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IEEM returns once more to Macau and we, at the organizing committee welcome industrial engineering and engineering management enthusiasts from all over the world participating in this year's conference. IEEM2019 brings together some high profile keynote speakers and workshop leaders, several sessions covering nineteen different topics on different aspects of industrial engineering and engineering management. A campus tour will be organized to the only public comprehensive University in Macau, the University of Macau, for visiting its State Key Laboratories and characterised Residential Colleges.

We live in challenging times. According to the world economic forum survey, climate change is top concern for the third year in a row. Large scale conflict, wars, and inequality is the other major concern. Engineering knowledge is relied upon to provide innovation and inventions that shape our society and improve the way we work and live. Hence, industrial engineering is one of the key influences that shapes our society. Please take this opportunity to listen to a talk, and imagine your contribution to the future.

Wishing you a successful conference to catch up on the latest developments in your field, forge new friendships and seek inspiration to use engineering management knowledge towards the solution of societal challenges. And while you are doing this enjoy the sounds, sights and culinary delights of Macau.

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[2]*Hubei University, China*
[3]*The Hong Kong Polytechnic University, Hong Kong SAR*
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Developing Bulk-liquid Traceability in Indonesian Coconut Oil Company

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Abstract - **Bulk-liquid food industry is identified as the most difficult industry in building a traceability system. A previous study has recommended an information system improvement. Therefore, the information system is proposed and discussed in this paper to improve the traceability system in the bulk-liquid food industry. This paper focused on the development of a bulk-liquid traceability information system architecture and prototype in Indonesian Coconut Oil Company. The system prototype has been verified. It was proven to reduce tracing and tracking time significantly. This system is also equipped with a feature to create a clear lot separation so as to prevent total recall. Finally, a future research direction is proposed.**

Keywords – **bulk-liquid, food safety, traceability, information system**

I. INTRODUCTION

Traceability information system in the food industry has received considerable attention over the past few years. Nowadays, the discussion of a traceability system is not only on food safety management area but also specialty foods such as halal food [1] and organic food [2]. Current technological support is no longer a barrier for developing a traceability system. It has been able to accommodate the needs of data collection, data transfer, and data processing accurately and timely. In terms of cost-benefit, reference [3] has proven that the most beneficial traceability system improvement for food industry is through an electronic information system. However, powerful drivers are still needed to trigger the food industry to develop its traceability system because of the high investment cost involved. The most powerful top-down driver is government regulation and the most powerful bottom-up driver is customer demand.

Food traceability is defined as a part of logistics management that captures, stores and transmits adequate information about food, feed, animals or food-producing substances at all stages in the food supply chain so that the product can be checked for safety, controlled for quality, traced upward, and tracked downward at any time [4]. The most common food safety management standard, ISO 22000: 2005, sets the minimum requirement for the food industry to track its products one-step-forward and one-step-backward. Then, the one-step-forward and one-step-backward traceability are known as internal traceability. The internal traceability has an important role in achieving the chain traceability that allows to track and to trace a product batch through the whole food chain. If there is one weak link, the chain traceability cannot be formed.

Food is no longer a commodity which is only transacted regionally. Even fresh food, nowadays, have been transacted internationally [5]. Food trade between developed and developing countries is inevitable. Developing countries tend to have less strict food safety regulation than developed countries [6]. By considering this condition, food commodities from developed countries are more easily traded in developing countries. Instead, it becomes a trade barrier for food commodities from developing countries. Therefore, wherever the food industry is located, it still has to be able to compete globally. The development of a traceability information system for a food industry is a way to overcome the international trade barrier and to maintain its existence.

The information technology is available and the triggers already exist. What is now needed by the food industry is an appropriate information system architecture. Each food industry is unique. Thus, there is no design that fits all. In the cattle sector, reference [7] has developed a traceability information system by utilizing RFID (Radio Frequency Identification) and Biotrack database. Reference [8] has proposed the framework of traceability information system for bulk grain supply chain. Reference [6] developed an electronic traceability system for mango. Reference [9] proposed e-pedigree, a food traceability system based on the integration of RFID, wireless sensor network, and data mining technique, to improve the traceability information system for kimchi producer.

Each food sector has its own challenges. However, at present, the most challenging food sector in developing traceability is the bulk-liquid food industry [3]. The rationale is a continuous transformation process makes it more difficult to define the traceable unit than a discrete reconfiguration process. Product transfer process through pipelines without being followed by its container makes impossible to attach the product identity. A small amount of high capacity storage causes unavoidably mixing between batches. If the product is in solid, even though it is uncountable like crystal, grain, or powder; creating a clear visible batch/ lot segregation is very possible. In the liquid product, to make a visible lot/ batch segregation needs a great investment. However, to date, there has been no study of the traceability information system framework that accommodates the characteristics of the bulk-liquid food industry. Therefore, this study highlights the development of internal traceability information system in the bulk-liquid food industry.

The objective of this study is to develop a bulk-liquid traceability information system that can help plan product storage, integrate information, and improve information quality. The limitation of this study is the traceability information system only accommodates one-step-forward tracking and one-step-backward tracing or internal traceability. The traceability system was developed for a coconut oil industry in Indonesia which trades its products in bulk. The five-step traceability system development proposed by reference [10] was adjusted then employed in this study to produce a prototype of electronic traceability information system for the bulk-liquid food industry. The five steps are (1) bulk-liquid food industry business process analysis, (2) bulk-liquid food industry business process modeling, (3) data collection, (4) data modeling, and (5) generation and customization of the web-based application. Step one and two had been conducted and published in reference [11]. Therefore, this paper continues the discussion of step three to five.

II. METHODOLOGY

An adjusted five-step methodological approach was used in developing the bulk-liquid traceability system. An adjustment was needed because the methodology was developed for a broader scope of the traceability system. Since the research subject is a coconut oil industry, the first step was studied and analyzed the coconut oil supply chain characteristics, identified the players, main processes and resources, including inputs required in every phase of product transformation. The result was presented in a case narrative. In the second step, the business process of the coconut oil industry was modeled using a well-proven process mapping method proposed by reference [12]. The result of step one and two have published in reference [11].

Step one and two are the essential steps to support step three: data collection. The main problem in designing an efficient traceability information system is the identification and classification of traceability data that is appropriate to be recorded and available whenever needed. Haphazard data collection method was used. Then, the data was selected and identified to determine the most important data to be recorded. In step 4: data modeling, Data Flow Diagram (DFD) was used to develop the traceability database model. The DFD can show the information flow more clearly than other techniques. The final step: generation and customization of the web-based application were conducted using a prototyping approach. The particularity of the prototyping approach is to carry out analysis, design, and implementation activities together. The aim is to shorten the development time of a new system prototype so that it quickly gets feedback from users [13]. The prototyping process can be seen in Figure 1. The users involved in this project are the members of production planning and inventory control (PPIC), warehouse, quality control, quality assurance, production, marketing, purchasing, and information management system.

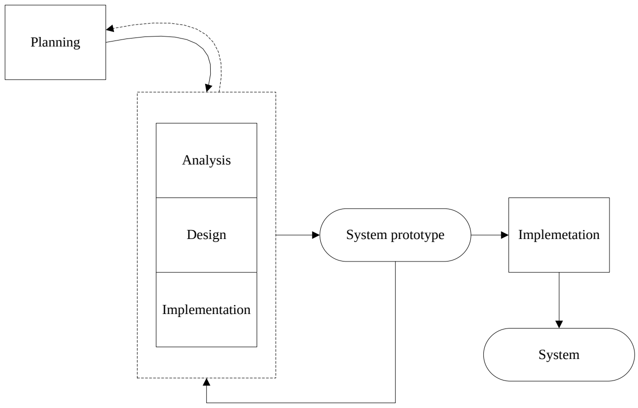

Fig. 1. Prototyping process.

III. RESULTS

The result of this study is a tailored traceability information system for bulk-liquid industry. The rationales behind the 'make' decision for the information system are flexibility and resource availability. The information system architecture of the proposed bulk-liquid traceability system is illustrated in Figure 2. The architecture was explained in four layers, namely: function layer, model layer, software layer, and auto_id layer. This information system was built with Structured Query Language (SQL) using MySQL. There are 14 modules in the bulk-liquid traceability system that can be accessed by the registered user. Each user will access different modules based on his/ her access right. Barcode system identification was used to shorten information collection. The barcode serial number can be used to trace the final product whenever there is a quality or safety issue. This barcode is printed on the order delivery form and tap seal so that it can be matched and archived by the customer. Barcode system is still capable of accommodating current needs so that there is no urgency to use higher technology.

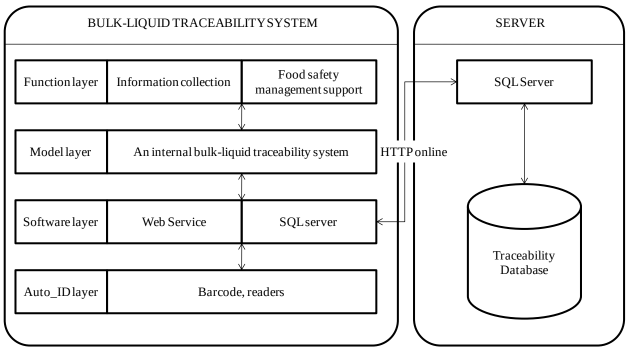

Fig. 2. The architecture of the bulk-liquid traceability system.

Based on the architecture, Data Flow Diagram (DFD) was generated to represent the data flow in a system. The DFD of bulk-liquid traceability system consists of a context diagram, DFD level 1and DFD level 2. The context diagram shows the overall process and the data flow to and from each entity. There are eight entities, which represent departments in the company, involved in the internal traceability information system. The context diagram can be seen in Figure 3. Then, there are one DFD in level 1 and 14 DFD in level 2 which represent the main process.

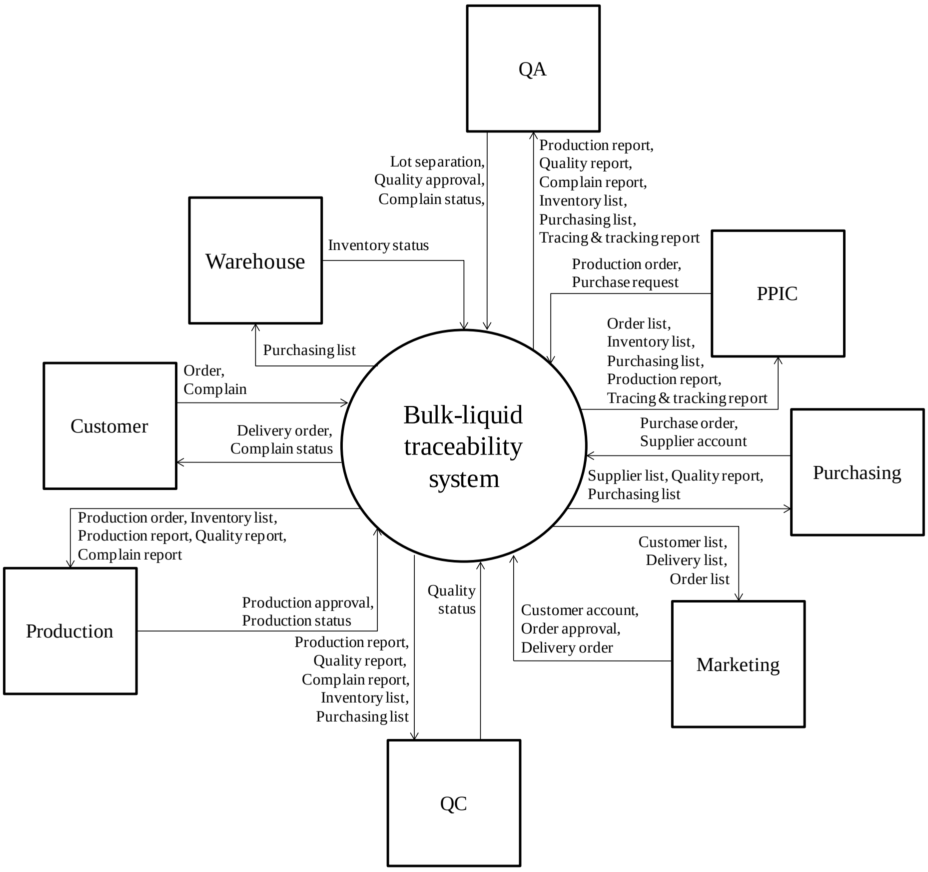

Fig. 3. The context diagram of the bulk-liquid traceability system.

Reference [11] has identified that there are 13 critical traceability points (CTPs) along the internal coconut oil process. These CTPs indicate that the information flow has not connected so that the product, actually, cannot be traced or tracked. To solve this problem, an internal code system was built. The flow of the internal product code can be seen in Figure 4. This internal code system guarantees the product can be traced and tracked. Then, the product identity is generated based on a combination of order number and delivery order number because each order is unique. Therefore, the logistic unit will be the traceable unit. The numerical system for a seal barcode is a nine-digit alphanumeric. In Figure 5, the detail of the numerical system for the barcode is shown.

IV. DISCUSSION

There are many people still asking about the reason why traceability system is developed rather than enterprise resource planning (ERP). The argument is each system has different purposes. The ERP is designed to focus more on integrated planning than traceability. Whereas, integrated planning is not the ultimate challenge for most process industries. Besides, ERP performance in the food sector is limited. Many ERP systems do not have specific features to accommodate food sector requirements [14]. Practices in the food sector such as mixing, blending, batching, and reprocess cannot be accommodated properly using an ERP system [15]. There were also many cases that the ERP still needed to integrate with traceability system [16]. Based on those arguments, specific traceability system is more essential for the food industry.

This bulk-liquid traceability system prototype allows the users to connect with dynamic web platform model and real-time data acquisition. The interface of the bulk-liquid traceability system can be seen in Figure 6. Although a tailored information system was used to increase flexibility, some critical operational procedures had to be changed. In the current condition, solid materials such as copra, activated carbon, and bleaching earth were stored in bulk without any allocation. Then, the traceability system will force the allocation of storage of raw materials but the amount of solid material allocated to the warehouse can be adjusted according to the amount of supply from the supplier. This storage allocation allows tracing to the suppliers. The interface for material data record can be seen in Figure 7.

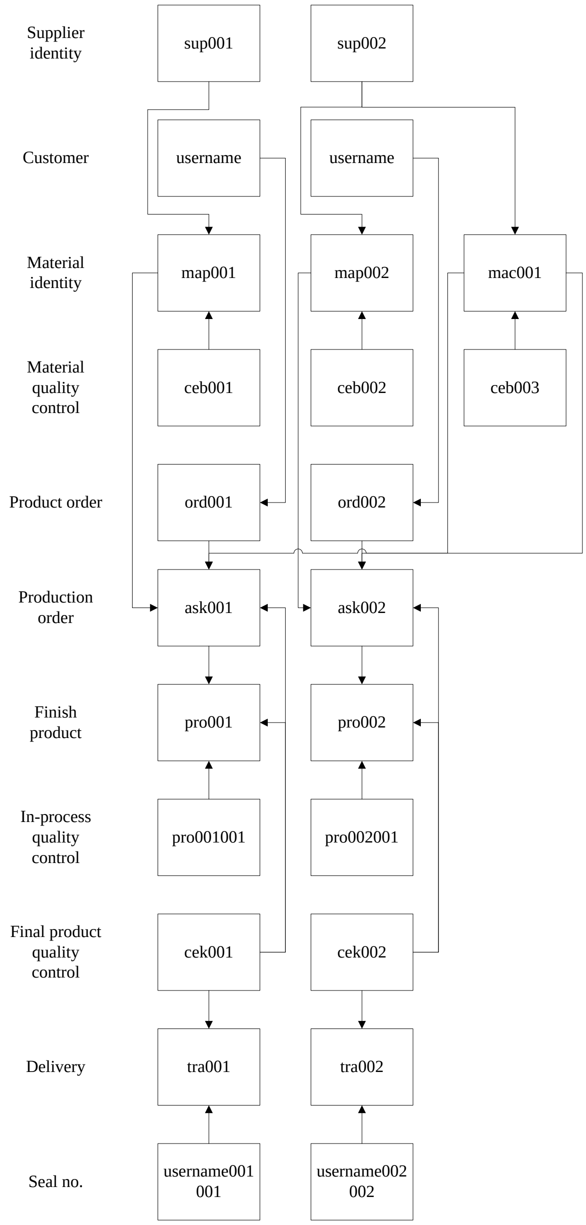

Fig. 4. The coding flow.

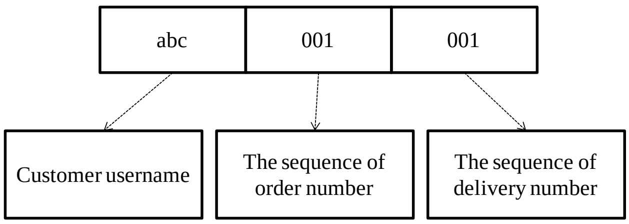

Fig. 5. The barcoding numerical system.

In the bulk-liquid industry, tank cleaning is a way to avoid cross-contamination between product lots and shows a clear separation between product lots. To accommodate this condition, there is a feature in the bulk-liquid traceability system which allows QA department to decide the separation of product lots in the storage tank by considering the amount of product left in the tank. To start a new product lot in the same storage tank, the QA department can press the 'reset' button. Thereby, the lot size can be 'liquid'. The interface can be seen in Figure 8.

Fig. 6. The user interface of the bulk-liquid traceability system.

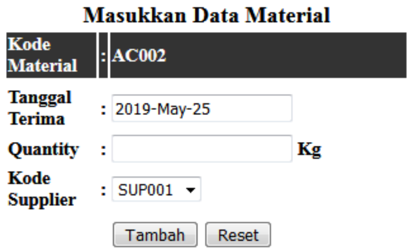

Fig. 7. The user interface of material input.


Cek Tangki

No	Nama Tangki	Isi	Kapasitas	Reset
1	1b	Bentoel	2178488 Kg	Reset
2	1w	Welcolin	2183900 Kg	Reset
3	2b	Bentoel	2200000 Kg	Reset
4	2w	Welcolin	2190044 Kg	Reset
5	3b	Bentoel	2200000 Kg	Reset
6	3w	Welcolin	2200000 Kg	Reset

Fig. 8. The user interface of finish product lot separation.

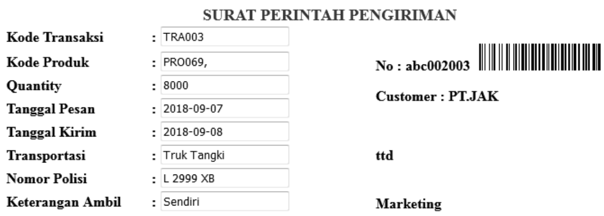

Fig. 9. Delivery order display.

To verify the system, the traceability feature was activated. Verification was conducted to ensure the system run correctly according to the design. Input for tracing and tracking feature can be based on customer code, order number, and seal barcode number. Figure 9 illustrates the delivery order equipped with the barcode system for tracing. If the information shown in the traceability feature is right, the information system will be verified. After several adjustments, this verification process showed a satisfactory result. The traceability result can be seen in Figure 10. Then, a field test was conducted to ensure the system met the user requirements.

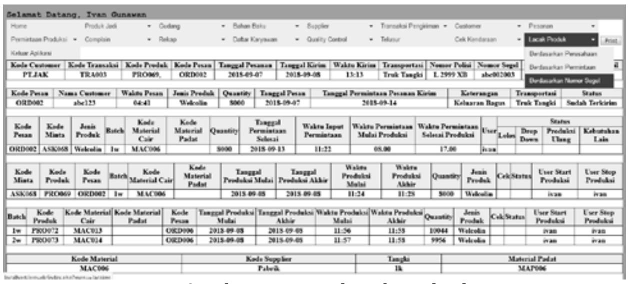

Fig. 10. The tracing and tracking display.

V. CONCLUSION

The architecture and traceability information system prototype for the bulk-liquid food industry has been developed. Its functionality to do one-step-forward tracing and one-step-backward tracing based on the logistic unit has been presented. Besides, this information system also helps the industry to regulate workflow, record the entire process of product transformation, and monitor the food safety and quality parameters. However, this system also required operational improvements to support the traceability system. The significant finding of this system is the feature to make a clear lot separation. Thus, the industry can avoid a total recall.

The verification process showed the ability of this system to trace a product based on the barcode number in less than a minute. This is a significant contribution to food safety emergency response because the same industry, Case 2 in reference [17], used to do tracing for 23 minutes. However, this system is not generic so that some adjustments are required if it will be applied in similar industries, both food and non-food. The ideas of the system were narrated as detailed as possible to ensure the transferability of this system to other phenomena.

This information system is still in ‘beta version’ or under supervision. Therefore, it needs further development. The direction of future research is to integrate traceability information systems with traceability optimization models such as batch dispersion so that the traceability information system can be upgraded to an intelligent traceability system.

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