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Quality improvement strategy of smoked catfish producer for e-commerce sales: a case study

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ABSTRACT

The expansion of digital technology, notably e-commerce, has revolutionized the business environment, offering immense potential for Indonesian SMEs. Small and medium-sized catfish processing businesses require improved process quality to reach online broader market. Meanwhile, there are several obstacles to improving quality in fish processing SMEs in Indonesia, include a lack of knowledge among producers and the absence of cold chain and food safety standards. Addressing these challenges is essential to enhance product quality, bolster SME competitiveness, and facilitate their integration into the digital marketplace. To solve this problem, this paper aims to identify consumer acceptance of the product, priorities of critical process, and priority procedures of smoked catfish production and e-commerce sales. This research employs a detailed single case study approach using both qualitative and quantitative methods. It starts with preliminary observations and in-depth interviews with business owners to understand the production process, quality challenges, and business goals, followed by consumer surveys and organoleptic tests to evaluate consumer acceptance of smoked catfish. The analysis method in this paper is modifications of House of Quality phases 1 and 2. The outcome of this research is the prioritization of measurable technical procedures as the focus for improvement by producers. By prioritizing critical processes such as smoking duration and implementing measurable operating procedures, SMEs can enhance product quality and meet e-commerce legal requirements, ensuring consistency and quality control throughout the production process.

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INTRODUCTION

Nowadays, digital technology has increased rapidly in many aspects of life in the last decades, and one of those affected by this change is the transaction in the business sector (Pagani and Pardo 2017). Digitalization has influenced the rising use digital platforms or electronic-based commerce (e-commerce). COVID-19 pandemic brings significant buying behavior from conventional methods to virtual purchases through e-commerce. Based on Statista Market Insights Data, Indonesia reportedly reached approximately 178.94 million e-commerce users in the end of 2020 and has increased by nearly 13% compared to previous year data (Mustajab 2023). Indonesia, as the largest e-commerce market in Southeast Asia, will provide greater opportunities for Small and Medium Enterprises (SMEs) in the food sector, especially to be able to develop their business transactions through e-commerce.

Indonesian SMEs have contributed significantly to the national economy due to their huge number of SMEs compared to other larger enterprises. The profile of marine and fisheries businesses in Indonesia based on the business scale is dominated by SMEs, with 60,429 units (98.8%) in 2019. In comparison, medium and large businesses only account for 1.2% or 718 units. Most fish-processing SMEs in Indonesia are located in East Java Province, with a total of 10,624 units, while Central Java stood in third place with 6,552 units in 2019 (DJDPSP Kelautan dan Perikanan, 2020). One of fishery commodities that has good prospect is catfish (*Clarias* sp.). Additionally, catfish is a type of freshwater fish widely cultivated and consumed by Indonesian people, so it has encouraged a significant increase in catfish production, accounting for 2.95%, reaching 1.06 million tons in 2021 (Widi 2022). According to this data, the potential for processed catfish production on an SME scale is very large to be marketed more widely via e-commerce.

In reaching a broader online market, small and medium-sized catfish processing businesses require improved process quality. This is because longer distribution distances and times increase the risk of decay and contamination. However, research found that fishery raw materials are more prone to deterioration than other raw materials, thus requiring special treatments from post-harvest handling to transportation (FAO 2016). Contamination can also originate from chemical, physical, and microbiological sources. Bacteria such as *Clostridium botulinum* and *Aeromonas hydrophilla* can infect fresh fishery products, while *Listeria monocytogenes* and *Staphylococcus aureus* contaminate through the processing steps (Boziaris 2014). Furthermore, previous research concluded that there are several obstacles to improve the quality in fish processing SMEs in Indonesia, such as producers' lack of knowledge regarding proper handling and processing (Wulandjani and Hatta 2019, Setyoko and Kristiningrum 2019), as well as the absence of cold chain standards from raw materials to marketing (Aminatuzzuhra et al. 2016). Apart from that, there is no implementation of food safety standards in the production process that refer to Good Manufacturing Practice (GMP) and Hazard Analysis and Critical Control Points (HACCP) (Citra et al. 2015). Those factors results in the low quality of SMEs products, causing the decrease of product value and hindering the entry of products into e-commerce (Voldnes et al. 2021).

The research gap lies in the limited exploration of quality improvement strategies specifically tailored for freshwater fish processing units for e-commerce sales. Existing research has investigated strategies for improving the quality of SME products. For instance, Herzallah et al. (2014) examined the the correlation between the Total Quality Management (TQM) framework and SME financial performance, while Eniola et al. (2019) explored the relationship between the framework and organizational structure. Some publications explain the aspects of e-commerce technology adoption by SMEs, including pressures from business stakeholders and the government (Kurnia et al. 2015), lack of understanding of the internet (Supriyanta and Anggraini 2021), and mastery of electronic mechanisms in business activities (Dharmawansa et al. 2023). In technical aspects, several studies have been conducted to enhance the quality of smoked catfish, including the use of spices for improved sensory quality and shelf life (Ekelemu et al. 2021), smoking technique (Adeyeye et al. 2017) and packaging (Ahmed 2019). However, their integration into an overarching quality improvement strategy for e-commerce sales remains unexplored.

A specific case study was conducted in one of the catfish producers in Pati Regency, Central Java, Indonesia. The background of this study is

the limited market reach of smoked catfish produced in the region. Additionally, there is currently no established quality standard for smoked catfish that ensures its suitability for marketing through e-commerce in accordance with consumer requirements. Through an in-depth study of a specific SME, this research aims to shed light on the unique challenges and opportunities faced by such enterprises. The urgency of this study, therefore, holds substantial importance in contributing practical solutions to the challenges faced by SMEs in the specific domain of processing freshwater fish products in Central Java. In particular, the research aimed to (1) identify consumer acceptance of the product, (2) identify priorities of critical process, and (3) identify priority procedures of smoked catfish production and e-commerce sales.

METHODOLOGY

This research applies a single detailed case study approach by using qualitative and quantitative method. It begins with preliminary observation and in-depth interview with business owner to gain a general overview of the production process, quality challenges, and business goals. Subsequently, consumer survey and organoleptic test were practiced to assess the level of consumer acceptance in consuming smoked catfish. After that, the technical qualification of smoked catfish products for e-commerce sales was developed involving expert panel in the processing of freshwater fish products to obtain valid technical specifications for the distribution of smoked catfish over long distances. In terms of business transactions with e-commerce, IT experts were also required to provide input on the electronic business transactions that SME need to master, as it explained in the publication of Dharmawansa et al. (2023).

Furthermore, priority manufacturing strategies were identified using the House of Quality (HoQ) tool (Oddershede et al. 2019). The steps in developing HoQ are :

1. Voice of Customer (WHATS): Identify and list customer needs obtained from consumer survey of consumer acceptability
2. Critical Process Attributes (HOWS): Convert customer needs into measurable technical specifications
3. Relationship Matrix: Map relationships between WHATS and HOWS using strength indicators
4. Calculate Relative Importance: Multiply importance ratings with relationship values to determine technical priorities
5. Calculate Priorities: Determine the importance of each technical requirement based on customer needs and relationship strengths.

For the WHATS phase, consumer acceptability is measured by sensory evaluation testing, where consumers conduct a comparative analysis between two product samples. During this testing, participants taste both the main sample and a benchmark sample, systematically identifying and rating key sensory attributes such as texture, flavor, aroma, and appearance.

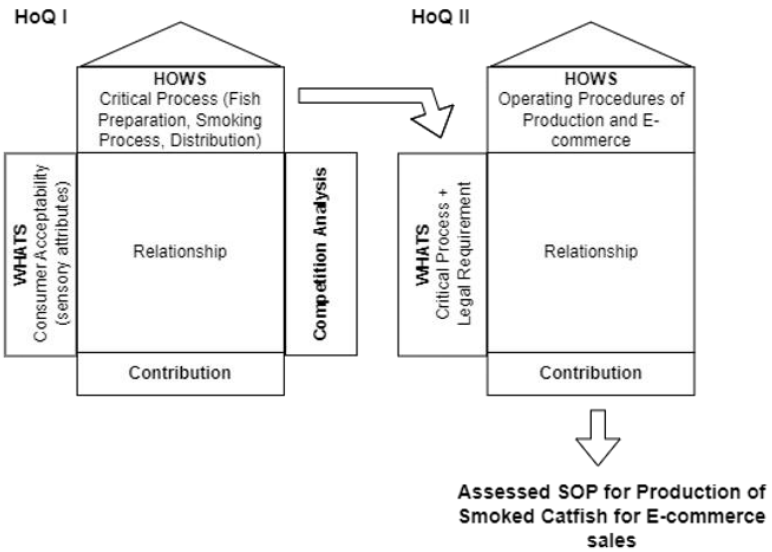


Figure 1 Research methodology

Table 1 WHATs List

No.	Sensory Attributes	Asymp. Sig.	No.	Sensory Attributes	Asymp. Sig.
1	Burnt aroma	0.753	10	Sweet taste	0.053
2	Smoky aroma	<0.001*	11	Smoky taste	<0.001*
3	Fat aroma	0.570	12	Watery texture	0.105
4	Fishy aroma	0.958	13	Soft texture	0.080
5	Sweet aroma	0.015	14	Compact texture	0.023*
6	Woody aroma	0.150	15	Sticky texture	0.036*
7	Sour taste	0.796	16	Shiny colour	0.009*
8	Salty taste	0.017*	17	Typical smoked fish colour	0.036*
9	Umami taste	0.006*			

* <0.05 : not significantly different

Table 2 Technical Qualifications (HOWS)

No.	Technical Attributes	No.	Technical Attributes
	Smoking Process		Distribution
1.	Smoking duration(Abraha et al. 2018)	4.	Long Product Shelf Life (Voldnes et al. 2021)
2.	Open/closed flame smoking process (Singh et al. 2016)	5.	Robust Packaging with minimum damage risk (Spruit and Almenar 2021)
3.	Smoke source materials (Arif et al. 2015)	6.	Vacuum packaging (Tocmo et al. 2014)
		7.	Cold chain distribution system(Voldnes et al. 2021)

The sensory evaluation survey uses a structured parameter system where consumers rate product performance on a 9-point hedonic scale (1 = Extremely Dislike to 9 = Extremely Like) for overall acceptance. The hedonic test results are then tested with the Kruskal Wallis statistical test to determine whether there is a significant difference between the main and benchmark samples (O'Mahony, 2017). The methodology of this research is depicted in Figure 1.

RESULTS AND DISCUSSION

Consumer Acceptability

In a consumer-centric approach to quality improvement, understanding and aligning with consumer acceptances are paramount. The product's success depends on aligning with customer preferences. Manufacturers should leverage these preferences for ongoing product innovation, moving away from relying solely on price-based competition (Zhou et al. 2015). Ultimately, a consumer-driven quality improvement approach, supported by positive customer acceptance, can significantly elevate the competitiveness of small-scale smoked catfish producers in the dynamic landscape of e-commerce sales.

The method to analyze consumer acceptability is hedonic testing. Byeon et al. (2023) applied those methods to identify factors influencing consumer acceptance. The results of consumer acceptability which show significant differences are used for the WHATs list (Wang et al. 2019) (Table 1).

Based on Table 1, the results of sensory evaluation show 17 attributes that were assessed by consumer panels using hedonic testing. Among these attributes, nine showed significant differences ($p<0.05$) between the main sample and benchmark: smoky aroma, salty taste, umami taste, smoky taste, compact texture, sticky texture, shiny color, and typical smoked fish color. These attributes are considered critical for inclusion in HoQ I because the performance of the main sample is expected to be improved to approximate that of the benchmark product. This improvement will be guided by an analysis of the relationship between these attributes and the corresponding technical qualifications, which will be discussed in the subsequent table. Based on Table I, the attribute with the most significant differences is aroma. To enhance the performance of the aroma

attribute in the product, the smoking process which combines the effects of curing, drying, heating, and smoking must be evaluated. (Huang et al. 2019).

Technical Qualifications (HOWS)

The next stage is to compile technical qualifications which describes critical process of smoked catfish. Technical attributes had been generated from literature, group discussion with producers (Kowalska et al. 2018) and expert panels having scientific background in aquatic product technology and e-commerce (Bevilacqua et al. 2012) (Table 2). Technical qualifications in Table 2 are divided into smoking process and distribution categories. The smoking process includes smoking duration, open/closed flame smoking process, and smoke source materials, all of which affect product characteristics. The distribution category consists of shelf life and cold chain system, robust packaging, and vacuum packaging to maintain product quality during e-commerce distribution. These attributes represent measurable engineering characteristics that address consumer requirements.

House of Quality I

HoQ is a tool used to translate consumer needs in the engineering design process. This research uses two HoQs: first, to translate consumer needs (WHATs) into critical process attributes (HOWs); second, to translate critical process attributes and legal requirements (WHATs) into measured operating procedures (HOWs). In the first HoQ, the WHATs were the results of consumer acceptability (Table 1), and then its relationship with the HOWs (Table 2) was assessed in the relation matrix within HoQ I (Table 3). The relationships are indicated using symbols representing strong (●), moderate (○), and weak (△) correlations, with corresponding values of 9, 3, and 1.

Table 3 HoQ matrix

	Column		1	2	3	4	5	6	7
Row	HOWs / WHATs		Smoking duration	n/closed flame smoking process	noke source materials	ong product shelf life	obust Packaging with inimum damage risk	Vacuum packaging	old chain distribution system
1	Burnt aroma	6.93	9	9	9	3	3	3	
2	Fat aroma	7.05	3	3	3	3	3	3	3
3	Fishy aroma	6.92	9	3	9	3	3	3	3
4	Sweet aroma	7.28	3	3	9	3	3	9	1
5	woody aroma	7.22	9	9	9	3	3	3	3
6	sour taste	7.00	3	3	3	9	3	3	
7	sweet taste	7.88	3	3	3	3	3	3	3
8	Watery texture	6.40	9	9	3	9	9	9	3
9	Soft texture	7.62	3	3	1	3	3	3	3
	Contributions		829.9	757.9	821.9	685.9	613.9	685.9	515.9
	Normalized Contributions		0.169	0.154	0.167	0.140	0.125	0.140	0.105
	Priorities		1	3	2	4.5	6	4.5	7

Table 4 WHATs of HoQ II

No.	Critical Attributes	No.	Critical Attributes
	Critical Processes		Legal Requirements
1	Smoking Duration	7	Applying GMP and HACCP (Arvanitoyannis and Kotsanopoulos 2012)
2	Smoke source materials	8	Halal Certification (Zulfa et al. 2023)
3	Open/close flame smoking process	9	Packaging Label Information (Elviana et al. 2022)
4	Long product shelf life	10	Fulfill chemical and microbiological paramaters of Indonesian quality standard (SNI 2325:2013) (Permanasari et al. 2020)
5	Robust packaging with minimum damage risk	11	E-commerce Operation
6	Cold chain distribution system	12	Capability to maintain e-commerce transaction (Kabanda and Brown 2017)
		13	Capability to maintain consumer engagement in SME e-commerce website (Di Fatta et al. 2018)

House of Quality I

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The results of HoQ I are process priorities that must be improved by producers because of the relationship between critical process and consumer acceptance.

House of Quality II

The next stage is to develop standard operating procedures resulting from the matrix between WHATs and HOWs. WHATs contain a list of priority critical processes resulting from HoQ I and legal requirements consisting of chemical, microbiological, halal certification and packaging information (Table 4).

Table 4 consists of critical processes (derived from HoQ I) and legal requirements. Critical processes include smoking duration, smoke source materials, open/closed flame smoking, shelf life, robust packaging, and cold chain distribution. Legal requirements cover GMP and HACCP implementation, halal certification, packaging labels, quality standards compliance, e-commerce operation, and consumer engagement capabilities. These requirements form the basis for developing technical procedures in the HOWs list.
The result of the HoQ II matrix shows the priority of operating procedures to improve the quality of smoked catfish (Table 6).

Table 6 shows the HoQ II matrix that maps relationships between WHATs (critical processes and legal requirements) and HOWs (technical procedures). After calculating the relative importance by multiplying importance ratings with relationship values, smoking for 8 hours at 60-70°C emerges as the highest priority procedure. This is followed by soaking fish in salt water and liquid smoke for 30 minutes, and using clean equipment during handling. The priority order indicates which technical procedures have the greatest impact on meeting both critical process requirements and legal standards

The second HoQ generates prioritized technical procedures that manufacturers must be aware of. The priority order shows how much influence the technical procedures in HOWs contribute to the critical processes in WHATs. Prioritizing technical procedures also allows manufacturers with limited capabilities to improve procedures in stages, starting with the highest-ranking procedures.

The first objective of this study was to identify consumer acceptability of smoked catfish by using hedonic testing. This step revealed several significant sensory attributes assessed by consumer panels. The most significant sensory attributes was fishy aroma, followed by sour taste and burnt aroma. The fishy aroma in smoked catfish products is due to the distinctive aroma inherent to catfish, characterized by earthiness and mud, particularly pronounced following the smoking process (Grimm et al. 2004). Smoking enhances the intensity of this fish aroma, thereby accentuating the fishy smell.

The second objective was to identify priorities of critical process that need enhancement based on consumer acceptability. The formulation of priorities utilizes the HoQ, which is a crucial component of Quality Function Deployment (QFD) (Ficalora 2009). The utilization of House of Quality (HoQ) across multi-phases of modified QFD enables researchers to integrate customer needs with technical specifications and legal requirements within the specific domain of the food industry. Previous studies, such as De Pelsmaeker et al. (2015) and Wang et al. (2019), used sensory attributes as a checklist in the WHATs, translating the Voice of Customer (VoC) into process attributes, consisting required ingredients and production processes. From this objective, we found that the first priority is smoking duration, as in research by Bolaji et al., (2022) that smoking duration with wood material can increase the scores of aroma, texture and overall acceptability.

Table 5 HOWs of HoQ II

No.	Technical Attributes	No.	Technical Attributes
	Raw Material Handling and Preparation		Distribution to customer
1	Removing fish guts	13	Using cooler or ice during product delivery
2	Washing fish with clean water (odorless, colorless and tasteless)		E-commerce Operation
3	Soaking fish with salt water and liquid smoke for 30 minutes	14	Using spesific smarphone/computer to operate transaction
4	Using clean, rust-free and non-porous equipment during material handling	15	Having strong motivation to access e-commerce
5	Handlers wear head coverings, masks and wash their hands regularly	16	Effective presentation of a product offered in the internet
	Processing	17	Competitive product price on e-commerce
6	Draining and hanging the fish in smoking cabinet	18	Relationship building with customers on e-commerce
7	Smoking for 8 hours in temperature of 60-70 ^{o}C		
	Packaging		
8	Cooling the hot smoked catfish in room temperature		
9	Using PP (Polypropylene) plastic for primary packaging		
10	Using vacuum packaging		
11	Using cardboard boxes for secondary packaging		
12	Including information of production date, composition and shelf life on secondary packaging		

Table 6 HoQ Matrix II

Row	WHATs \ HOWs		1 removing fish guts	2 ...ter (odorless, colorless and tasteless)	3 ...ing with salt water and ...d smoke for 30 minutes	4 ...on-porous equipment ...ring material handling	5 Handlers wear head ...erings, masks and wash ...their hands regularly	6 ...aining and hanging the ...sh in smoking cabinet	7 ...moking for 8 hours in ...mperature of 60-70 ℃	8 ...oling the hot smoked ...sh in room temperature	9 ...g ... plastic for primary packaging	10 Vacuum packaging	11 ...g cardboard boxes for ...econdary packaging	12 ...rmation of production ..., composition and shelf ...on secondary packaging	13 ...using ... ...narphone/computer to ...operate transaction	14 ...ng strong motivation to ...access e-commerce	15 ...product offered in the internet
1	Smoking Duration	0.15						1	9								
2	Smoke source materials	0.14			9			1	9								
3	Open/close flame smoking process	0.13			3	1	1	9	9	1							
4	Long product shelf life	0.12	9	3	9	3	9	1	9	3	1	9	1	9			
5	Robust packaging with minimum damage risk	0.10									3	3	9	3			
6	Cold chain distribution system	0.09								1	1	3	1				
7	Applying GMP and HACCP	0.08	9	9	9	9	9	1		1	1	9	3				
8	Halal Certification	0.06	1		1	1	1						1	9			
9	Packaging Label Information	0.05			1								9	9			
10	Fulfill chemical and microbiological paramaters of Indonesian quality standard	0.04	9	3	9	9	3	1	9	1		1		1			
11	Capability to maintain e-commerce transaction	0.03													9	9	9
12	Capability to maintain consumer engagement in SME e-commerce website	0.01											3	3	9	9	3
	Contributions		2.141	1.154	3.846	1.577	2.038	1.679	5.192	0.679	0.590	2.346	1.923	2.462	0.346	0.346	0.269
	Normalized Contributions		0.081	0.043	0.145	0.059	0.077	0.063	0.195	0.026	0.022	0.088	0.072	0.093	0.013	0.013	0.010
	Priorities		5	10	2	9	6	8	1	11	12	4	7	3	14	14	15

The last step of this research is to produce priorities of operating procedures in the production of smoked catfish and selling on e-commerce. The WHATs on HoQ II encompass critical processes and legal requirements that manufacturers must fulfil to enable the sale of their products through e-commerce platforms. Including legal requirements in the WHATs list is a consideration in the decision-making process for manufacturers, as compliance with these lists ensures food safety and quality assurance for consumers.

CONCLUSION

This paper has described an approach to identifying technical strategies for smoked catfish SME by utilizing modified House of Quality phase 1 and 2. The foundation for preparing technical strategies is consumer acceptance of the sensory products attributes using organoleptic test methods. This test produced 17 sensory quality attributes, which were eliminated into 9 attributes based on the differences significance between the main sample and the comparison product.

HoQ phase 1 results the priority of critical process dengan urutan pertama adalah smoking duration. Furthermore, the results of HoQ phase 2 are included in the WHATs list, supplemented by legal requirements for products to be sold through e-commerce platforms. The HOWs list in HoQ phase 2 utilizes measurable operating procedures covering the entire production process of smoked catfish until the product is sold through e-commerce. The HoQ phase 2 matrix generates the priority procedure, which is smoking for 8 hours at 60-70°C. This procedure should be addressed first.

The recommendations from the findings are tailored for small and medium-sized enterprises (SMEs). Given the priority identified in the House of Quality phase 1, SMEs should concentrate efforts on optimizing smoking duration and

condition. Further implication of the research findings is that SMEs can develop and implement measurable operating procedures that cover the entire production process, from raw material procurement to online sales. This includes standard practices for curing, packaging, storage and shipping to ensure consistency and quality control throughout the value chain.

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