health of humans. Instead, a potential solution would be to use fermented fish industrial waste as an alternative feed element to reduce pollution and disposal issues based on the circular economy concept. Converting food waste into animal feed is more sustainable than other environmental and health implications for food waste processing [8]. Previous research articles investigated the use of food waste as an ingredient in animal feeds, including fish waste [8–13]. Additionally, food waste is frequently used as animal feed, notably in modern pig production methods [9,10]. However, fermented fish industrial waste has not been utilized before in Thailand.

There is a growing interest and trend in new product development (NPD) from food and food waste. Several research papers related to new product development (NPD) employed qualitative approaches [14–16]. However, most new product development (NPD) approaches have mainly focused on product development models and strategies rather than customer needs and expectations [17–20]. For instance, Hendler [21] studied the digital product development process by conducting semi-structured interviews with open-ended questions to explore process design-related project tasks for digital development. Moreover, Falck and Rosenqvist [22] examined the automobile product development process by interviewing engineers in product development departments regarding their opinions, experiences, and knowledge. Campos et al. [23] studied the development of new drugs and vaccines by using expert opinions and commentaries to implement product development processes. In addition, prior work on new product development used the qualitative research method to explore new advanced technologies and efficient processes for new product development [14–16,24].

According to the stated literature regarding new product development [14–16,21–24], previous research used qualitative interview approaches to collect primary data from experts before developing a product design. However, those product development methods could not answer our current research objectives because this recent study aims to discover the root cause of the customers' pain points involving specific problems faced by the existing users or prospective customers of swine feed in Thailand regarding the usage of swine feed products and related aspects. Furthermore, the previous research still lacks a proper understanding of customer needs (desired outcomes) and problems in product usage, which is the essential principle of the lean entrepreneur concept [25]. Based on the lean entrepreneur concept by Cooper and Vlaskovits [25], this concept considers customer behaviors, desired outcomes, and pain points as the crucial elements for identifying the potential customer and customer segmentation. In this case, customer behavior refers to how farmers feed and raise their swine, desired outcomes mention the actual needs of farmers in using swine feeds, and pain points refer to the specific problems that farmers face from using current swine feeds. Therefore, developing a sustainable swine feed product prototype could be more viable when the research and development team understands swine farmers' behavior, desired outcomes, needs, and pain points/problems regarding the existing swine feed products. Based on the lean entrepreneur concept, which highly emphasizes customers, a swine feed product prototype can provide need-addressing utility, solve pain points, and resonate at an emotional level to become long-term customers.

This research introduces the lean entrepreneur concept for product development, which is a market-centric approach that recognizes customer insights and minimizes ineffective implementation at the early stages of a business [20]. Therefore, the lean entrepreneur concept addresses the first research gap. Product development solely relying on expert opinions may introduce bias when disregarding the views of the target users or customers. For instance, Ahmad and Wong [26] utilized the qualitative approach in the Malaysian food sector. However, this recent research conducted the qualitative interview technique by collecting the data from academia, research centers, and industry experts, which are not the actual consumers. Hence, this current study argues that customers who employ the products are the best group for an in-depth interview since they have

pains and passions that need to be addressed before creating the right products for the right customers.

Furthermore, the second research gap can be addressed. Taylor-West et al. [27] studied the market segmentation approaches for automotive products. However, this recent research classified the customers based on demographic variables. Thus, the second research gap is presented in that traditional market segmentation approaches are the methods to classify customers but not to gain an understanding of customers. This argument is consistent with the previous research papers on traditional market segmentation critique, which lacks customer insights and experiences [28,29]. Hence, this current research argues that it makes more sense to recognize how to create value to classify customers based on their buying grounds rather than demographics. The lean entrepreneur concept contributes to the closure of research gaps presented by the traditional qualitative interview method and conventional market segmentation. It is a customer-centric approach enabling the researchers to better understand the target customers' behavior and pain points, as well as the potential for adapting fermented fish waste to create a sustainable swine feed prototype.

Therefore, this study aims to (1) explore the swine farmer behaviors, desired outcomes/needs, and pain points/problems in using swine feedstuffs, (2) select three representative segments and identify high-value customers of swine feeds from the fermented fish industrial residues, and (3) develop feed product prototypes of swine feeds from the fermented fish industrial residues. Consequently, this study addresses the following research question: RQ. Which swine farmer segment has the most potential to be the target segment for sustainable swine feed made from fermented fish industrial residue?

This article is constructed as follows. Section "Introduction" begins with an explanation of food waste issues and the purpose of the study. Next, Section "Literature review" outlines the related theories and academic literature. Then, Section "Research methodology" displays the research method, including participants, data collection, and qualitative research tools. Next, the findings and analysis of the study are described in Sections "Results" and "Discussion." Finally, Section "Conclusion" summarized this study by deliberating the significant conclusions drawn from this article and recommending research implications.

2. Literature Review

Several recent research papers on the new product development employed qualitative research [14–16]. Various research articles have demonstrated new product development concepts by using expert opinions to explore the most efficient new product development processes and strategies [14–16,21]. This literature review identifies and discusses prior qualitative research on new product development. For example, Singh and Sarkar [16] studied the qualitative interview technique for new product development in the Indian automotive industry. The experts were selected to be interviewed and identify the eco-design of the automobile. However, when it comes to the first gap, where expert opinions are expressed, some bias is evident during the interviews since the experts conveyed their knowledge and experiences related to the eco-design practices for sustainable automotive designs. Moreover, they mainly focused on the new innovations and technologies that could develop new products, but not the concerns about customer needs. Thus, this current study argues that people who use the products and services are the best experts at coming up with and evaluating new ideas for products and services.

Moreover, Wijewardhana et al. [30] collected qualitative data from the experts in the context of the new product development process in the apparel sector. This previous study focused on the technology and processes that create attire products. However, when it comes to the second gap, this research discusses the idea of being product-centric, which focuses on research and development and makes new, unique items. As seen in the literature, previous research studies have used the qualitative interview method in the context of new product development (NPD). Bhatia et al. [31] studied robotic development by using semi-structured interviews to collect primary data from experts regarding robotic processes and development. Moreover, Khan et al. [32] studied new product development

by focusing on business innovation models and developing newer and more advanced products, demonstrating that this approach focuses on creating product ideas, not building customer best experiences. However, unlike the conventional new product development method, the concept of lean entrepreneur employed in this current study focuses on customers' insight in terms of pain points in product usage. This is because identifying pain points results in offering the right solutions. Therefore, the lean entrepreneur approach is more market-centric, whereas the conventional new product development method seems product-centric. The lean entrepreneur concept aims to understand customers' pain points and problems with product usage in order to deliver the most suitable products that solve the customers' problems, which indicates that this concept focuses on the market rather than the product. Thus, from the business point of view, it is more feasible to use the lean entrepreneur concept in new product development rather than the conventional new product development method because lean entrepreneurs provide customer insights regarding behaviors, desired outcomes, and pain points. Ultimately, after identifying the pain points, the approach delivers the optimal solutions as features to sustainably solve the customers' pain points.

2.1. Lean Entrepreneur: Segmentation Matrix

The lean entrepreneur concept aims to eliminate inefficient practices at the initial phase of a business, increasing the likelihood of long-term success. In addition, this approach is used to navigate to the right market segment. Traditional market segmentation allows companies to better understand their clients by employing the four traditional basic types. Consumers can be categorized according to these segmentation criteria, referred to as geographic, demographic, psychographic, and behavioral variables. The problem with these approaches is that it does not get to the customer's needs. It is a technique to distinguish, but not to gain, the understanding of customers. Unlike conventional market segmentation, the segmentation matrix approach allows companies to identify a potential segment by grouping customers based on need and pain. Customers purchase products for different reasons. Therefore, it makes more sense to recognize how to create value to classify customers based on their buying grounds rather than their demographics, including age, gender, and income. Hence, the more companies understand their customers, the more they appreciate their segments and subsegments. Individuals represent different market segments in terms of their depth of pain or passion, expected solutions, and various sales methods. Thus, the segmentation matrix consists of five criteria: depth of pain, budget, ease of reach, ease of minimum viable product (MVP), and market size. Consequently, this approach enables the firms to explore the pain points in product usage, customer purchasing power, the possibility of buying, abilities to create the product, and the number of potential customers that are derived from the five criteria. Eventually, the segmentation matrix delivers a narrow and well-defined group of individuals who share a similar pain or passion.

2.2. Lean Entrepreneur: Personas and Zoom Tools

In the lean entrepreneur concept, customer personas are employed as a tool to guarantee that products are produced in a way that resonates with purchasers. A customer persona (alternatively referred to as a buyer persona) is a semi-fictional archetype that embodies the main characteristics of a large segment of the customers, based on data gathered via user research. Hence, this tool explores the needs of real users by understanding their characteristics, behaviors, needs, and pain points, which is beneficial in understanding the customers and how to market and sell to them. Unlike the traditional sales and marketing approach, the lean entrepreneur concept focuses on customer engagement, desirability, and problem rather than treating sales and marketing. Furthermore, it is better to recognize someone suitable for the company's ideal customer profiles.

Moreover, to enhance the personas, the startup must utilize the customer, problem, and solution zoom tools. The purpose of zoom tools is to discover what makes consumers

genuinely passionate. The more the company understands its clients and needs, the more likely it will build a product that meets those demands and resonates emotionally. To truly comprehend client emotions, you must zoom in on specific individuals, not on generic personalities. First, the customer zoom tool enables companies to describe real people's features and behaviors to ascertain their needs, ambitions, and aspirations. Then, after focusing on the customers, narrow its focus to specific problems or needs that the company hopes to address. Second, the problem zoom tool enables the company to articulate the customer's obstacles and desired outcomes. Next, to determine the particular functionality, the minimum viable product (MVP) must be provided to bring value to the customers or users. At this stage, the company should hypothesize what MVP may require. Finally, the solution zoom tool assists companies in determining which aspects of their design should be validated before construction.

2.3. Food Waste for Animal Feed

Several studies have revealed that vegetable waste can be used in animal feed [8,33–35]. For example, according to Garcia et al. [33], animal feed formulations may involve vegetable and fruit by-products. In addition, Esteban et al. [36] investigated vegetable, fruit, and fish waste as a substitute for conventional raw materials for pig feed and the effect of subsequent treatment on their digestibility. Some articles utilized the various organic wastes, including meat, fish, fruit, vegetables, and restaurant and residential waste, as feedstuff [33]. Crop leftovers are heavy in fiber, low in protein, carbohydrate, and fat, and thus suitable for animal feed [37]. Alternatively, food scraps can be fed to insects, which can be used as livestock feed [38]. Besides pigs, food waste can be fed to birds, fish, and ruminants [39,40].

Moreover, recent research indicates that raising insects for human food and cattle feed has environmental benefits [41,42]. In addition, insects have a significant nutritional value, particularly as a source of protein for animals [43]. Thus, insect-based feed ingredients can be used instead of conventional feed ingredients such as fishmeal or soybean meal, which have a high environmental impact [44]. Previous articles studied the fermentation of leaf vegetable waste to use as animal feed [34]. In addition, Hammoumi et al. [12] investigated the fermentation of fish waste utilized in broiler feeding trials. Nevertheless, none of these studies explored how fermented fish industrial residues may be transformed into high-value-added swine feeds.

Maize and soybeans are the primary energy and protein sources in poultry and swine diets [45,46]. Therefore, food waste could be used to replace a portion of the cereal grains and plant protein sources required in animal nutrition, thereby alleviating human–animal food competition [10]. Additionally, feed costs account for a sizable portion of the cost of meat production, eroding financial advantages [47]. For example, in the EU, feed expenses account for between 55% and 75% of total pig production costs and between 55% and 75% of total poultry production costs. As a result, manufacturing costs could be reduced by utilizing food waste, which is less expensive than conventional feeds [47].

2.4. Study Context and Research Framework

In the researchers' view, pig farmers are the target users and customers of a sustainable swine feed prototype. In this case, all participated farmers are the owners and decision-makers of the farms. Thus, this study may use the term "farmers" and "farm owners" interchangeably. A qualitative study is required to discover farmers' insights, including behaviors, opinions, and experiences involved with pig feedstuffs. Hence, this study utilized the lean entrepreneur concept to identify farmers' behaviors, desired outcomes, and pain points regarding sustainable swine feed materials. In addition, customer insights enable the researchers to get a holistic view of how farmers think and feel about the sustainable swine feeds made from fermented fish industrial residue. By recognizing the customer insights, this study could develop significant customer empathy beyond simply understanding what farmers required and why they required it. As a result, this study

combined a qualitative approach, namely, thematic analysis, with the lean entrepreneur concept before developing a swine feed prototype for the right pig farmer segment. Figure 1 depicts the overall framework for this investigation. The first step is to understand the customers' behavior, intended objectives, and pain points referred to as the customer empathy stage. The segment selection stage is the second step in determining the most likely client for the pig feed products from fermented fish industrial residues. The solution design stage is the third and last step in the process.

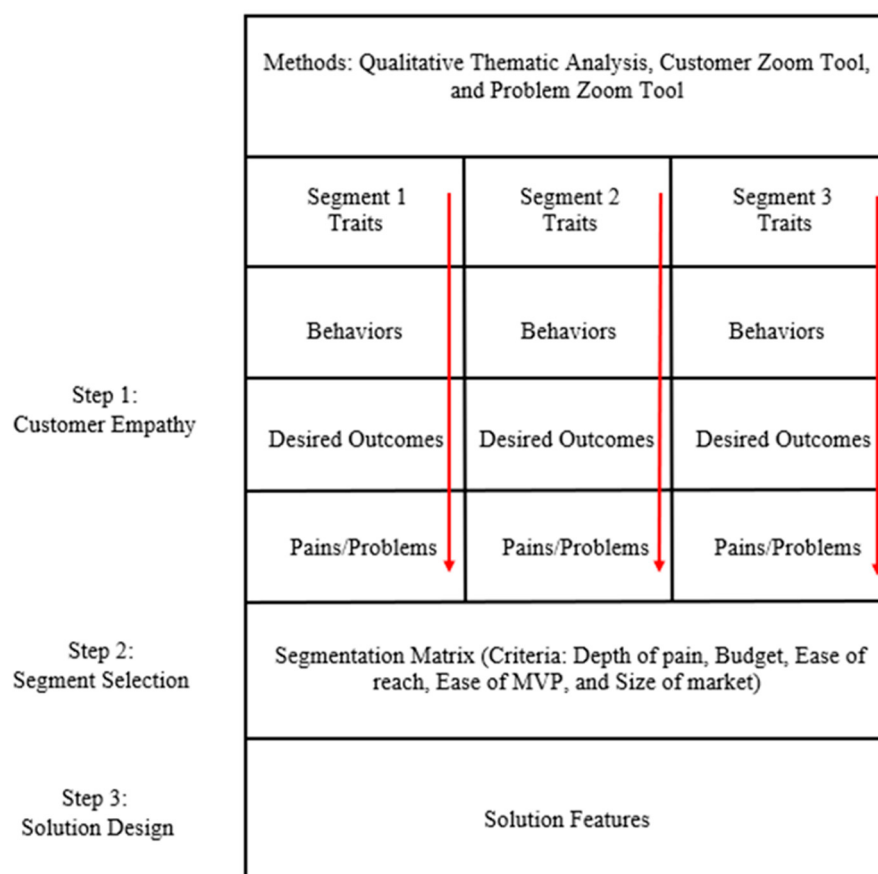


Figure 1. Research Framework. Source. Figure created by authors (2022).

3. Research Methodology

3.1. Participant Recruitment

This study interviewed the pig farmers who were actual pig feedstuff users. Additionally, all the participated farmers were owners and decision-makers of the entire production farm, including contract, household, and organic farms. In the case of contract farms, even though they operate pig farms that comply with the company's regulations in terms of feeds and other related pig production, they can terminate the contract agreement by paying compensation. Twenty-four pig farmers were recruited via making phone calls and asking screening questions. The inclusion and exclusion criteria were employed to determine the existing pig feed users. Therefore, pig feed products' inclusion and exclusion criteria were categorized based on the farmers' character traits and behaviors. For example, based on the research ethics standard, the inclusion criteria were pig farmers aged above 20 years in the Northeast of Thailand. In contrast, exclusion criteria were people aged below 20 years and who were not located in the provinces in the Northeast of Thailand.

3.2. Script Development and Data Collection

Qualitative data gathering methods such as semi-structured interviews were used to gain comprehensive data on pig feedstuff usage. In addition, semi-structured interviews

were used to get participants' comments on an experience relevant to the research topic [25]. The interviews lasted approximately ten minutes, and they were recorded and transcribed word for word with permission. Participants were asked to fill out a short demographic questionnaire at the end of the interview.

As presented in Figure 1, prior to the interviews, customers were categorized into three main proposed segments, including contract farms, household farms, and organic farms. The proposed customer segments were associated with the pig farmers' personas, as mainly segmented by their behavior, desired outcomes, and pain points. Based on our survey, contract farming has become the biggest proportion in commercial pig production in Thailand because several large-scale and medium-scale pig farm owners attend the contract farming scheme. In addition, contract farming has the highest degree of private sector involvement [48]. Moreover, company sponsors provide financial security in terms of wages, feeds, and other production costs. Contract farmers should comply with strict timetables and regulations since the contract provides guidelines on what practices must be followed in terms of pig production systems. On the other hand, domestic pig farming originally started in small backyard households and large fields of local families in rural areas in Thailand [49]. Additionally, the number of organic pig farms has increased in recent years. Comparatively, though, it is still less than in other areas of the pig farming industry in Thailand [50].

Pilot tests were also done to ensure that the three pig farmer groups identified were representative of the market. The surveyors interviewed three participants of each customer segment from the pig farms in the Northeast of Thailand. The summarized customer segments were divided into three groups because consumers in each group have similar traits, needs, and pain points. As we proposed previously, the three selected customer segments were contract farms, household farms, and organic farms.

Then, the potential customer segments were prioritized using the segmentation matrix [20] demonstrated by Table 1. This matrix evaluates the depth of pain, the budget, the ease of reach, the ease of MVP, and the market size of customers in each segment and ranks the scores in order. To evaluate those criteria, we created a questionnaire based on the zoom tools to determine the customers' behaviors, desired outcomes, and pain points [20]. This questionnaire includes semi-structured interview questions used checklists, open-ended inquiries, and rating scales. The questionnaire consists of two sections: (1) demographic characteristics of pig farmers, which relate to the customer zoom tool (*gender, age, education level, income, and purchase frequency*), and (2) general information about the purchase of pig feeds of the respondents, which relate to the behaviors from the customer zoom tool (e.g., *What food do you feed pigs?/How do you raise your pigs?*), desired outcome, and pains/problems from problem zoom tool (e.g., *What are specific features of pig feed do you want?* and *What pain points hinder you from reaching the desired outcomes of using pig feedstuffs?*) (see Appendices A.1 and A.2).

Table 1. The Example of Segmentation Matrix.

Customer	Depth of Pain	Budget	Ease of Reach	Ease of MVP	Size of Market	Total Scores	Rank
Segment 1	H, M, L	H, M, L	H, M, L	H, M, L	H, M, L		
Segment 2	H, M, L	H, M, L	H, M, L	H, M, L	H, M, L		
Segment 3	H, M, L	H, M, L	H, M, L	H, M, L	H, M, L		

Source. Data created by authors (2022).

Participants then rated the intensity of pain on a scale from mild to severe (L = low; M = medium; H = high), given that H = 3 points, M = 2 points, and L = 1 points. Finally, researchers used participants' monthly income to calculate budget ratings on low, medium, and high scores. In addition, we created questions on the ease of interaction with customers and the speed and regularity with which items can reach customers to identify reachability requirements. By adopting a low, medium, and high levels of accessibility, researchers could determine which level of accessibility best suited their study objectives. The solution

zoom tool was also used to assess the MVP's simplicity of use by analyzing the list of features and the minimum effort required to develop solution functionality [25]. After that, we determined the MVP solution and scored the options on low, medium, and high scales. Finally, secondary data from prior statistical information on the target customers were used to assess the market's size. Because of this, the scores for low, medium, and high were evaluated separately. Finally, we calculated average score of each criterion in Table 1 by segment, then summed up the total score for each segment, and ranked the segment in order, given 1, 2, and 3 = segment with the highest score, the second highest score, and the lowest score, respectively.

3.3. Data Analysis

All interviews were taped and transcribed verbatim by a team of experienced transcriptionists. The thematic analysis results were used to identify common threads in the responses and how they related to the research questions [51]. The interviews were initially coded thematically using customer and problem zoom tools, employing a deductive coding method [25]. The coding approach was revised and enhanced using an inductive method as new subjects emerged during the study [52]. ATLAS, a program for qualitative data analysis, was used to help organize the data.

4. Result of the Study

Table 2 summarizes the demographic characteristics of the participants. Seven male and three female interviewees participated in the contract farm segment. The majority of participants were between the ages of 41 and 60. They had bachelor's degrees and earned between 60,001 and 80,000 baht per month. The majority of respondents bought pig feeds 1–2 times per week.

Table 2. Demographic Profiles of In-Depth Interview Participants ($n = 24$).

Demographic Variable	Category	Number of Participants		
		Three Customer Segments		
		Contract Farm ($n = 10$)	Household Farm ($n = 10$)	Organic Farm ($n = 4$)
Gender	Male	7	6	4
	Female	3	4	0
Age (years)	20–30	1	0	1
	31–40	1	2	2
	41–50	4	3	0
	51–60	4	5	1
Education level	Secondary education	4	4	0
	Vocational certificate/ diploma	1	3	0
	Bachelor	5	3	3
	Master	0	0	1
	PhD	0	0	0
Income (Baht)	0–20,000	0	0	0
	20,001–40,000	1	5	0
	41,001–60,000	3	2	1
	60,001–80,000	4	2	1
	80,001–100,000	2	1	2
	More than 100,000	0	0	0
Purchase frequency (per week)	Less than once	1	1	3
	1–2 times	6	3	1
	3–4 times	3	4	0
	More than 4 times	0	2	0

Source. Data adapted from authors (2022).

Additionally, in the household farm segment, the majority of participants were male. The majority of participants were between the ages of 51 and 60, which accounted for five interviewers. Many respondents had completed secondary school and earned between 2000 and 4000 baht per month. The majority of respondents reported purchasing pig food 3–4 times per week.

In contrast, there were four male interviewees in the organic farm segment. Two interviewees were between the ages of 31 and 40, which accounted for the majority of participants. They had bachelor's degrees and monthly incomes ranging from 80,001 to 100,000 baht. Most respondents said they bought pig feed less than once a week.

Table 3 shows the procedures of interviews and interviewees for segment 1. In segment 1, the interviews were conducted from 2 July 2021 to 11 July 2021. Table 4 exhibits the procedures of interviews and interviewees for segment 2. In segment 2, the interviews were conducted from 15 July 2021 to 22 August 2021. Finally, Table 5 illustrates the procedures of interviews and interviewees for segment 3. In segment 3, the interviews were conducted from 4 September 2021 to 8 September 2021.

Table 3. Interviews and interviewees: Segment 1.

Interviewee No.	Province	Date	Duration
1	Khon Kaen	2 July 2021	5 min
2	Kalasin	2 July 2021	4 min
3	Buri Ram	3 July 2021	8 min
4	Nakhon Ratchasima	4 July 2021	10 min
5	Chaiyaphum	5 July 2021	5 min
6	Surin	6 July 2021	7 min
7	Udon Thani	7 July 2021	9 min
8	Ubon Ratchathani	8 July 2021	6 min
9	Sisaket	10 July 2021	7 min
10	Yasothon	11 July 2021	8 min

Source. Data adapted from authors (2022).

Table 4. Interviews and interviewees: Segment 2.

Interviewee No.	Province	Date	Duration
11	Khon Kaen	15 July 2021	5 min
12	Roi Et	17 July 2021	4 min
13	Nong Khai	20 July 2021	8 min
14	Nakhon Ratchasima	24 July 2021	6 min
15	Maha Sarakham	1 August 2021	10 min
16	Nakhon Phanom	4 August 2021	5 min
17	Udon Thani	7 August 2021	10 min
18	Ubon Ratchathani	8 August 2021	10 min
19	Mukdahan	11 August 2021	7 min
20	Amnat Charoen	22 August 2021	9 min

Source. Data adapted from authors (2022).

Table 5. Interviews and interviewees: Segment 3.

Interviewee No.	Province	Date	Duration
21	Khon Kaen	4 September 2021	9 min
22	Maha Sarakham	5 September 2021	10 min
23	Buri Ram	7 September 2021	8 min
24	Nakhon Ratchasima	8 September 2021	7 min

Source. Data adapted from authors (2022).

4.1. Contract Farm

4.1.1. Behaviors

Theme: Instant Feeding Behavior

The contract farmers usually use the swine feeds from agribusiness companies that contain proper feed formulation for each age of swine. However, they were not allowed to use other feeds due to the company rules. Based on the interview, contract farmers should

comply with strict regulations. In the contract farming system, the company facilitates its contracted farms in many ways, for instance, feeds, veterinarian services, and financial security in terms of wages. Hence, veterinarians were sent to the contracted farm regularly to examine pigs' health. Ten of the respondents replied as follows:

"I raise fattening and weaning pigs an agribusiness company. I usually use instant food from the company without mixing it with other food. The company regularly delivered the feedstuffs, drugs, and veterinarians to the farms. I feed them twice a day. Moreover, feeds from other sources are not permitted since they violate company policy." (Interviewee no. 1)

"My farm operates under the supervision of an agribusiness company. I own approximately two hundred piglets. I normally feed them with instant swine feeds from the company." (Interviewee no. 2)

"I own pig farm in the small village, but under the contract agreement with a big company. I raise almost four hundred fattening pigs on the farm. I regularly feed them with proper formula feed that the company's experts calculate." (Interviewee no. 3)

"Since I signed the contract agreement with an agro-industrial firm, I only feed piglets and weaning pigs with ready-to-use instant feeds from the firm." (Interviewee no. 4)

"I raise different ages of pigs and feed them with the proper instant formula provided by a company. The feedstuffs probably have protein and other essential nutrients for the pigs" (Interviewee no. 5)

"I used to raise pigs by my own and sold them to the abattoir, but now my farm become a part of contract farming. I operate everything under the agreement." (Interviewee no. 6)

"My husband and I raise have chicken and pig farms under the contract agreement. We usually feed them with the feed materials that contain nutritional values." (Interviewee no. 7)

"I have fifty piglets and eighty fattening pigs at the farm. I feed them with milk and instant feed materials from a firm." (Interviewee no. 8)

"I raise fattening pigs and use instant feeds directly from a company. The company provide feeds for me. So I do not need to choose the feeds that I will feed the pigs." (Interviewee no. 9)

"I raise piglets, fattening, and weaning pigs with the feedstuffs from an agribusiness company. I often clean the pigsty every week." (Interviewee no. 10)

4.1.2. Desired Outcomes

Theme: Nutrition Concerns

The results revealed that this segment needs the swine feeds containing nutrients according to the nutrient requirements of farm livestock. Nevertheless, agribusiness companies usually provide feedstuffs for contract farmers. Moreover, the company implemented the feed formulation and livestock veterinarian. The farmer only raises the swine for the companies and operates the farms based on the company regulations. In addition, this segment required the feeds that had a positive impact on the health and growth of the swine because they earned a salary from the agribusiness companies. Hence, the better they raise the swine, the more they reach the company standard of farming operations. Ten of respondents replied as follows:

"I need pellet food for fattening and weaning pigs. Pigs require approximately 22% of crude protein to be properly nourished. So, they can be healthy and grow faster. Additionally, the pig feeds with nutrients that fulfill basic nutritional needs for pigs. Hence, I earn a good salary from the company because I can raise the pigs very well." (Interviewee no. 1)

"I generally require feed materials with essential nutrients for pigs because if the pigs regularly eat proper feed, then all the pigs can sell at excellent prices." (Interviewee no. 2)

"It would be better to feed pigs with excellent pig feeds with nutrients, which I receive instant foods from the company every month. I must feed them with the company's feed brand only. Otherwise, I will break the rules." (Interviewee no. 3)

"I prefer pellet feed for my pigs because it might be easier to feed them. Additionally, the feeds should have nutritional values for maintaining good health of pigs." (Interviewee no. 4)

"I want instant pellet feed with protein." (Interviewee no. 5)

"I just want to use pellet feeds that might be better than the powdered feeds that I currently use. However, the most important thing is the nutrients from the feed ingredient." (Interviewee no. 6)

"We require some really good feed materials for our pigs." (Interviewee no. 7)

"I want good quality pig foods that make pigs are healthy, and pork meat have a natural red color. In other words, I want to raise the pigs that can reach the company standard." (Interviewee no. 8)

"It might be good for the pigs if the feedstuffs had protein, vitamins, and minerals because these elements are essential for pig growth." (Interviewee no. 9)

"I probably need feed materials that include nutrients." (Interviewee no. 10)

4.1.3. Pain Points

Theme: Non-Operational Issues

The findings found that most contract farmers had no pain points related to the swine feeds since they use agribusiness companies' feeds. When they encountered pig production problems, including feeds, disease, and insects, the companies would immediately provide the experts or veterinarians to the farms. Ten of the respondents replied as follows:

"There were no issues at any point during the operation because every month the company's staff visit the farm to investigate the pigs' health and farm's environment." (Interviewee no. 1)

"I hardly think about the problems during pig production since I sign the contract agreement with an agro-industrial company." (Interviewee no. 2)

"The problem I encounter is moldy feed, but it wasn't a big deal because a company representative came to inspect the food and replace it immediately. Furthermore, I'm not allowed to use foods from other sources outside the company brand's foods." (Interviewee no. 3)

"I probably have biting insect issues at my farm. However, when I inform the company, they provide the staff to the farm right away." (Interviewee no. 4)

"The issue I ran across was moisture in the container during transit. If the packing is damaged, I must inform the firm. Then, they will send the new ones as soon as possible." (Interviewee no. 5)

"I had pest problems, but now the company provide the pest controls systems at the farm." (Interviewee no. 6)

"There were some mosquito issues, but I solved the problems by setting mosquito killer lamps at the pigsty. So, I rarely have problems related to the pig production." (Interviewee no. 7)

"The problem is diarrhea disease in piglets due to feeding change. However, there will be a company veterinarian to take care of it immediately." (Interviewee no. 8)

"The problem I've confronted is that the pigs have a lot of parasites. Nevertheless, a veterinarian will come and change the feed formula. They also give medicines to cure parasites in pigs." (Interviewee no. 9)

"I encountered parasites issues last year, but the firm sent the specialists to investigate the parasites of pigs." (Interviewee no. 10)

4.2. Household Farm

4.2.1. Behaviors

Theme: Alternative Feeding Behavior

The results revealed that most household farmers fed their pigs with alternative feed such as vegetables, fruits, rice bran, and rice husk. They tend to select the feeds that are easy to prepare for the pigs. In addition, they were more likely to feed them with feed

ingredients that contained high energy and protein since these substances can promote optimal growth and average weight. Seven of the respondents replied as follows:

“I feed milk for piglets in the first week. After that, I will use the instant feed formula. When the pigs are 14–20 days old, the formula is changed by adding banana pods, instant food pellets, and bran.” (Interviewee no. 12)

“I raise about 50 pregnant pigs by using the generic instant feed. I choose the brands that are easiest to purchase. I mix instant meals with rice bran, broken-milled rice, and water. I try to control diets so they do not get too fat.” (Interviewee no. 14)

“I raise weaning, fattening, and pregnant pigs by using wet feeds, rice husks, and vegetable scraps. I tried various brands of pig feeds to find the most suitable feeds for my pigs.” (Interviewee no. 15)

“I raise fattening pigs to use the instant feed formula based on the age of the pig. Sometimes, I feed breeder pigs with broken rice, rice bran, fish meal, salt, and banana stalks.” (Interviewee no. 16)

“I have three pregnant pigs and seven fattening pigs in the farm. I usually feed them with food scraps and vegetable wastes.” (Interviewee no. 17)

“I raise piglets and weaning pigs by feeding them with instant feeds, milk, and fruits.” (Interviewee no. 19)

“I own twenty pigs at my farm. I regularly feed them with marinated banana stalks.” (Interviewee no. 20)

4.2.2. Desired Outcomes

Theme: Feed Pellet with Nutrients

The findings found that the household farmers required the feed pellet due to convenience. They currently use wet and powdered feeds for their pigs. Furthermore, they needed nutrients in feeds that improve growth and health and prevent disease. Seven of the respondents replied as follows:

“I want pelleted pig food.” (Interviewee no. 11)

“I need a pellet diet that makes pigs have average weight and good health because it can sell with the high price to the slaughterhouse. I am interested in pig feed products from the fermented fish meals but need to know the pig feed ingredients before using them.” (Interviewee no. 13)

“I prefer pellets for the sows because it’s more convenient when I feed them. Moreover, I want feeds with high nutrients for pregnant sows.” (Interviewee no. 14)

“I require excellent pellets with nutrients because good feeds can make pigs grow faster.” (Interviewee no. 15)

“I want a nutritious pellet. I also want a package that could store feeds longer.” (Interviewee no. 16)

“I want pelleted pig feed to make the pig grow faster and become pork that has red color.” (Interviewee no. 17)

“I would like to get pellet feed due to the convenience of use. I always feed dry feeds with other vegetable wastes and banana stalks. I want my pigs to grow according to the criteria.” (Interviewee no. 18)

4.2.3. Pain Points

Theme: High Cost of Feed

The results indicated that the household farmers had pain points involving the high cost of feed. They were responsible for the entire farming productions, including feeds, utilities, medicines, and other costs. Hence, they need to reduce the cost of feeds. Four of the respondents replied as follows:

“The problem that I found was mosquitoes biting pigs, which can cause a skin wound. I currently solve the problem by using anti-mosquito lamps. I also have a problem related to the prices of feeds. I want to decrease the production cost of pig farming. If the swine

feed from fermented fish waste can reduce the high cost of feeds, I am probably interested in using this swine feed.” (Interviewee no. 11)

“The problem is the high expense of food. Thus, I usually feed my pigs with wet feeds and leftover foods that I eat. However, I am currently looking for substitute feed materials to minimize the cost of feeds. So, I want to try pig feed from fish waste because it might be better than the current feeds. I also want to diminish the cost related to the farming production.” (Interviewee no. 12)

“I encounter the feed cost issues due to the high soybean price.” So, this caused price of swine feed to increase. Now, I try to use less instant feed and other food scraps instead. However, I am interested in alternative feed ingredients if this can solve the high-cost problem.” (Interviewee no. 14)

“The main issue that I am concerned about right now is the high expenditure of feeds and other miscellaneous expenses. Thus, it might be good to use pig feed from food waste due to cost reduction.” (Interviewee no. 15)

Theme: Mold in Feeds

The findings revealed that the household farmers encountered problems involving the mold in feeds due to inefficient storage and transportation. Four of the respondents replied as follows:

“The problem I encountered was moist food easy to cause mold. Even though I try to store the feeds in closed containers, there is still high moisture in the swine feeds. Unlike my friends who use a contract farming system, the company takes care of everything. However, I think contract farming takes advantage of farmers. So, I decided not to sign the contract with them.” (Interviewee no. 13)

“The pain point is that the feed is spoiled quickly. Another problem is the mold may occur in the feed.” (Interviewee no. 16)

“The problem is that I bought feedstuffs for a long time, which causes the mold. I usually use the feed from a well-known agribusiness company. However, I hesitate to participate in the company’s contract farming system. I realize that it is not easy to break away from the company when I want to.” (Interviewee no. 18)

“The issue is powdered feed is prone to mold from moisture and dust in the pigsty. I am also concerned about the price of feeds because feeds that contain 16 percent of protein are more expensive than conventional formula feeds.” (Interviewee no. 19)

4.3. Organic Farm

4.3.1. Behaviors

Theme: Organic Feeding Behavior

The findings exhibited that the organic farmers usually feed pigs with organic ingredients such as organic vegetables, fruits, grass, and rice. In addition, they avoided using antibiotics and vaccines with their pigs. Four of the respondents replied as follows:

“I’ve been farming organically for about nine years. We do not use any antibiotics or vaccines. The organic materials are non-toxic vegetables and fruits.” (Interviewee no. 21)

“My farm uses organic rice bran and fruits as the feedstuffs. Besides, I raise the pigs in a large field that allows them to have more space for sleeping and running. This method can benefit the pigs’ physical and mental health.” (Interviewee no. 22)

“I use organic fruits grown locally as the feeds for the pigs. Furthermore, piglets are fed by using sow milk.” (Interviewee no. 23)

“My farm is a medium-sized pig farm with 700–800 pigs. I feed them with natural foods, including grass, corn, and rice bran.” (Interviewee no. 24)

4.3.2. Desired Outcomes

Theme: Nutrient Concerns

The results showed that organic farmers needed the feeds with nutrients the same as the other two groups. Four of the respondents replied as follows:

“I consider the nutritional requirement of pig feeds. So, I would like pig feeds to contain protein, calcium, and other nutrients that are important for the growth of pigs.” (Interviewee no. 21)

“I want feedstuffs that positively affect the pigs’ health and growth. Finally, I want pork meat to have natural red color and good smell.” (Interviewee no. 22)

“I need feeds containing 16 percentages of protein for fattening pigs.” (Interviewee no. 23)

“I require nutritional feeds but lower prices.” (Interviewee no. 24)

4.3.3. Pain Points

Theme: The More Extended Period of Raising and High-Cost Organic Farming Process

The findings revealed that the organic farmers hardly had the pain points related to the feedstuffs. However, they stated that organic farming took longer to raise pigs than industrial or conventional pig farming. Furthermore, the cost of organic farming processes could be high due to organic feeds, large spaces, and hygiene systems. Four of the respondents replied as follows:

“The pain points could be the time-consuming process and high cost for operating the entire organic farming systems.” (Interviewee no. 21)

“The organic pig farm takes longer time to raise pigs than the chemical pig farms.” (Interviewee no. 22)

“I think the pain point is the period for raising the swine because the organic deep-pit swine take longer time to raise than the industrial swine.” (Interviewee no. 23)

“The challenging must be a high cost for installing the organic farming systems based on the organic requirements. I think raising organic pigs may take times as well.” (Interviewee no. 24)

After interviewing the three customer segments on their behaviors, desired outcomes, and pain points, we used the segmentation matrix to prioritize the most potential customer for swine feed from fermented fish residue. There are five criteria, including depth of pain, budget, ease of reach, ease of MVP, and size of the market. First, we estimated these five criteria of each segment by analyzing the interview transcripts. Then, we measured the scores, which were high, medium, and low.

According to Table 6, the contract farm had a low score for depth of pain because the agribusiness companies were responsible for drugs, veterinarians, feeds, and other associated services. In addition, the companies provided feedstuffs and proper feed formulation for the farmers. Hence, this segment rarely has problems involving feedstuffs. The budget of this segment had a high score because the agribusiness companies supported capital funds relating to the entire pig productions. However, the ease of reach was low because the contract farmers could not use the other feedstuffs outside the companies according to contract agreements and regulations. The ease of MVP was a medium score because the feed producers can moderately produce the feed product features that meet the contract farmers’ needs. Finally, the size of the market has a high score since the number of swine contract farmers is rising in Thailand.

For household farmers, the depth of pain was high because they encountered problems involving insufficient nutrients and the high cost of feedstuffs. In contrast, the budget was low since they were financially self-supported on the entire farm operations. They also encountered a shortage of budget during pig production. On the other hand, the ease of reach was high because household farmers regularly purchase instant feeds with other food ingredients, including fish, vegetables, rice bran, and rice husk. Thus, there were possibilities that the household farmers would attempt to use the other alternative feed products. However, the feed makers can reasonably provide the feed product features that satisfy the needs of the contract farmers; therefore, MVP was given a medium score for simplicity of use. Ultimately, the market size has a medium score because the number of household farms decreases compared with the contract farms in Thailand.

Table 6. Segmentation matrix.

Customer	Depth of Pain	Budget	Ease of Reach	Ease of MVP	Size of Market	Total Scores	Rank
Contract farm	L	H	L	M	H	10	2
Household farm	H	L	H	M	M	11	1 *
Organic farm	M	M	L	L	L	7	3

Source. Data adapted from authors (2022). Note. H = high; M = medium; L = low. Note. * Implying the highest possible scores.

For organic farmers, the depth of pain was medium because they usually grew the chemical-free vegetables, fruits, and rice that at the farms to use as organic pig feeds. They only encountered problems related to the organic vegetable growing techniques. Hence, they rarely had the pain points involving the feedstuffs. The budget of this segment had a medium score because they were self-sufficient in all aspects of the farm's activities, but they could make profits when selling organic pork. Nevertheless, the ease of reach was low because the organic farmers utilized authentic organic feed ingredients. Thus, they were less likely to attempt to use other feeds than non-organic produced feeds. The ease of MVP was given a low score because the feed from the fermented fish wastes was not made from organic feed ingredients. Eventually, the market size has a low score because Thailand has very few organic pig farms.

In conclusion, the segmentation matrix (Table 6) suggests that household farmers are the optimal target segment for the sustainable swine feed prototype.

5. Discussion

Participants in segment 1 were the most likely to use instant feed materials from agri-industrial companies because they were operating pig farm productions under the contract agreement with the companies. This result was consistent with a previous study by Porter and Phillips-Howard [53]. They concluded that contract farmers should comply with strict timetables and regulations since the contract provides guidelines on what practices must be followed in terms of pig production systems. In contrast, participants feed pigs in segments 2 and 3 according to their knowledge and experience. The participants in segment 2 were most likely to use other alternative feeds instead of pure instant feeds because the main reason was to reduce production costs. Food scraps, rice bran, rice husk, banana stalks, and vegetable wastes could all be used as alternative feeds. In addition, some of them did not have much nutritional knowledge for feeding the proper feedstuffs to their pigs. Therefore, this could cause disease and the death of swine. According to Chittavong et al. [54], pig farmers are unaware of nutritional deficiencies in pigs due to a lack of nutritional knowledge. Finally, participants in segment 3 are most likely to use organic feeds due to organic farming guidelines, which is different from segments 1 and 2. The participants in segment 3 utilized the organically produced feed ingredients by growing chemical-free vegetables, fruits, and rice on their farms. The finding was consistent with Ambrosius et al. [55], demonstrating that organic pig production involves organic feeds, less sophisticated diets, good health management schemes, and outdoor access.

The participants in the three segments generally require nutritional compositions in swine feeds that impact the growth performance and meat quality traits, consistent with a previous study by Bock and Van Huik [56]. This study demonstrated that the main incentive for farmers to select swine feed is the nutritional value contained in the feed, which results in high-quality production. In addition, most participants in segment 2 required pellet feed due to the convenience of use and pig health benefits. According to De Vries et al. [57], pellets are healthier for pigs because they are easier to digest and absorb. Additionally, pellets perform well in storage and transportation.

Most people in segment 1 do not have problems with production because the companies help pig contract farmers with nutrition and other things. Furthermore, the companies provide financial support to the farmers. Moreover, the companies oversee other related

issues, including health, drugs, and vaccines. Hence, swine specialists and veterinarians were on-hand to regularly check the pigs' growth performance and health. This result was consistent with Miyata et al. [58], suggesting that company sponsors provide financial security to the farmers to minimize pig production risk and uncertainty and increase company sponsors' profitability. Segments 2 and 3, on the other hand, had production issues due to high costs and a lengthy production time. Segment 2 encountered the high cost of production in terms of feed materials and other related farming operations. As a result, most participants in segment 2 were most interested in swine feeds made from fermented fish industrial residues because they aim to reduce the cost of production in terms of feed prices. This finding was consistent with Florou-Paneri et al. [59], indicating that protein sources were costly, which caused feed prices to increase dramatically. Hence, fermented fish residue feed could be a viable substitute for traditional pig feed if the cost is low enough.

Moreover, participants in segment 2 experienced pig diseases that caused sudden death in pigs, which resulted in profit losses in commercial swine production. This result was consistent with a previous study by Niemi et al. [60], which indicated that swine fever epidemics cause financial losses in the pig production industry. Participants in segment 2 also had problems with the moisture in pig feed because of storage problems. According to Souza et al. [61], the defective feed storage caused the growth of mold, which can result in the production of mycotoxins and bug and pest damage, lowering the feed's nutrient density. This results in the production of mycotoxins, which contaminate the diet and can be highly harmful to pigs.

In contrast, most participants in segment 3 claimed that they took an extended period to raise organic pigs than industrial pigs. Farmers carefully grow the organic pig for about six months. This is longer than the time it takes to grow an industrial pig. In contrast, industrial pigs grow faster because they feed instant feeds containing essential substances for growing pigs. In addition, participants in segment 3 experienced high costs in the organic farming processes. Organic farming can be more time-consuming and expensive, and organic feed is significantly more expensive than non-organic feed, which is consistent with Jouzi et al. [62]. Hence, the organic farmer segment seems interested in using swine feed from fermented fish industrial waste. However, segment 3 needs to be concerned whether the raw ingredients from fermented fish wastes are organically produced.

6. Research Implications

The following recommendations were made based on the research findings to three primary stakeholders in Thailand: producers, farmers, and policymakers. First, the results of this study suggested that the household farmer was the target customer of swine feed from fermented fish industrial wastes. Hence, this study suggested feed product prototype features derived from solutions that resolve the household farmers' pain points. First, the feed producers are expected to produce excellent quality feed that contains essential nutrients. The feeds should improve growth rate and health status, enhance immunity, and prevent disease. Additionally, the feeds should be in closed or sealed bags that prevent moisture. This ensures that the pellet feed will not be contaminated with mold.

Furthermore, the farmers are expected to select the proper feed formulation suitable for different ages of swine. To achieve optimal and healthy growth change of pigs, the farmers need to recognize nutritional requirements. For instance, a finisher pig or an adult pig requires a lower protein and energy diet than a weaner or young pig.

Moreover, to enhance the quality of pig feeds, the policymakers are expected to enforce nutrition values such as protein to the production of pig feed in Thailand to ensure that each age of swine is healthy. The policymakers should regulate the quality and quantity of substances used as feed ingredients. In addition, the policymakers should support the concept of alternative feed ingredients, such as fermented fish industrial wastes, to use as the protein in pig diets. Policymakers should improve the awareness of pig farmers regarding the use of protein source substitutes from other food wastes generated by food

manufacturers, so they can better understand alternative feed ingredients and how to reduce environmental issues related to food waste. Lastly, using alternative feed ingredients from food waste minimizes the food waste issues and allows swine farmers to reduce their cost of production in terms of feed materials.

7. Strengths and Limitations of This Study

To our knowledge, this is the first published qualitative study related to the development of a sustainable pig feed prototype made from fermented fish industrial residues, which adopted the lean entrepreneur concept created by Cooper and Vlaskovits [25]. First, the study focused primarily on understanding the farmers' behaviors, desired outcomes, and pain points. Then, the researchers provided the optimal solutions to resolve the farmers' pain points and suggested the solution features for the feed product.

Finally, this study has some limitations, but they also provide prospective arenas to enhance future research. First, as for the data collection, the number of organic pig farmers was less than the other two segments (contract farms and households) because there were limited organic pig farms in the Northeast of Thailand. Second, although the research participants were from 11 provinces across the Northeastern Region of Thailand, sampling and data collection were exclusively conducted only in the specific region of Thailand. Therefore, the suggested product features would fit well with the pig farmers in this region. Although this research may have empirical relevance, one should be cautious when interpreting the results.

8. Conclusions

Given that an estimated 1500 tons of fermented fish industrial residue is discarded and the demand for animal feed is expected to increase, fish waste utilization as animal feed can contribute to the diminishment of feed ingredient shortages. In addition, fish waste may contain nutrients that facilitate its transformation into swine feed. Moreover, to develop sustainable swine feed products, this research adopted the lean entrepreneur concept to understand the pig farmers' behaviors, desired outcomes, and pain points in using feedstuffs.

The findings revealed that the household farmer was the target customer of swine feed from fermented fish industrial wastes. We found that the household farmers fed their pigs with instant feeds and alternative feeds, including vegetables, fruits, rice bran, rice husk, and banana stalk. In addition, their desired outcomes were the pellet feed materials since feed pellets were easier to use than wet or powdered feeds. Furthermore, the farmers require swine feed to have nutritional compositions that enhance pig growth performance and meat quality traits.

Moreover, the pain points of the household farmers were the expensive cost of feeds and mold in feeds. Therefore, this segment needs to minimize the cost of feeds by using other alternative feeds such as the wastes of fish, vegetables, and fruits. They also need a better way to avoid mold in feed storage. Thus, the producers need to contain feeds inside a closed plastic sack with a moisture-proof bag to prevent mold contamination in feeds. Hence, the sustainable swine feed made from fermented fish residue can fulfill the household farmers' needs in terms of nutritional value and solve their pain points in terms of cost reduction.

In the future, the addition of low-cost, waste-derived items to animal diets may be a way to minimize production costs, which make up a significant part of overall swine production costs for Thai farmers. This could be a good reason for stakeholders in the business sectors to get involved in using fermented fish industrial waste as animal feed, as long as quality and safety are guaranteed. Finally, food waste recycling in animal nutrition may assist in reducing environmental effects, improving the environmental footprint of livestock production, and contributing to the UN Sustainable Development Goals Target 12.3 to halve food waste by 2030.

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Appendix A. Questionnaire

The questionnaire explores consumer behavior, desired outcome, and pain points using pig feeds.

Appendix A.1. Demographic Data of Respondents

1. Gender
☐ Male ☐ Female
2. Age (years)
☐ 20–30 ☐ 31–40
☐ 41–50 ☐ 51–60
3. Education level
☐ Secondary education ☐ Vocational Certificate/Diploma
☐ Bachelor ☐ Master
☐ PhD
4. Income (Baht)
☐ 0–20,000 ☐ 20,001–40,000 ☐ 40,001–60,000 ☐ 60,001–80,000 ☐ 80,001–100,000 ☐ More than 100,000
5. Frequency of buying pig feeds per week
☐ Less than once a week
☐ 1–2 times a week
☐ 3–4 times a week

Appendix A.2. General Information about the Purchase of Pig Feeds of the Respondents

6. Behaviors
 - 6.1 What food do you feed pigs? / How do you raise your pigs?
7. Desired outcomes
 - 7.1 What are specific features of pig feed do you want?
8. Pain points
 - 8.1 What pain points hinder you from reaching the desired outcomes of using pig feedstuffs?
9. Would you be willing to try the pig feeds from fermented fish industrial residues when launching in the markets?
10. Would you be willing to recommend the pig feeds from fermented fish industrial residues products to other people?

References

- Gustavsson, J.; Cederberg, C.; Sonesson, U.; Emanuelsson, A. The Methodology of the FAO Study: “Global Food Losses and Food Waste—Extent, Causes and Prevention”—FAO, 2011. The Swedish Institute for Food and Biotechnology. Sweden. 2013. Available online: <https://www.diva-portal.org/smash/get/diva2:944159/FULLTEXT01.pdf> (accessed on 8 January 2022).
- FAO—Food and Agriculture Organization of the United Nations. Food Loss and Food Waste. Available online: <https://www.fao.org/food-loss-and-food-waste/flw-data> (accessed on 21 January 2022).
- Food Loss and Waste and the Right to Adequate Food: Making the Connection Right to Food Discussion Paper*; FAO: Rome, Italy, 2018.
- Castrica, M.; Tedesco, D.E.A.; Panseri, S.; Ferrazzi, G.; Ventura, V.; Frisio, D.G.; Balzaretto, C.M. Pet food as the most concrete strategy for using food waste as feedstuff within the European context: A feasibility study. *Sustainability* **2018**, *10*, 2035. [CrossRef]
- Lipinski, B.; Hanson, C.; Lomax, J.; Kitinoja, L.; Waite, R.; Searchinger, T. *Reducing Food Loss and Waste. Working Paper, Installment 2 of Creating a Sustainable Food Future*; World Resources Institute: Washington, DC, USA, 2013; Available online: <http://www.worldresourcesreport.org> (accessed on 8 January 2022).
- In Bangkok, Tech Startups Take on Food Waste. Available online: <https://www.unep.org/news-and-stories/story/bangkok-tech-startups-take-food-waste> (accessed on 8 January 2022).
- Ingrao, C.; Faccilongo, N.; Di Gioia, L.; Messineo, A. Food waste recovery into energy in a circular economy perspective: A comprehensive review of aspects related to plant operation and environmental assessment. *J. Clean. Prod.* **2018**, *184*, 869–892. [CrossRef]
- San Martín, D.; Ramos, S.; Zufía, J. Valorisation of food waste to produce new raw materials for animal feed. *Food Chem.* **2016**, *198*, 68–74. [CrossRef] [PubMed]
- Salemdeeb, R.; zu Ermgassen, E.K.H.J.; Kim, M.H.; Balmford, A.; Al-Tabbaa, A. Environmental and health impacts of using food waste as animal feed: A comparative analysis of food waste management options. *J. Clean. Prod.* **2017**, *140*, 871–880. [CrossRef] [PubMed]
- Georganas, A.; Giamouri, E.; Pappas, A.C.; Papadomichelakis, G.; Gallioui, F.; Manios, T.; Tsiplakou, E.; Fegeros, K.; Zervas, G. Bioactive compounds in food waste: A review on the transformation of food waste to animal feed. *Foods* **2020**, *9*, 291. [CrossRef] [PubMed]
- Shurson, G.C. “What a Waste”—Can we improve sustainability of food animal production systems by recycling food waste streams into animal feed in an era of health, climate, and economic crises? *Sustainability* **2020**, *12*, 7071. [CrossRef]
- Hammoumi, A.; Faïd, M.; El Yachoui, M.; Amarouch, H. Characterization of fermented fish waste used in feeding trials with broilers. *Process Biochem.* **1998**, *33*, 423–427. [CrossRef]
- Hassan, T.E.; Heath, J.L. Biological fermentation of fish waste for potential use in animal and poultry feeds. *Agric. Wastes* **1986**, *15*, 1–15. [CrossRef]
- Wehrle, M.; Birkel, H.; von der Gracht, H.A.; Hartmann, E. The impact of digitalization on the future of the PSM function managing purchasing and innovation in new product development—Evidence from a Delphi study. *J. Purch. Supply Manag.* **2021**, 100732. [CrossRef]
- Konu, H. Developing nature-based tourism products with customers by utilising the Delphi method. *Tour. Manag. Perspect.* **2015**, *14*, 42–54. [CrossRef]
- Singh, P.K.; Sarkar, P. A framework based on fuzzy Delphi and DEMATEL for sustainable product development: A case of Indian automotive industry. *J. Clean. Prod.* **2020**, *246*, 118991. [CrossRef]
- Azanedo, L.; Garcia-Garcia, G.; Stone, J.; Rahimifard, S. An overview of current challenges in new food product development. *Sustainability* **2020**, *12*, 3364. [CrossRef]
- Guiné, R.P.F.; Florença, S.G.; Barroca, M.J.; Anjos, O. The link between the consumer and the innovations in food product development. *Foods* **2020**, *9*, 1317. [CrossRef] [PubMed]
- Henriques, A.S.; King, S.C.; Meiselman, H.L. Consumer segmentation based on food neophobia and its application to product development. *Food Qual. Prefer.* **2009**, *20*, 83–91. [CrossRef]
- Siró, I.; Kápolna, E.; Kápolna, B.; Lugasi, A. Functional food. Product development, marketing and consumer acceptance—A review. *Appetite* **2008**, *51*, 456–467. [CrossRef] [PubMed]
- Hendler, S. Digital-physical product development: A qualitative analysis. *Eur. J. Innov. Manag.* **2019**, *22*, 315–334. [CrossRef]
- Falck, A.C.; Rosenqvist, M. What are the obstacles and needs of proactive ergonomics measures at early product development stages?—An interview study in five Swedish companies. *Int. J. Ind. Ergon.* **2012**, *42*, 406–415. [CrossRef]
- De Pinho Campos, K.; Norman, C.D.; Jadad, A.R. Product development public-private partnerships for public health: A systematic review using qualitative data. *Soc. Sci. Med.* **2011**, *73*, 986–994. [CrossRef]
- Wu, Y.J.; Chen, J.C. Stimulating innovation with an innovative curriculum: A curriculum design for a course on new product development. *Int. J. Manag. Educ.* **2021**, *19*, 100561. [CrossRef]
- Cooper, B.V. *The Lean Entrepreneur: How Visionaries Create Products, Innovate with New Ventures, and Disrupt Markets*, 2nd ed.; John Wiley & Sons: Hoboken, NJ, USA, 2016.
- Ahmad, S.; Wong, K.Y. Development of weighted triple-bottom line sustainability indicators for the Malaysian food manufacturing industry using the Delphi method. *J. Clean. Prod.* **2019**, *229*, 1167–1182. [CrossRef]
- Taylor-West, P.; Saker, J.; Champion, D. Market segmentation strategies for complex automotive products. *J. Strateg. Mark.* **2020**, *28*, 266–283. [CrossRef]

28. Plank, R.E. A critical review of industrial market segmentation. *Ind. Mark. Manag.* **1985**, *14*, 79–91. [\[CrossRef\]](#)
29. Dibb, S. Market segmentation: Strategies for success. *Mark. Intell. Plan.* **1998**, *16*, 394–406. [\[CrossRef\]](#)
30. Wijewardhana, G.E.H.; Weerabahu, S.K.; Nanayakkara, J.L.D.; Samaranayake, P. New product development process in apparel industry using Industry 4.0 technologies. *Int. J. Product. Perform. Manag.* **2021**, *70*, 2352–2373. [\[CrossRef\]](#)
31. Bhatia, A.; Chandani, A.; Chhateja, J. Robo advisory and its potential in addressing the behavioral biases of investors—A qualitative study in Indian context. *J. Behav. Exp. Financ.* **2020**, *25*, 100281. [\[CrossRef\]](#)
32. Khan, R.S.; Grigor, J.; Winger, R.; Win, A. Functional food product development—Opportunities and challenges for food manufacturers. *Trends Food Sci. Technol.* **2013**, *30*, 27–37. [\[CrossRef\]](#)
33. García, A.J.; Esteban, M.B.; Márquez, M.C.; Ramos, P. Biodegradable municipal solid waste: Characterization and potential use as animal feedstuffs. *Waste Manag.* **2005**, *25*, 780–787. [\[CrossRef\]](#)
34. Du, G.; Shi, J.; Zhang, J.; Ma, Z.; Liu, X.; Yuan, C.; Zhang, B.; Zhang, Z.; Harrison, M.D. Exogenous probiotics improve fermentation quality, microflora phenotypes, and trophic modes of fermented vegetable waste for animal feed. *Microorganisms* **2021**, *9*, 644. [\[CrossRef\]](#)
35. Angulo, J.; Mahecha, L.; Yepes, S.A.; Yepes, A.M.; Bustamante, G.; Jaramillo, H.; Valencia, E.; Villamil, T.; Gallo, J. Quantitative and nutritional characterization of fruit and vegetable waste from marketplace: A potential use as bovine feedstuff? *J. Environ. Manag.* **2012**, *95*, S203–S209. [\[CrossRef\]](#)
36. Esteban, M.B.; García, A.J.; Ramos, P.; Márquez, M.C. Evaluation of fruit-vegetable and fish wastes as alternative feedstuffs in pig diets. *Waste Manag.* **2007**, *27*, 193–200. [\[CrossRef\]](#)
37. Obi, F.O.; Ugwuishiwu, B.O.; Nwakaire, J. Agricultural waste concept, generation, utilization and management. *Niger. J. Technol.* **2016**, *35*, 957–964. [\[CrossRef\]](#)
38. Van Zanten, H.H.E.; Mollenhorst, H.; Oonincx, D.G.A.B.; Bikker, P.; Meerburg, B.G.; De Boer, I.J.M. From environmental nuisance to environmental opportunity: Housefly larvae convert waste to livestock feed. *J. Clean. Prod.* **2015**, *102*, 362–369. [\[CrossRef\]](#)
39. Angulo, J.; Mahecha, L.; Yepes, S.A.; Yepes, A.M.; Bustamante, G.; Jaramillo, H.; Valencia, E.; Villamil, T.; Gallo, J. Nutritional evaluation of fruit and vegetable waste as feedstuff for diets of lactating Holstein cows. *J. Environ. Manag.* **2012**, *95*, S210–S214. [\[CrossRef\]](#) [\[PubMed\]](#)
40. Cheng, Z.; Yin Mo, W.; Man, Y.B.; Lam, C.L.; Choi, W.M.; Nie, X.P.; Liu, Y.H.; Wong, M.H. Environmental mercury concentrations in cultured low-trophic-level fish using food waste-based diets. *Environ. Sci. Pollut. Res.* **2015**, *22*, 495–507. [\[CrossRef\]](#) [\[PubMed\]](#)
41. Sánchez-Muros, M.J.; Barroso, F.G.; Manzano-Agugliaro, F. Insect meal as renewable source of food for animal feeding: A review. *J. Clean. Prod.* **2014**, *65*, 16–27. [\[CrossRef\]](#)
42. Phonthanukitithaworn, C.; Sae-eaw, A.; Tang, H.; Chatsakulpanya, P.; Wang, W.; Ketkaew, C. Marketing Strategies and Acceptance of Edible Insects Among Thai and Chinese Young Adult Consumers. *J. Int. Food Agribus. Mark.* **2021**; in press. [\[CrossRef\]](#)
43. Megido, R.C.; Desmedt, S.; Blecker, C.; Béra, F.; Haubruge, É.; Alabi, T.; Francis, F. Microbiological load of edible insects found in Belgium. *Insects* **2017**, *8*, 12. [\[CrossRef\]](#)
44. Chia, S.Y.; Tanga, C.M.; van Loon, J.J.; Dicke, M. Insects for sustainable animal feed: Inclusive business models involving smallholder farmers. *Curr. Opin. Environ. Sustain.* **2019**, *41*, 23–30. [\[CrossRef\]](#)
45. Beski, S.S.M.; Swick, R.A.; Iji, P.A. Specialized protein products in broiler chicken nutrition: A review. *Anim. Nutr.* **2015**, *1*, 47–53. [\[CrossRef\]](#)
46. Rojas, O.J.; Stein, H.H. Processing of ingredients and diets and effects on nutritional value for pigs. *J. Anim. Sci. Biotechnol.* **2017**, *8*, 48. [\[CrossRef\]](#)
47. zu Ermgassen, E.K.H.J.; Phalan, B.; Green, R.E.; Balmford, A. Reducing the land use of EU pork production: Where there's swill, there's a way. *Food Policy* **2016**, *58*, 35–48. [\[CrossRef\]](#)
48. Singh, S. Contract farming system in Thailand. *Econ. Polit. Wkly.* **2005**, *40*, 5578–5586.
49. Ström, G.; Halje, M.; Karlsson, D.; Jiwakanon, J.; Pringle, M.; Fernström, L.L.; Magnusson, U. Antimicrobial use and antimicrobial susceptibility in *Escherichia coli* on small- and medium-scale pig farms in north-eastern Thailand. *Antimicrob. Resist. Infect. Control* **2017**, *6*, 75. [\[CrossRef\]](#)
50. Thanapongtharm, W.; Linard, C.; Chinson, P.; Kasemsuwan, S.; Visser, M.; Gaughan, A.E.; Epprech, M.; Robinson, T.P.; Gilbert, M. Spatial analysis and characteristics of pig farming in Thailand. *BMC Vet. Res.* **2016**, *12*, 218. [\[CrossRef\]](#) [\[PubMed\]](#)
51. Braun, V.; Clarke, V. Using thematic analysis in psychology. *Qual. Res. Psychol.* **2006**, *3*, 77–101. [\[CrossRef\]](#)
52. Juliet Corbin, A.S. *Basics of Qualitative Research: Techniques and Procedures for Developing Ground Theory*; Sage Publications: Thousand Oaks, CA, USA, 1998.
53. Porter, G.; Phillips-Howard, K. Comparing contracts: An evaluation of contract farming schemes in Africa. *World Dev.* **1997**, *25*, 227–238. [\[CrossRef\]](#)
54. Chittavong, M.; Lindberg, J.E.; Jansson, A. A field study on feed supplementation, body weight and selected blood parameters in local pigs in Laos. *Trop. Anim. Health Prod.* **2012**, *45*, 505–510. [\[CrossRef\]](#) [\[PubMed\]](#)
55. Ambrosius, F.H.W.; Kramer, M.R.; Spiegel, A.; Bokkers, E.A.M.; Bock, B.B.; Hofstede, G.J. Diffusion of organic farming among Dutch pig farmers: An agent-based model. *Agric. Syst.* **2022**, *197*, 103336. [\[CrossRef\]](#)
56. Bock, B.B.; Van Huik, M.M. Animal welfare: The attitudes and behaviour of European pig farmers. *Br. Food J.* **2007**, *109*, 931–944. [\[CrossRef\]](#)

-
57. de Vries, S.; Pustjens, A.M.; Schols, H.A.; Hendriks, W.H.; Gerrits, W.J.J. Improving digestive utilization of fiber-rich feedstuffs in pigs and poultry by processing and enzyme technologies: A review. *Anim. Feed Sci. Technol.* **2012**, *178*, 123–138. [[CrossRef](#)]
 58. Miyata, S.; Minot, N.; Hu, D. Impact of Contract Farming on Income: Linking Small Farmers, Packers, and Supermarkets in China. *World Dev.* **2009**, *37*, 1781–1790. [[CrossRef](#)]
 59. Florou-Paneri, P.; Christaki, E.; Giannenas, I.; Bonos, E.; Skoufos, I.; Tsinas, A.; Tzora, A.; Peng, J. Alternative protein sources to soybean meal in pig diets. *J. Food Agric. Environ.* **2014**, *12*, 655–660.
 60. Niemi, J.K.; Lehtonen, H.; Pietola, K.; Lyytikäinen, T.; Raulo, S. Simulated financial losses of classical swine fever epidemics in the Finnish pig production sector. *Prev. Vet. Med.* **2008**, *84*, 194–212. [[CrossRef](#)] [[PubMed](#)]
 61. Souza, C.F.; Da Silva, A.S.; Müller, L.K.F.; Baldissera, M.D.; Bottari, N.B.; Schetinger, M.R.C.; Santurio, J.M.; Gloria, E.M.; Machado, G.; Zanette, R.A.; et al. Changes of adenosinergic system in piglets fed a diet co-contaminated by mycotoxin and their effects on the regulation of adenosine. *Microb. Pathog.* **2018**, *114*, 328–332. [[CrossRef](#)] [[PubMed](#)]
 62. Jouzi, Z.; Azadi, H.; Taheri, F.; Zarafshani, K.; Gebrehiwot, K.; Van Passel, S.; Lebailly, P. Organic Farming and Small-Scale Farmers: Main Opportunities and Challenges. *Ecol. Econ.* **2017**, *132*, 144–154. [[CrossRef](#)]