Role of Supply Chain Management in Supporting Agroindustry: A Study Case from Thailand

Kanya Auckara-aree[a], Wanatchapong Kongkaew[b], Sivasit Wittayasilp[b], Nikorn Sirivongpaisal[b,*]

[a]*Department of Management Technology, Faculty of Agro-Industry, Prince of Songkla University, Kho Hong, Hat Yai, Songkhla, 90112, Thailand*
[b]*Department of Industrial Engineering, Faculty of Engineering, Prince of Songkla University, Kho Hong, Hat Yai, Songkhla, 90112, Thailand*

Abstract

Thailand's economy has relied on agriculture sector and agroindustry for a long time. Yet with changing and fluctuation of world trade situation, plus with the climate change, the impact on agriculture sector and agroindustry is inevitable. If there is no adaptation, Thailand may lose competitiveness. Consequently, under Thailand's Agricultural Development Plan Year 2012-2036, it aims to strengthen the agriculture sector and agroindustry. This article will illustrate the role of supply chain management in strategic planning and operational planning to support Thailand's Agricultural Development Plan Year 2012-2036.

Keywords: Supply Chain Management; Agricultural Zoning; Supply Chain Collaboration; Information Sharing

1. Introduction

Value of agroindustry to Thailand's growth can be evidently disclosed by the following Gross Domestic Product (GDP) data from agricultural sector, which has been primary indicator for country development since 1957. Based on National Statistical Office (NSO), GDP during the past ten years of agricultural sector can be illustrated in Figure 1.

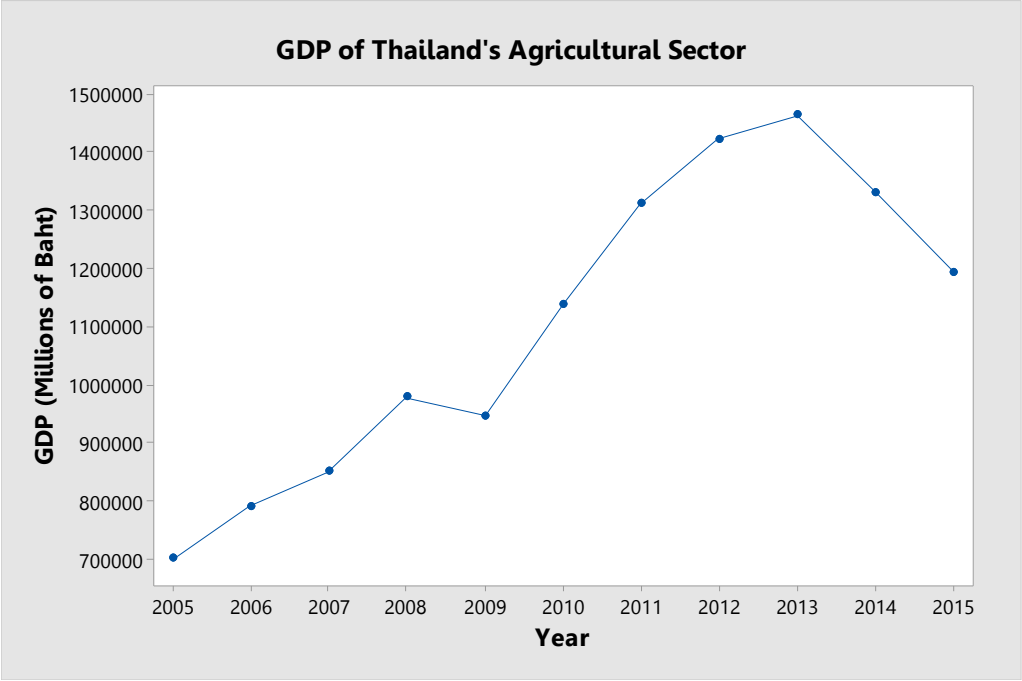


Fig. 1. GDP of agricultural sector

It can be grasped from Figure 1 that GDP gradually increased in first four years and slightly dropped in year 2009. After that it abruptly escalated during year 2010-2013 and later it has drastically decreased. However, agricultural exports still play a major role to the total value of Thailand's export such illustrating in Figure 2. It can be determined that value of agricultural products export was accounted for 31.20 percent in average of all products export during the past ten years. In addition, it may contribute to the fall of GDP in year 2014 and 2015 as it can be perceived from Figure 1 and Figure 2.

* Corresponding author. Tel.: +66-74-287-153 ; fax:+66-74-558-829.
*E-mail address:*nikorn.s@psu.ac.th

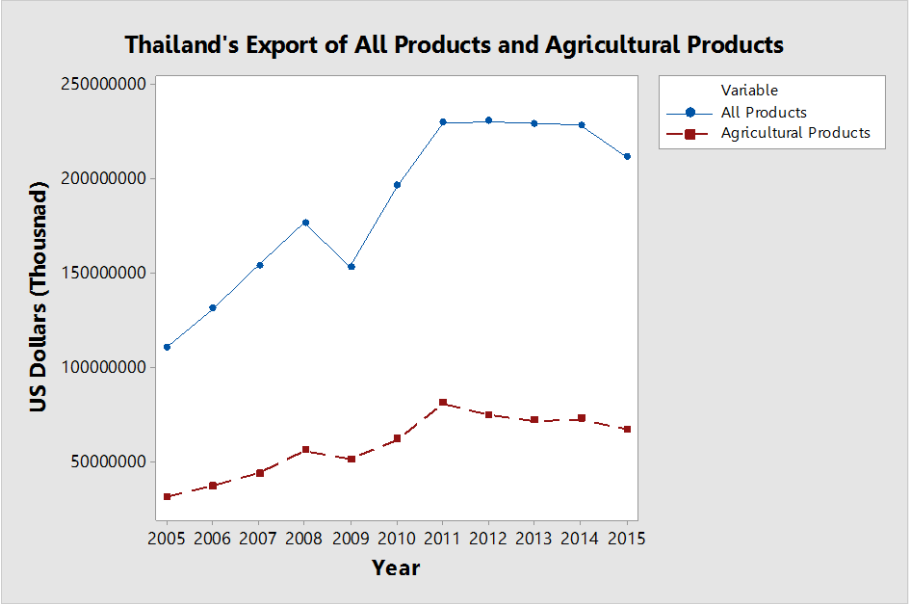


Fig. 2. Thailand's Export [1]

NSO's census reported that Thailand's population is about 65.5 million persons in year 2017. Also the latest Agricultural Census in 2013, it revealed that Thailand had totally 5.9 million of agricultural holdings with family members about 19.7 million persons, which was accounted for 25.2 percent of total households of the country. And the total land area of the kingdom is around 51.4 million hectares while the total area of agricultural holdings was 18.64 million hectares or averagely 3.16 hectares per holding. However, with detailed consideration, it can be seen the distribution of size of total area in Figure 3 following, which is illustrated that there were only ten percentages of holders who had an area greater than 6.40 hectares, while the rest are small holders through last twenty years.

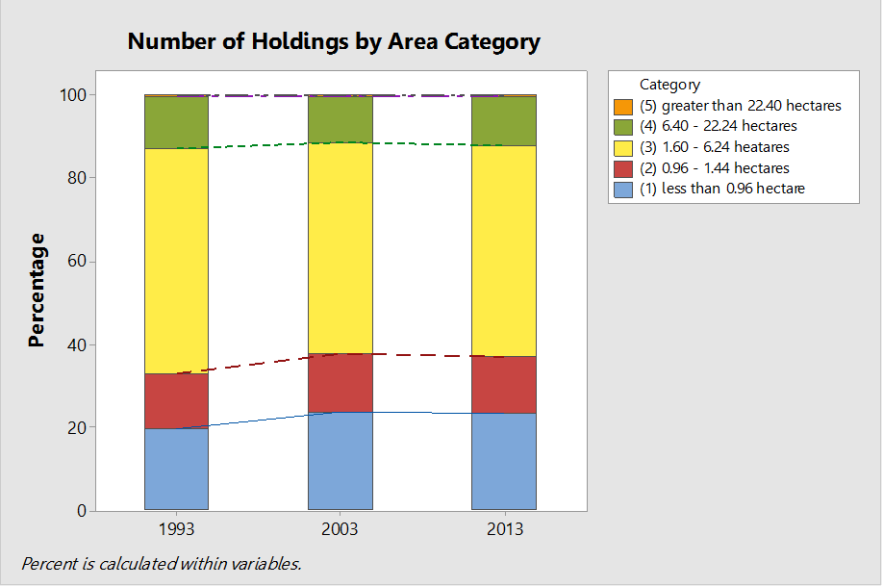


Fig. 3. Number of agricultural holders by area

By area of holding, types of agricultural production in Thailand can be respectively classified into rice, field crops, rubber, and permanent crops, which crop production was accounted for more than 60 percent in year 2013. The main commodities are rice, rubber, fishery, and animal products.

For characteristics of Thailand's agriculture, problems, which have been perpetually existed, can be considered from each input factors which are land, labor, capital, and technology. First, normally area of farm is small size, which can be obviously seen in Figure 3 that about 90 percent of holders have land area lower than 6.24 hectares. Next, percentages of farmers who have their own farms are declined. And most of the farms are dependent to the weather and other environments. Nutrients in soil are exhausted and the damage areas are increasing, as a result production efficiency is plunged. Regarding on labor, there are decrease in agricultural labor and increase in average age of labor. For capital, logistics costs such transportation cost are still high and incompetent. Last but not least, the applications of modern technology are still low [2].

In order to settle agricultural problems, Thailand's Agricultural Development Plan Year 2017-2036, which is a 20-year program to modernize the country's agricultural sector, has just released under vision of secure farmers, prosperous agricultural sectors, and sustainable agricultural resources, which can be formulated in five strategies, which are (1) strengthening farmers and farmers institutions, (2) escalating production efficiency and upgrading product standards, (3) enhancing competitiveness in agricultural sectors with technology and innovation, (4) managing agricultural resources and environments with equity and sustainability, and (5) developing governmental administration and management system. And policies, which were afterward deployed from strategies, can be illustrated in the following Figure 4.

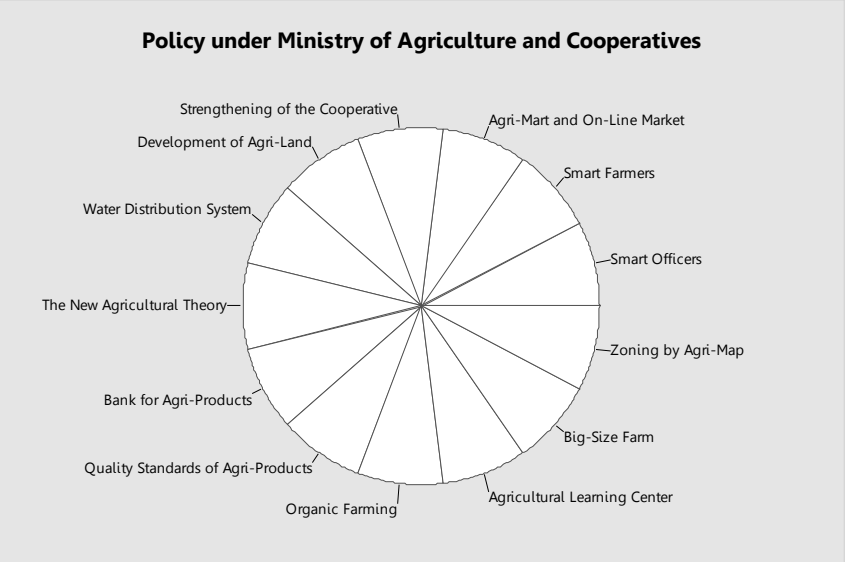


Fig. 4. Policy of agricultural development plan year 2017-2036

From Figure 4, it can be seen the key policies which were set for the next twenty years from now. The review period will be scheduled every 5 year. And these policies will be driven by three mechanisms, which are (1) sufficiency economy philosophy, (2) integration to agenda based and area based, and (3) technology, innovation, and knowledge. Final goal at the end will be aimed at better quality of farmers' life.

2. Agroindustry in South of Thailand

Southern Thailand, located on the Malay Peninsula, comprises of 14 provinces with a total area of 7.07 million hectares, accounting for 13.8 percent of the whole country. The region stretches from north to south, which is about 750 kilometers in distance. And it is approximate 220 kilometers in width from east to west. The southern coast has a total of 1,643 kilometers. The climate is tropical monsoons, which has rainy season alternating with short drought due to its location close to the equator. In 2014, the South had a population of 9.21 million persons, or 14.1 percent of the country's population. The Gross Regional Product (GRP) was valued at 1.13 trillion Baht, accounting for 8.6 percent of gross domestic product. The leading economic structure of the South is agricultural sector, which accounts for 27 percent of GRP. Following by industry sector, trade sector, transport and tourism sectors are accounted for 12, 10, 9 and 8 percent of GRP, respectively [3].

Agriculture is always important manufacturing sector of the South because most of the populations are dependent on agriculture. It can create employment to 43 percent of total employment, which were classified into (1) cultivation accounted for 83 percent, and (2) fishery accounted for 17 percent [3]. Some of agricultural products are consumed in southern region and other regions in country. The remaining products are used as raw materials for agroindustry, which can add value and create labor employment. Besides, they can be exported in forms of such smoke sheet rubber, concentrated latex, rubber glove, rubber wood, crude palm oil, frozen and chilled shrimp, and canned seafood, which can increase revenue and reduce the loss in international trade balance for Thailand. The following subsection will provide the synopsis of vital agricultural products from Southern Thailand.

2.1. Rubber

Rubber is a major economic crop of the South and the nation, which Thailand is the foremost rubber producer in the world among the top five producers, which the rest are Indonesia, Vietnam, China, and Malaysia, respectively. In year 2016, Thailand has total area of 3.14 million hectares of rubber plantations, which increase 122,808 hectares or accounted for 3.9 percent from the previous year. The most plantations are located in the south approximately 2.05 million hectares, accounted for 67% of the total cultivated area, which 0.28, 0.21, 0.20, and 0.19 million hectares are in Surat Thani, Songkhla, Nakhon Si Thammarat, and Trang, respectively. Rubber production is mainly for export 86 percent in forms of block rubber, smoked sheet rubber, concentrated latex, and rubber glove; while the rest is 14 percent for domestic consumption. In year 2015, the total rubber export volume was 3.75 million tons, which is 170, 418.73 million Baht.

2.2. Oil palm and palm oil

Oil palm is also a key economic crop of the South and the nation, which its role is gradually rising in aspects of economic, food security, and alternative energy for country. Thailand is the third largest for palm oil production in the world. In year 2017/2018, the total world's palm oil production was 66.85 million tons, which Indonesia and Malaysia were the first and second largest producers with 36 million tons and 21 million tons of production volume, respectively. Then Thailand was the third largest producer with 2.2 million tons of production [4]. It can be seen from statistics that total production volume from three countries were accounted for 88 percent of the world's production. In year 2016, Thailand has total area of 730,223 hectares of oil palm plantations, which increase 42,642 hectares or accounted for 6.2 percent from the previous year. Not unlike rubber, the most plantations are located in the south approximately 622,828 hectares, accounted for 85.29% of the total plantation area.

Although Thailand is currently the third largest palm oil producer in the world, however it has very small share of the world's export market. Most of products are domestically consumed, which can generate domestic economic value throughout the supply chain of industry more than 92,000 million Baht in year 2010 and more than 100,000 million Baht in year 2012. In addition, it can produce income from annual export averagely 23,000 million Baht with the small number of export. In year 2015, about 50 percent of crude palm oil was used for domestic consumption and industry, and about 40 percent were used for biodiesel production. The rest were exported and kept for stock in country.

2.3. Chilled and frozen shrimp

White leg shrimp, or Litopenaeus Vannamei is another main economic product of the South and the nation, as a result the chilled and frozen shrimp industry is one of the vital Thailand's industry. In year 2011, Thailand was accounted for 24.29 percent of the world's shrimp production, or second largest producer whereas China was number one. For ASEAN's shrimp production, it was nearly 1.14 million tons, accounted for 55 percent of the world's production; which Thailand could produce 502,000 tons or 47.40 percent of ASEAN's production. The major shrimp farming areas in Thailand are located in the South about 60 percent and in the east 30 percent. Most of finished products around 90 percent are exported.

Unfortunately, the disease so called Early Mortality Syndrome (EMS) had pervasively infected in the farms since the end of year 2012, the shrimp production in Thailand plunged sharply. So Thailand lost world's champion in shrimp exporter, which Thailand had possessed for a long time. Thus Thailand regressed to the fourth place in year 2013 and to the fifth place during year 2014-2015. And India became the leading exporter of the world, followed by China, Vietnam, and Indonesia in year 2015. However, a better trend could be observed in year 2016 as Thailand's shrimp export was amounted at 1,735.15 million US dollars. In addition, exports of chilled, frozen, and value-added shrimp during January – February 2017 were 205.56 million US dollars, which are increased 7.17 percent over the same period of the previous year. Major markets are the United States, Japan, Vietnam, South Korea, and Australia, accounting for 83.89 percent of total.

3. Role of Supply Chain in Supporting Agroindustry

As discussed in previous section, Thailand growth has been fundamentally founded on agricultural and agroindustry. Nevertheless, Thailand's agriculture is subjected to fluctuate because of depending on external factors such climate and internal factors such higher production cost, lack of farm management, irrigation system, etc., as a result productivity and yield have scarcely improved. When agricultural sector, which is upstream, has fluctuation so agroindustry, which is downstream, cannot inevitably run into problems. Downstream agroindustry such rubber industry, palm oil mill, frozen food factory, may be unable to compete in globalized industry. Thus, supply chain management has an essential role to agroindustry because any broken link in the chain may affect to chain performance. The key reason is that supply chain management fundamentally relates to total business process excellence and represents a new way of managing business within each link and the relationship with other members of the supply chain [5].

By typical definition of supply chain, it is the tasks, activities, events, processes, and interactions undertaken by all suppliers and all end users in the development of procurement, production, delivery, and consumption of a specific goods or service. Once agricultural sectors and agroindustry adopt the supply chain concept, it can be represented its network as shown in the following figure.

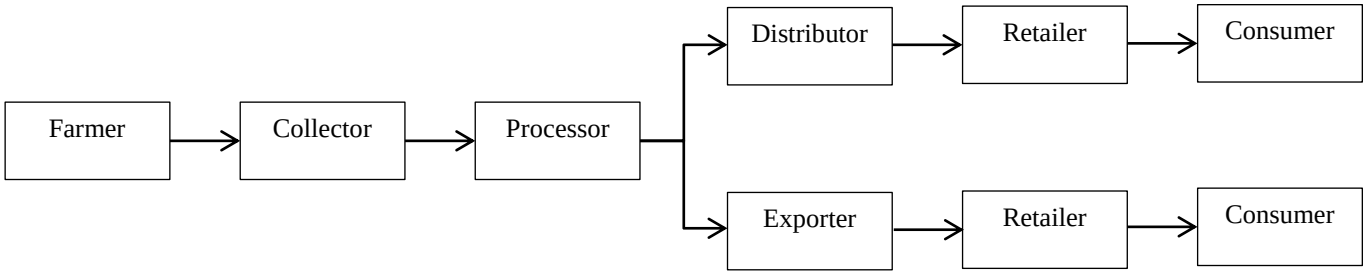


Fig. 5. Supply chain network of agroindustry

In next section, role of supply chain management in supporting agriculture and agroindustry will be demonstrated by research study relating to policies issued by Ministry of Agriculture and Cooperatives.

4. Case Study

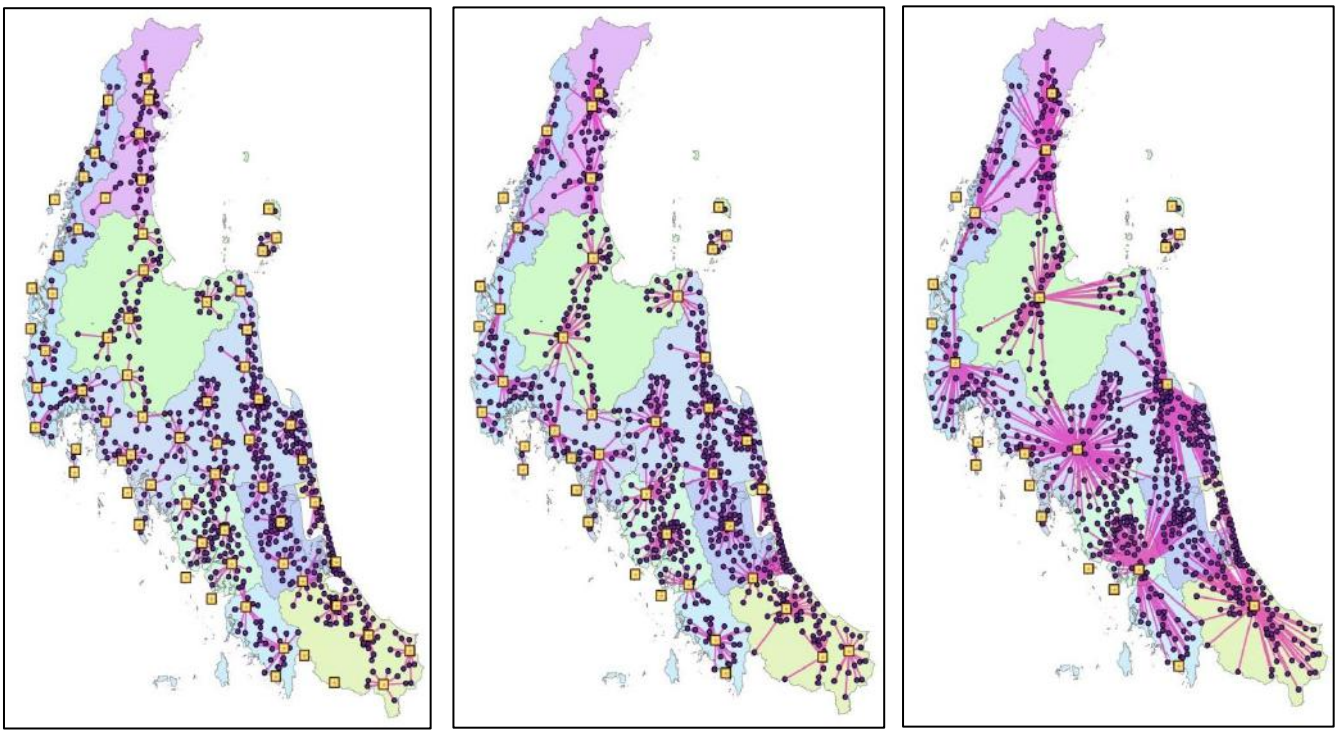
Some case studies will be demonstrated in this section along with the Agricultural Development Plan Year 2017-2036 under different policies, which can be exemplified such (1) agricultural zoning plan, (2) big size farm, (3) smart farmer. These case studies will adopt and integrate the supply chain management principles, which can deploy the policies into action.

4.1. Zoning by agri-map

With the goal to enhance farm productivity and farmers' incomes, the policy of zoning area has been emerged. Under this policy; the six economic crops, which are rice, maize, sugar cane, cassava, oil palm, and rubber, are designated the zoning area. It is estimated about 1.95 million hectares which is proper for growing these crops. However, the comment from agricultural experts cited that the idea of zoning for economic crops is not novel. It has been implemented in the past for the sugar cane crop but the problems were such no seamless policy or management system for managing the products in case of the high quantity or lower price. So the drawback in the past can be resolved and fulfilled under supply chain management, which can facilitate in planning form upstream to downstream.

A study on the directions for the establishing of crude palm oil (CPO) factories in oil palm supply chain has been studied to support this policy into action. The objectives were to study the current inbound transportation system of fresh fruit bunch (FFB) to CPO factories and to recommend the directions for establishing the CPO factories in order to balance between plantation area and production capacity CPO factories with mathematical formulas and multiple decision making criteria. This study was initiated from benchmarking of CPO factories utilization between Thailand, Malaysia, and Indonesia. It was uncovered that Thailand's average factory utilization was about 58 percent, while Malaysia and Indonesia were at 95 percent and 82 percent, respectively in year 2013. Key reason for least factory utilization is because the growth of CPO factories is unlimited and unbalanced to the growth of plantation. It can be disclosed that in year 1987 one CPO factory had plantation area around 6,700 hectares to feed FFB to factory production, but in year 2015 plantation area per one CPO factory decreased to 4,440 hectares.

To prevent the recurrence of the utilization problem, planning to establish the number of CPO factories matched with the plantation area under the zoning area of Ministry of Agriculture and Cooperatives is required. New plantation in the zoning area for oil palm is around 1,048,670 hectares; not only number and location of CPO factories, but also allocation of FFB from plantations, via collectors, to CPO factories are the solution for better planning in the future. Illustration of the research output can be shown in the following figure.



(A) 30 kilometers (B) 50 kilometers (C) 100 kilometers

Fig. 6. Location and allocation of oil palm supply chain network

Figure 6 provides the idea of how to locate and allocate from plantation areas to collectors and from collectors to CPO factories. Solution provided from this research can be presented three different alternatives in the following table.

Table 1. Result of location and allocation

Alternatives	Initial number of CPO factories	Adjusted number of CPO factories	Total transported FFB (million tons/year)	Total transportation cost (million IDR/year)	Utilization of CPO factories
Within 30 kilometers	52	36	11.21	67,389	96.25
Within 50 kilometers	28	21	13.36	131,004	97.44
Within 100 kilometers	8	7	13.85	306,107	95.02

Note: exchange rate is 400 IDR equal 1 Baht

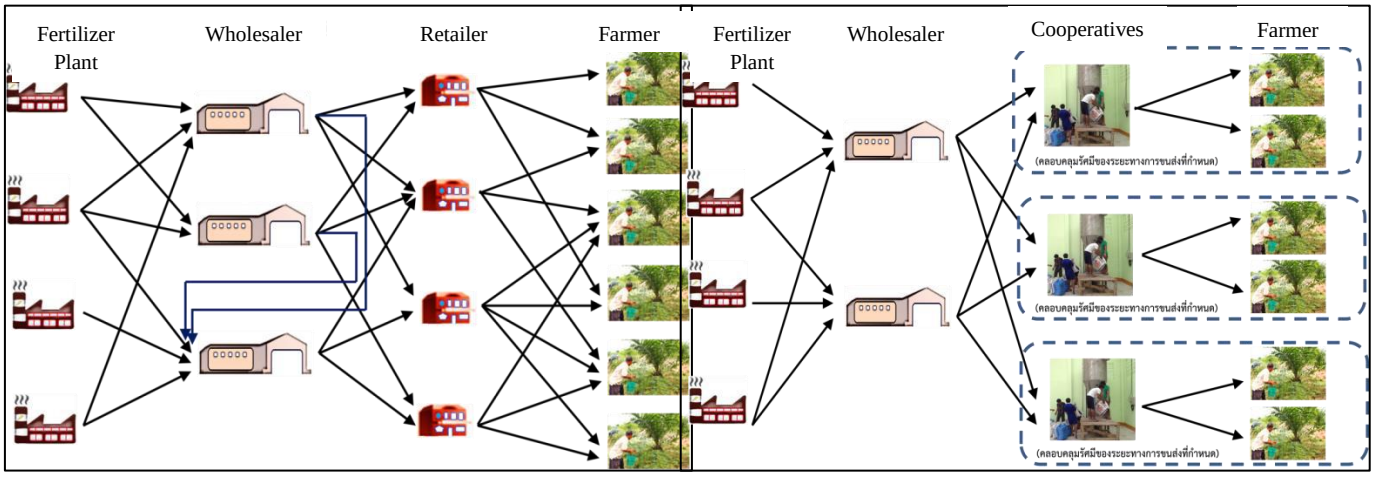
In Table 1, solution offered is categorized into three alternatives based on the distance from collectors to factory. Under each alternative, number of CPO factories will be decreased as the distance of raw material procurement is increased. Nevertheless; the preliminary solution must be adjusted because of overlapping with the existing CPO factories and nonconforming to factors or criteria in facility location selection. Then total FFB transported and total transportation cost can be evaluated as shown. Research outcome can be measured in terms of both balance between plantation areas and number of CPO factories, and increment of utilization.

4.2. Big size farm

With the goal of gaining advantage from economies of scale and higher bargaining power, the policy of promoting big size farm also has been issued to help small holders, who are the major portion of the agricultural sector. In order to support this policy, 800 cooperatives across the country will have significant role. Idea behind this policy is specifically associated to supply chain collaboration. However, relationship within supply chain can be classified into various classes depending on the degree of relations, which are cooperation, coordination, integration, and collaboration [6].

A study on the collaboration in fertilizer management to reduce supply chain cost for the oil palm industry was initiated from the fact that more than 1.3 hundred thousand holders in oil palm industry were small holders and oil palm plantation cost was somewhat high because there was much less collaboration. In addition, fertilizer cost was accounted to almost 50 percent of production cost in the first three years and about 60 percent during the fourth and fifth year of plantation. So objective of this study was to develop collaboration model in fertilizer management, focusing on procurement and distribution activities, within upstream of oil palm supply chain.

To develop collaboration model based on mathematical model, the "AS-IS" situation was studied and the "TO-BE" model was proposed. Contrast between "AS-IS" and "TO-BE" models can be illustrated in the following figure.



(A) "AS-IS" Model (B) "TO-BE" Model

Fig. 7. "AS-IS" model versus "TO-BE" model

From Figure 7; it can be seen that if farmers can collaborate, they will have larger volume of fertilizer usage so they will have more bargaining power to wholesaler. And under setting up new cooperative groups or existing groups, they need to manage their groups and act as retailers. By running mathematical model, transportation cost of "TO-BE" model compared to "AS-IS" model can be reported in the following table.

Table 2. Cost comparison between "AS-IS" and "TO-BE"

Distance (kilometers)	Number of cooperatives	Percent of transportation cost decreased (-) / increased (+)			Percent of total transportation cost decreased (-) / increased (+)
		Fertilizer plant to wholesaler	Wholesaler to cooperative	Cooperative to farmer	
10	50	-50.33	-12.08	-62.53	-42.34
15	29	-49.59	+2.57	-45.56	-38.17
20	19	-38.27	+3.24	-10.50	-27.56
25	14	-39.59	-0.28	+14.57	-27.38
30	11	-37.59	-9.71	+31.47	-26.38

In Table 2, solution can be shown by different scenarios based on the distance of covering each farmer and unifying them to one cooperative. Under each scenario, total transportation cost can be fragmented into tier by tier, which cost in distinct tier may decrease or increase under various scenarios. But overall transportation cost always decreases. However, inventory cost has not been considered in this study. Research outcome can be stated in term of collaboration will provide the approach for cost reduction to small holders, which are major sector in the agriculture of the country.

4.3. Smart farmers

Thailand 4.0 is a current economic model, which focuses on a value-based economy. It aims to change in Thailand's economy and production thru three mechanisms. First mechanism is developing a knowledge-based economy by research and development, science and technology, creative thinking and innovation. Second is providing equitable access to the success of prosperity and development for all levels and everyone in society. And third is depending on sustainable growth and development. Incidentally, Thailand's Agricultural Development Plan Year 2017-2036 deployed from Thailand 4.0 economic model, which is a 20-year program to modernize the country's agricultural sector, has an aim to change the traditional farming to smart farming.

As explained in section 2.3 about the rise and fall of chilled and frozen shrimp industry, industry's strengthening is truly compulsory for the sake of the industry's competitiveness. However, the competitiveness in the globalization will be measured by the chain competitiveness; hence supply chain management which is strategic management is absolutely right for now. The following research aims to modernize the chilled and frozen shrimp industry by integrating all members in the chain through information technology, which can be illustrated in the following figure.

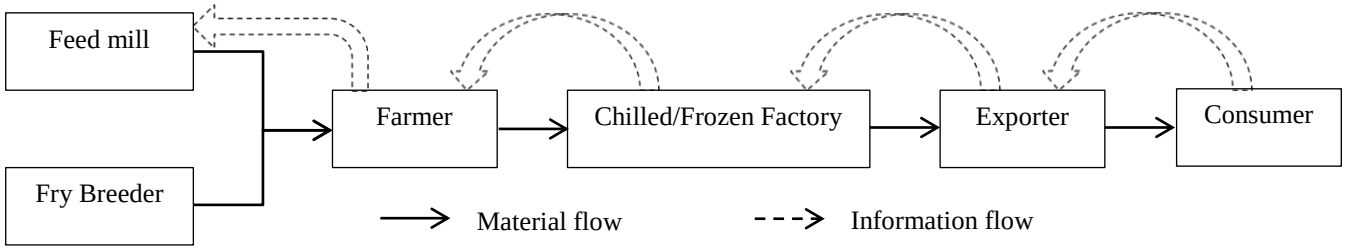


Fig. 8. Industry supply chain

Starting at the consumers or demand side, ideally data such order requirements can trigger the process in supply chain network, so called pull system. Yet the practice in reality is quite far from ideal since the farmers or supply side hardly know the true demand such size, quantity, and quality of shrimp; consequently, the farmers just anticipate what the demand side needs and raise shrimp as they expect, so called push system. Sometimes there is mismatch between supply and demand, it causes total loss to supply chain network. Thus the best practice that has been widely famous in supply chain management is information sharing.

In order to develop the information system, business processes along the industry chain were analyzed both intra-firm and inter-firm. Subsequently, database system was developed in order to obtain key information from both supply side and demand side such amount and size of shrimps or order requirements and delivery date. Finally, information can be shared along the supply chain via the technology such internet. Conceptual system design can be represented in the following figure.

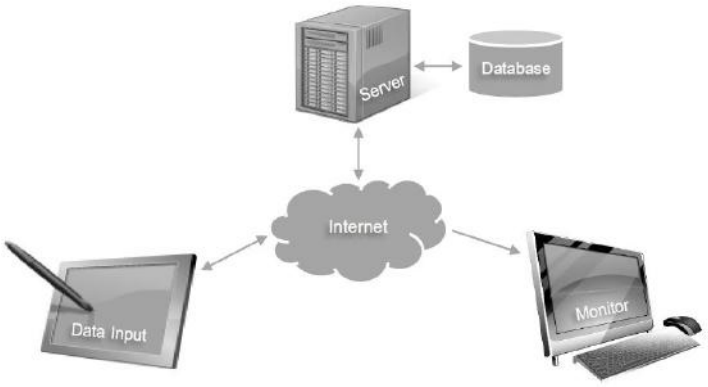


Fig. 9. Conceptual design

With the development of information technology system for supply chain integration, it will be benefit for industry competitiveness in the globalization era and it will transform the traditional farmers to smart farmers in accordance with the business situation.

5. Conclusion

This article presents the role of supply chain management to the development of agricultural sector and agroindustry which are the backbone of the country. It can be evidenced from various case studies that adopted the principle of supply chain management to provide in level of both strategic and operational planning in accordance with the policy of Ministry of Agricultural and Cooperatives. Contribution of supply chain management to several areas ranging from manufacturing, agriculture, construction, tourism to healthcare has already been proved for more than two decades. Nevertheless; there are numerous problems still waiting for researchers and practitioners to desirably explore with the supply chain theory as long as the business world is constant change, undeniably.

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Transforming The Agriculture Industry with Internet of Things

Erry Yulian Triblas Adesta[a*], Avicenna[b]

[a,b]*Department of Manufacturing and Materials Engineering, Faculty of Engineering, International Islamic University Malaysia, Gombak 50728, Malaysia*

Abstract

The IoT applications in the agriculture industry is intertwined in many ways, creating a hybrid construct of traditional businesses with digital connectivity implementations. Strategic issues and principles on the assimilation of IoT solutions are prevail through time: investment costs, data interconnectivity, management and analysis, as well as data security. The agriculture industry is expected to be always alerted for the changes that may apply, with all the contemporary challenges and future directions responding to the situations, so it can reap the optimum use of the IoT connectivity.

Keywords: IoT; Agricultural Industry; Connectivity; RFID

1. Introduction

1.1. Internet of things and industrial Big Data

A world where all objects the human capable of interacting are connected to the network, and generating and collecting data for a decision-making purpose is not far beyond mankind grasp. The early stage of such aspired world has already begun when the concept of Internet of Things (IoT) was introduced for the first time in 1999 where the phrase was originally started as the title of a presentation by Kevin Ashton [1] at Procter & Gamble (P&G). The definition by Alkhalil & Ramadan [2] for what we call as the IoT today may describe and generally fits what is needed in this study: 'A worldwide network of interconnected entities'. The core concept of the term describes itself as a global infrastructure for the information society, with enabled advanced services by interconnecting physical and virtual things based on existing and evolving interoperable information and communication technologies [3].

In the IoT, 'things' are defined as objects of the physical world (physical things) or of the information world (virtual things) capable of being identified and integrated into the information and communication networks [4]. The characteristic of IoT lies on the entities that are capable of transferring data across networks in the absence of human-to-computer interaction [2]. It is realized in environments with trillions of device and information objects are connected through networks. Thus, IoT can also be understood as a networking infrastructure for cyber-physical systems (CPS) that can be identified as an engineered system that is built from the seamless integration of computational algorithms and physical constituents [5]. Fundamentally, it is the 'interconnectivity' and 'things-related service', where any object will have the potential to be interconnected to the communication infrastructure, and proficient of providing thing-related services within the constraints of the things [6]. The transition starts with more and more devices, manufacturing tools and equipment, plants as well as vehicles, to be equipped with sensors [7]. Supporting not only limited to individual scope but also companies, to start optimizing their performance by gathering and analyzing data through the whole product lifecycle.

With the advent of the fourth industrial revolution, all industrial systems will be transformed into digital ecosystems. Thus, the emergence of IoT resulted in the generation of large volumes of data exploding at really high rates [8], where by 2020 is predicted to exceed 40 trillion gigabytes (or 40 yottabytes). The collection of these vast amounts of data is usually referred to as "big data". The basic attribute that makes Big Data generated from the IoT unique are the high volume, velocity, and variety of information, with new characteristics have been continuously introduced with the value being the most important [9]. Today, more than 98% of global information is being stored in digital format. Experts predict that the amount of stored information will be 20,000 times larger in 2045 [10].

The relation of IoT and the industry is the main concern in this study. With all the benefits that can be taken in, an attempt is necessarily required to intermingle what today classified as digital business model patterns with those from the non-digital world to create a hybrid construct of business. The value of an IoT solution in the industry is found in combining a classic type of industry that in the past was not linked to the internet but now is upgraded with information technology and connectivity [11].

Both IoT and Big Data will pose a key role in the future. The steadily growing amount of data will enable mankind to predict the spread of diseases, foresee where natural disasters will strike, and in time it may even be possible to predict human behavior [10]. The IoT will collect even more information and feed directly into Big Data concept, where to provide meaningful information from the abundant data requires a special manipulation and analysis [12]. Presently, the IoT remains a wide-open playing field for enterprises. It is still in its early stage, heterogeneous, and full of uncertainty. It is estimated that the potential economic impact by 2020 range from about USD 2 trillion to more than USD 14 trillion [13].

* Corresponding author. Tel.: +60 (03) 61964414; fax: +60(03)61964853
E-mail address: eadesta@iium.edu.my

1.2. State-of-the-art agro-industrial system

The matter of discussion in agriculture industry varies in a wide spectrum, and the agro-industrial systems are intertwined in many ways, from the trade-in raw materials to final products [10]. Issues are there and prevail through time; from farmers issue to establish local food systems with incomplete product-related data; who delivers to whom? How are products delivered? And what are the transport costs and other expenses? [14], food processing technologies and their acceptance at consumers, to another contrast issue of environmental sustainability, e.g., in the events of extremes drought and moisture, due to the impact of agricultural activities [15]. However, there is one affinity that relates one issue of a particular sector to another. It is that most of their efficiency, performance, and productivity can be improved by the integration of automation and information technology to overcome the distinctive issues that hinder the sector.

It is relatively easy to find the assimilation and adoption of IoT in the developed and big scale agricultural sectors. It is not the infancy phase that the agriculture industry has been developing from typically conventional practices towards the utilization of sensors and other technologies. The main industry itself has been starting its upgrade years back where at the later time some agricultural companies, like Deere & Company, started to commercialize the advance technologies for agricultural, construction, and forestry machinery. It is expected that the rapid evolution of science and technology in agroindustry, along with the recent advances in computer sciences and information technologies forms the basic foundations for the adoption of Cyber-Physical Agro-Industrial System. From a mundane and small application in a greenhouse farming, such as intelligent environmental control system for precision culture [16], to a larger application in agricultural zone management to search specific locations that fit with plant growth condition and environmental conditions [17].

There has been an example of a study by Zhou et al. [18] on the readiness of major technologies of IoT to be employed into agricultural system. With an approach from the perspective of the technological aspect itself, technology system framework of IoT should be capable of solving defects in the traditional monitoring system and make public capable of acquiring agricultural information at any time. The claimed integrated system was said to be capable of realizing the automatic configuration and self-organization transmission of information collected node, thus expressing and storing the obtained agricultural information.

This study aims to evaluate the transition and the implementation of IoT in agriculture industry. Strategic issues on the adoption of the IoT are discussed in Section 2 to review the critical points and principles when one agribusiness adopts the technology. Section 3 provides the contemporary challenges of the IoT and predict how the future researches and policies will be directed to answer those challenges.

2. Strategic IoT solutions for agriculture industry

The internet of things (IoT) has been transforming the agriculture industry, allowing farmers to cope with the enormous challenge they face. The methods for the implementation with the definite roadmap are circumstantial and general principles without distinctive details may provide visions that allow stakeholders to develop a better IoT strategy customized to their needs. Embedding the technology and successfully implementing the strategy for increasing the quality, quantity, sustainability and cost effectiveness of agricultural production are the main goals for those who would like to start integrating the conventional system with the IoT solutions.

2.1. Embedding the IoT into agriculture industry

Agriculture industry applies sensors, monitors, and other devices to improve their own operation and optimization of business, without developing and implementing the underlying technology of digital information. Thus Burkitt [13] coined the term ‘embedding’ as the nature of their business does not involve the activity of providing or enhancing the IoT so other users can benefit from their own system.

In 2016, Poppe [19] presented in the workshop of the Organisation for Economic Co-operation and Development (OECD) that the implementation of the IoT can support the application of smart farming, agri-food supply chains, and consumer interaction. This leads to several business models the IoT can be embedded into the agriculture industry. In the developed countries, for examples, John Deere leads with the product innovation through heavy investments in the machinery industry. While basic data sales in the utilization of commercial equivalent open data have been dominated by Farmobile company. Another type provided by Monsanto company with value chain integration (e.g., Monsanto’s Fieldscript) who provides Integrated Farming Systems (IFS) research platform, supplying a variable rate planting prescription for farmers’ individual fields.

Few examples of typical embedded IoT technology into farming systems were presented by Romeo [20] on Sensing Technologies for Effective Land Management Workshop. These emphasized the low power wide area (LPWA) applications for farming such as water metering for remote monitoring of water meters and leak detection and precision livestock for tracking animals grazing in the open pastures.

In the research scale, a study by Liu [16] for the precise culture of grape (*Vitis vinifera* ‘Wink’) in a greenhouse was conducted with a design of an intelligent monitoring-environmental control system. Sensors were fully equipped and located to obtain multiple sources of data. The data were then fused at the gateway to be a universal type before they were stored, analyzed, and modified. Monitored factors included the dynamic of grape growth, air temperature, air humidity, soil moisture, illumination, and CO_2 concentration.

The study on precision farming also has been known for embedding the IoT technology into their system. The precision agriculture involves the evidence-based farm management coupled with records on cultivation that resulted in information-added produce and information-oriented fields. It involves a thinking process of (1) describing facts and evidence with spatio-temporal coordinates to comprehend variability in the field, (2) making decision and action at the correct time and location, (3) recording the results of executed actions, and (4) reviewing the approaches by field-base geographic information system (GIS) [21]. A Japanese agricultural corporation, Aguri Co., Ltd., has experienced a strategy of precision paddy management. They have been keeping quality and yields of production with the data collected using the real-time soil sensor from the fields with more than 5-year organic management. The strategy resulted in records of big size data of field-level GIS which is applicable to decision support of farmers.

2.2. Principles for IoT strategy implementation in agriculture industry

Implementation and integration of IoT should be reflected in the improvement of production and service, whereby good implementation of key technologies & infrastructure, data management, and analysis, should resulted in the accurate decision making for enterprises. In order to successfully integrating IoT solutions into the business thus optimizing the results, there are several principles should be addressed. Some contents of section 2.2.2 to 2.2.6 were adapted from Burkitt [13].

2.2.1 Key technologies and infrastructure

For the agricultural sectors to embrace transition from conventional practices to digitalization, progress in certain technologies contributes significantly to the IoT being implemented. The deployment of these IoT technologies will significantly impact and change the way enterprises do business, thus affecting many processes inside. To reap the many potential benefits that have been postulated the initial processes of designing the architecture of the system, infrastructure and hardware installation, and finding the right sensors and instruments are critical to be taken into account. It also must be highlighted that sufficient infrastructure and communication technologies, starting from machine-to-machine (M2M) interfaces and electronic communication protocols, wireless communication, RFID technology, energy harvesting technologies, sensors and location technology, as well as software should be maintained in good condition [22].

2.2.2 Addressing the industries and markets

A thorough assessment by business process modeling should be done towards how the business environment is being transformed by the IoT. This covers the assessment on how the services and products are expected to be combined, or affected by the IoT. How far the demand of the company to transform the activities inside may be affected by the IoT availability that already exists in the industry. It is suggested that the more the IoT technology exists, the more rapidly the business should have to move [13].

2.2.3 Business engagement

It has to be highlighted that value in the IoT will be created through the transformation of customer experience. With that reason, the establishment of IoT technologies should be formerly initiated from a strong capability in experience design. It is important to assess the issue on what capabilities the company already had in this area, and what should be further developed. With a direct customer contact and when the opportunities for engagement appear, the IoT could eventually transform the business.

2.2.4 Connected products and services

If products and services have been established prior to IoT implementation in the business, assessment to how can the two are integrated and enhanced with IoT connectivity should be performed. The new ones could be then developed expressly for the IoT. When new launches and innovations involved, the establishment of the connectivity, the analysis of the resulting data, and which other companies should the business collaborate with, must be taken into account immediately. *2.2.5 Enhanced connectivity*

When initial wave of basic connected devices and services have been employed, a business may consider building further services by using analytics to gain insights from the big data the IoT provides them. For example, when a greenhouse of an agricultural company gains a periodical environmental data for the growth of exotic plants, they may offer analytics with a certain value, for other companies who have the same interest of growing a similar commodity. As the level of IoT deployment unfolds in agriculture, companies will usually look for ways of increasing value. Sometimes, new business models may emerge as the result of such activity.

2.2.6 The capabilities of the organization

Organizations' capabilities become the most critical part of the quest improving the company through IoT. In short, the company who would like to employ connectivity should be able to distinguish itself in this space, assessing on what other company does and does not in the same field. Technically, improvements and investments aspects should be detailed before the transition started. Time, money and attention should be defined on where they are coming from, and what activities should be divested and downplayed so the resources can be allocated appropriately [13].

The company should also learn to develop "table stakes" capabilities. These include the skill to manage and analyze a vast number of data, integrating diverse portfolios, and to build business relations with IoT-related companies. Without these capabilities, the company will be burdened to hire third-party to execute all the tasks mentioned.

3. Challenges and future directions

The connectivity brought hailed as one of the greatest breakthroughs in the history of industrial technology. However, this innovation comes with forewarnings and specific requirements, and taking a full comprehension of the current situation and challenges will help the industry to provide a better direction in the future.

3.1. Internet of things and its contemporary challenges

There are several challenges in the implementation of IoT connectivity today. Some are critical from agriculture point-of-view. The others may be approached from the side of the technology itself, from sensors data collection, communication relay, information analysis, and service layers.

3.1.1 The high cost of IoT establishment

In agriculture industry, the use of sensors is imminent and perpetual. An enormous number of sensors are regularly used, and the cost for installation and maintenance is a major concern. The larger the scale of the initial deployment of sensors into the business, the higher the amount of investment required, which is rare for a small scale agricultural-based business. In this context, Chen [23] responded to the situation by emphasizing to the sensors maintenance cost, that the challenge is to produce a technology that requires minimal or even zero effort to deploy and maintain. However, despite the high level of IoT adoption in the industry, cost-efficient and plug-and-play approaches that allow systems interoperability are still missing [7].

3.2 Data Interconnectivity

The multitude of data generated by sensors when the system is running (e.g., sensors data on the plantation, environmental data, and consumer data in the market) is higher as the number of devices employed increased. The big data require careful management to ensure a smooth connectivity not only between the devices, but also communication to the middleware and to the central storage. Sometimes interconnectivity can be an issue when there is a barrier in the area due to the demographic coverage. For the areas with poor connectivity, Ferretti [24] describe the main communication scheme by focusing on communication technologies, wireless solutions such as sensor networks, ad-hoc and D2D communications, and multi-homing techniques (for customer) should be massively employed to guarantee the interconnection.

3.3 Big Data Management and Analytics

One of the main challenges, when IoT started to be implemented, is the difficulties in capturing, visualizing, and analyzing the mega-data created by the sensors and devices [2]. Riggins [25] described the big data with high volume, velocity, and variety of information assets, requires a new form of processing to enable enhanced decision making, process optimization, and insight discovery. Thus, one of the main challenges is the visualization of the results. When a farming business generates data from the sensors on the field, the new approaches for context-aware visualization should be followed in order to support the decision-making in the different levels [7]. The fact is many farms did not survive the transition to large IT-controlled enterprises, and were subsequently acquired by IT specialists [10].

Since for most of the time the agriculture industry is not prepared for the experts that could store, manage and perform the data analytics, this can be a new issue. However, it can be approached by using services from the third party. A supporting vision was given by Mourtzis [7], who stated that the main aspects of industrial big data are not found inside one company but in a network of interconnected companies where different data should be collected in a place to process them, and derive meaningful insights for the decision-making. However, an alternative way can be used if the business has the capability of hiring people with the right competencies. Since in the more advanced agricultural system the work on the fields are automated, this made these days farmers are data analysts rather than people in overalls getting dirty.

3.4 Data Security

Data security is probably the most critical things to be secured when a business started to employ sensors and devices to collect data. Sensor readings from the plant growth, environmental data, and even customer-engagement data can be very critical for the company. Not only without the data the analytics could not be properly conducted, or probably resulted in an inaccurate information. Also if the data is compromised, it will be beneficial for those who obtained it. Either by selling the data to the competitors, or probably by committing an unethical crime act of data ransom.

3.5. Future directions for IoT in agriculture industry

There are key enabling technologies and application domains in the agriculture industry that are likely to drive IoT research in the near future. The next generation Internet of Things will be directed to overcome the contemporary challenges and bring the innovations for future implementations of connected world. With the new technology to come, agriculture industry is expected to support the changes, participating in directing the future research for the benefits of the industry.

For the realization of IoT vision on a decent interconnectivity with economical and low-cost technology, wireless communications, and digital electronics, varieties of technologies have been emerged. With the rapid development in the decades, agricultural sensing and networking technologies have been more and more mature. It has been observed by Lee [26], that hardware technology evolved by time. In the early presence, RFID tags and some sensors may be built by smaller

and cheaper MEMs technology. In between 2010 to 2015, we observed some secure and low-cost tags development along with multi-protocol and multi-standards readers. Beyond 2020, it is predicted that new low-cost materials and nanotechnology will improve the evolution of the hardware.

Cloud computing answers the challenges arise in data management, as the most recent paradigm which promises reliable services delivered through next generation data centers that are based on virtualized storage technologies [27]. Magnetic recording has been the storage industry standard for decades. However, new emerging technologies such as bit-patterned media recording (BPMR), Shingled Magnetic Recording (SMR), and non-volatile memories (NVM) are bringing new feasible points for faster and higher-density storage [28]. It can be expected that in the near future, high reliability, scalability and autonomy to provide ubiquitous access, dynamic resource discovery and composability needed for the next generation IoT applications can be achieved.

Security aspect will still be a major concern wherever massive connectivity is deployed. There can be many ways the system could be attacked—from accessing customer personal information, disabling network availability, or pushing erroneous data into the network [27]. These complex problems have solutions through cryptographic methods which deserved more research before they can be widely accepted. Data encryption ensures confidentiality against outside attackers, and message authentication codes safeguard data integrity and authenticity.

Agricultural data securities and privacy issues should always be protected. Future development in connectivity should always be followed. Keeping the update in terms of hardware and software technology may not completely eliminate the threats, but will push the imminent danger below the threshold.

4. Conclusion

The agriculture industry has been assimilating and adopting the IoT for quite some time, transforming the typically conventional practices towards the utilization of sensors and other technologies. For this, the methods with a definite roadmap and general principles of IoT strategies are circumstantial, as it allows one business to embed the technology and successfully, increasing the quality, quantity, sustainability and cost effectiveness of the company. However, the industry should always keep an eye open and observe relentlessly the challenges that come with the technology. The connectivity of IoT may have passed the stage of infancy, and is still developing with promising potential for the agriculture industry to reap.

Acknowledgements

Acknowledgements and Reference heading should be left justified, bold, with the first letter capitalized but have no numbers. Text below continues as normal.

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Utilization of Edible Coating and Film from Mocaf Flour to Extend Shelf Life of Gelamai

Hafnimardiyanti[a*], M. Ikhlas Armin[a]

[a]*Departemen of Analytical Chemistry, Polytechnic of ATI Padang,Jl. Bungo Pasang, Tabing, Padang25171, Indonesia*

Abstract

Plastic is the most widely used for packaging material, but plastic polymers have weaknesses such as heat-resistant, tear-free and contamination by monomer transmission to packaged materials and non-biodegradable properties. Then developed the type of packaging from organic materials and derived from renewable materials, economical and edible packaging. Mocaf (Modified Cassava Flour) has become one of the potential sources of starch for edible packaging. Mocaf is a derivative product from cassava flour made with the principle of modification of cassava cells in fermentation with lactic acid bacteria. The purpose of this research is to observe the effect of mocaf edible packaging (film and coating) on the storability of the gelamai packaged with this edible packaging. In this study, gelamai is packed with edible packaging in the form of edible film with 1% glycerol plasticizer, edible coating with glycerol and sorbitol plasticizer with concentration of 1, 1.5 and 2%. Then performed organoleptic test to see panelist reception to gelamai which is packed with this edible packing, then the determination of water content and tiobarbiturat acid level to see the effect of edible packing during storage of gelamai. From the research that has been done obtained that based on organoleptic test, the increase of plasticizer concentration decrease panelist's preference level to gelamai. This edible packaging has an effect on the shelf life of the galamai, wherein gelamai with edible coating plasticizer glycerol 1% provides longer shelf time compared to other packing types, marked by the growth of fungus at week 4, although rancidity has begun to appear at week 3. The other packers such as plastic, edible film glycerol 1% and sorbitol, rancidity have arisen at week 2 and fungus grows at week 3.

Keywords: mocaf, edible coating, edible film, organoleptic, plasticizer

1. Introduction

Indonesia is a country rich in various types of processed foods, one of this types is the gelamai. This traditional food is a snack from West Sumatra made from glutinous rice flour mixed with coconut milk and brown sugar or palm sugar. Almost every area in Indonesia has this type of traditional food known as dodol or jenang. Galamai is the same as dodol, has a dark brown and shiny, if taste tasted chewy and tender tongue.

Gelamai is semi-wet food, contains water content ranges from 15-50% and water activity less 0.6-0.9. Damage that occurs in this gelamai because of the aroma of rancid caused by the oxidation of fat, especially in coconut milk that produces aldehyde and peroxide compounds. The oxidation process produces odors and flavors that can degrade the quality of food [1]. The damage causes the gelamai to have a relatively short shelf life.

Foodstuffs are generally very sensitive and susceptible to quality degradation due to environmental, chemical, biochemical and microbiological factors. One of method to prevent or slow the phenomenon is with proper packaging. Packaging of food products is a packaging process with suitable packing materials to maintain and protect food to the consumers so that quality and safety can be maintained. In order for product quality to be maintained, packing and storage is necessary and appropriate. Packaging and storage are two things that cannot be separated in the food industry. In addition, good packaging and storage will extend the life of the product [2].

One of the most commonly used packaging materials of packaging material derived from petrochemical polymers or better known as plastics, is the most widely used packaging material. This is due to various plastic advantages such as flexible, easily formed, transparent, not easily broken, and the price is relatively cheap. However, plastic polymers also have many disadvantages, namely its non-heat resistance, tear ability, and most importantly contamination through its monomer transmission to packed material. Another disadvantage of plastic is its non-biodegradable nature, used plastic waste will not be destroyed even if it has been dumped for decades, as a result of the buildup of plastic waste can cause pollution and damage to the environment [3].

Along with the human consciousness of this problem, it developed a type of packaging from organic materials, and derived from renewable and economical materials [4]. One type of packaging that is environmentally friendly is edible packaging. The advantage of edible packaging is that it can protect food products, the original appearance of products can be maintained, and can be directly eaten and safe for the environment. Edible packaging is grouped into two parts, which

* Corresponding author. Tel.: +62751 7055053; fax: +62751 41152.
*E-mail address:*hafni_cien@yahoo.com

serves as an edible coating and an edible film [5]. Edible film and coating packaging is potentially applied to food to extend the life of food stores [6].

Edible packaging can be made from several polymers, namely: hydrocolloids (in the form of polysaccharides: cellulose, starch, pectin, etc. and proteins: collagen and gelatin), lipids (fatty and fatty acids) and composites [7].

Some research that has been done in packing semi-wet food with edible packaging is edible coating tapioca to pack the lempok durian [8], edible film palm fruit with antioxidant to pack the lempok durian [9], edible coating breadfruit starch for jenang dodol packaging [10], edible coating starch Seeds jackfruit for jenang dodol packaging [11], edible film starch canna tuber to package gelamai [12], edible film sodium alginate to pack seaweed dodol [13], edible coating pectin durian for packing gelamai [14].

Polysaccharide is one of the edible packaging materials [15]. Indonesia as an agricultural country has enormous potential to produce polysaccharides, both from agricultural products and from agricultural waste. One of the Indonesian agricultural products is cassava, from this cassava can produce some derivative products such as mocaf. Mocaf flour is made by fermentation with lactic acid bacteria by modifying cassava starch cells [16].

Hafnimardiyanti [17] has done research making edible film of mocaf flour with various plasticizer. The best edible film was produced by the addition of a 1.5% glycerol plasticizer with a tensile strength of 60.2 MPa and a maximum strain of 5.3%. In this study edible mocaf film produced is applied to pack semi-wet food gelamai, beside that the packaging will also be done in coating.

2. Method

2.1. Edible Film Making

The making of edible film is based on Hafnimardiyanti's research (2016). Where 4 g of mocaf flour was dissolved in 100 mL of aquades then heated with hot plate with constant stirring of 700 rpm, until it reached gelatinating temperature (80-90oC). After the gelatinization temperature was reached, a glycerol plasticizer was added with a concentration of 1.5%. After mixing then the solution is heated for approximately 30 minutes. Strain with whatman paper, then mold into a 40x60 cm baking sheet of 250 mL and dried in an oven at 85 ° C for 3 hours, open the film from the plastic mold and store in the desiccator before being used to package the gelamai.

2.2. Edible Coating Solution Making

4 g of mocaf flour is dissolved in 100 mL of aquades and then heated with hot plate with constant stirring of 700 rpm, until gelatinating temperature (80-90oC) .. After gelatinization temperature is achieved, plasticizer added with various concentration variations (0%, 1.0% ; 1.5% and 2.0%). After mixing then the solution is heated for approximately 30 minutes and strain with whatman paper

2.3. Application at Gelamai

The resulting edible film was applied to pack the gelamai.

The edible solution of mocaf flour with plasticizer variation was applied to the gelamai by immersion into an edible solution (with variations of 1x, 2x and 3x dipping) then dried in an oven at 60 ° C for 1 hour.

2.4. Organoleptic Test

The test is conducted to determine the effect of coating and film on the appearance of the overall taste, aroma and texture of the stored gelamai.

2.5. Storage Gelamai

Coated and enclosed edible films are inserted into the container and stored for 30 days at room temperature. On days 7, 14, 21, 30, a water content test with gravimetric method and fat loss (TBA number) was performed using AOCS cd 19-90 (1990) method from gelamai to determine its quality.

3. Results and Discussion

3.1. Organoleptic Test

The organoleptic test is performed to determine the level of panelist acceptance of the resulting gelamai. The organoleptic test was performed by 30 untrained panelists with parameters including color, flavor, taste and texture.

From organoleptic test that has been done to gelamai which have been packed with various edible coating got the most accepted product of panelist is gelamai with edible coating sorbitol 1% as seen in Figure 1 below.

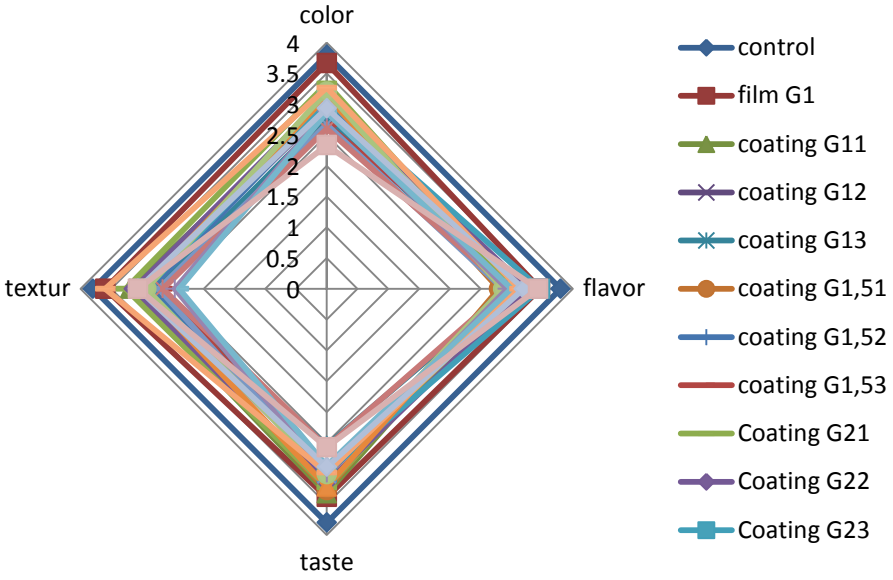

Figure 1. Panelist reception of gelamai with edible coating with several plasticizers

3.2. Water Content

The influence of moisture is very important in the formation of durability of food, because water can affect physical properties or chemical changes [1]. The result of test of water content of gelamai which have been dicoating can be seen in following picture 2.

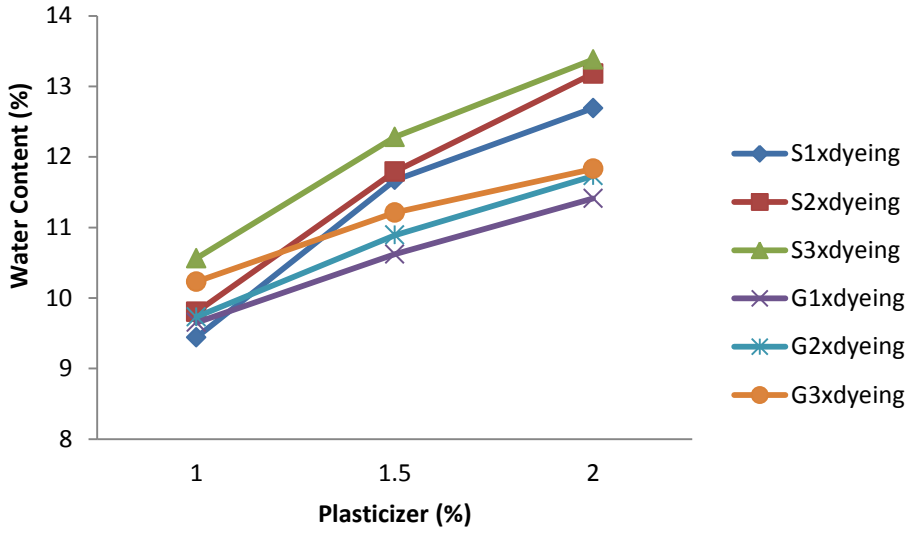

Figure 2. Graph of Moisture Water Content coated with edible plasticizer glycerol and sorbitol

From Figure 2. it can be seen that the water content of the gelamai increases after coating with edible solution. Increased moisture content is strongly influenced by the type and concentration of plasticizer and the amount of dyeing. This is due to the increase of hydrophilic properties of the edible coating solution with the increasing of OH group of plasticizer so that it will increase the amount of water tied up and make the solution becomes more viscous.

3.3. Tiobarbituric Acid Number

Changes in nutritional value such as fat during the precipitation can form rancidity in foodstuffs. Rancidity is caused by the formation of peroxide numbers that occur during storage [18]. Measurement of Tiobarbiturate (TBA) number is used to determine the level of oil rancidity and according to Sudarmadji [19] a minimal TBA number indicating that a rancid product is 0.300 mg malonaldehyde / kg.

Glycerol Plasticizer

Determination of TBA to gelamai during storage can be seen in Figure 3.

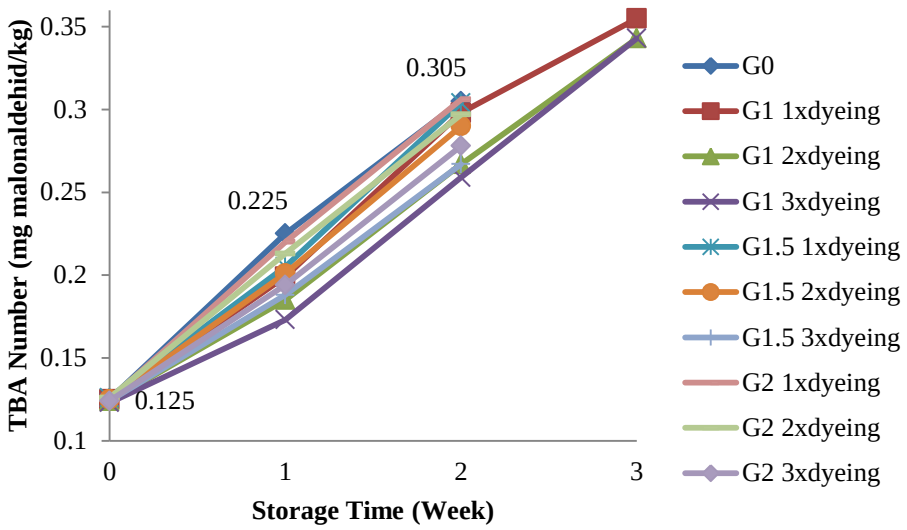

Figure 3. Graph of TioBarbituric Acid Number of Gelamai with Edible Coating Glycerol

From Figure 3 it was seen that the level of TBA from the gelamai increased during storage, but the rate of TBA number increase was slower when compared to the controls that had shown rancidity at week 2. From the figure it was also shown that 1% glycerol gave longer shelf life time compared to glycerol 1.5 and 2%, this is due to the higher concentration of plasticizer the higher moisture content of the product thus accelerating rancidity and growing its fungus.

Sorbitol Plasticizer

When compared between edible coatings with glycerol plasticizer, the value of rancidity with sorbitol plasticizer occurs at 2 weeks after coating, as shown in Figure 4. This is due to the good sorbitol permeability properties of water vapor and oxygen (Sobral, et al in Pokatong, 2014) thus accelerating the hydrolysis and oxidation of oils in the gelamai into free fatty acids and peroxide compounds.

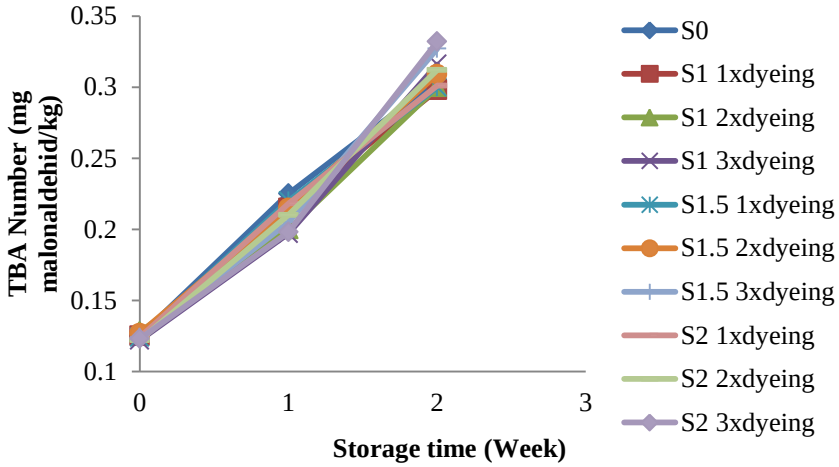

Figure 4. Graph of TioBarbiturate Acid Number with Edible Coating Sorbitol

Type of packaging of TBA Number

To see the effect of storage time to the type of packaging, then comparisons of the number of TBA that have been packed with various types of packaging, as in figure 5 below.

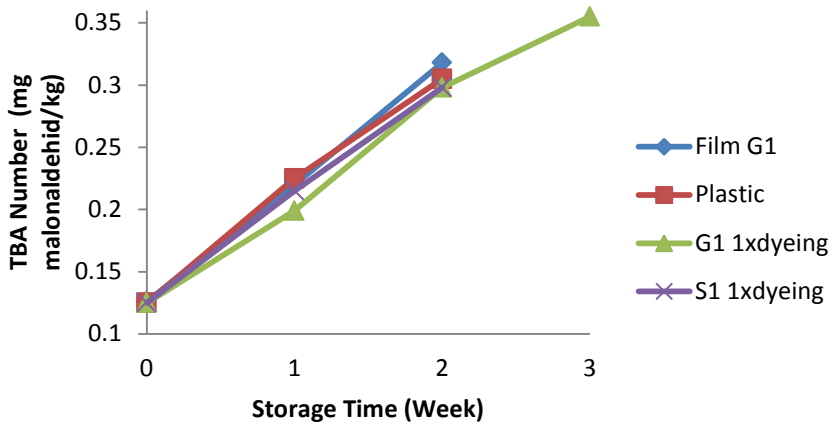

Figure 5. Graph of TBA Number of gelamai with various types of packaging

From Figure 5 it can be seen that edible coating with 1% glycerol plasticizer gives longer self life time compared to other packing type, marked by the growth of fungus at 4th week although rancidity has started to appear 3 weeks. Other packing types such as plastic, edible 1% glycerol film and sorbitol rancidity have arisen at 2 weeks and the fungus grows at week 3.

4. Conclusion

From the research that has been done can be concluded that:

1. Edible mocaf flour film with 1% glycerol plasticizer had the same self life time with plastic which is 2 weeks.
2. Edible coating with 1% glycerol plasticizer able to preserve the gelamai for 3 weeks, while plasticizer sorbitol 2 weeks.
3. Edible coating with glycerol plasticizer gives best storage result compared edible film glycerol 1% and edible coating sorbitol

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The Effect of Various Plasticizer for Making Edible Coating from Canna Starch Tuber to Traditional Food (*Gelamai*)

M. Ikhlas Armin[a*], Hafnimardiyanti[a]

[a] *Polytechnic ATI Padang Jl. Bungo Pasang Tabing Padang, 25171, Indonesia*

Abstract

Indonesia is rich with plants as a source of starch, one of the plants is the canna (Canna edulis Kerr). During this time canna plant is only used as an ornamental plant, in fact canna has tuber as the source of starch that has not been widely used. Besides that, canna also easily cultivated, so the availability was abundant. Starch is one of the edible packaging material as a replacement for plastic packaging. The advantages of using edible packaging is to protect the food product, the original appearance of the product can be maintained and can be eaten as well as safe for the environment. The purpose of this research is the detection of materials that can be used as raw material for packaging edible, edible packaging manufacture and application to semi-moist food *gelamai*, especially to its quality during storage. In this research the extraction of starch from the canna tuber is done by maceration. Starch solution obtained was made into edible packaging in a way diluted with distilled water and heated to gelatinization temperature (75-80^{o}C) is reached, after that the plasticizer is added to add plastic properties to packaging edible. Plasticizer used is glycerol, sorbitol and polyethylene glycol with various concentrations 1, 1.5 and 2%. After mixed, solution was heated for 30 minutes. Edible solution is applied to *gelamai* with variations immersion of dyeing 1 times, 2 times and 3 times, then dried in an oven at 60 °C for 1 hour. From the research that has been done obtained packaging edible coating from starch canna tuber with the addition of 1% sorbitol got the best reception from panelists based organoleptic test. Packaging edible coating give effect to the shelf life of this galamai characterized by decreasing the rate of increase in the value of Thiobarbituric acid to coated *gelamai* compared with the control. Control undergo rancidity at week 2, *gelamai* with platicizer glycerol at weeks 4 and sorbitol in week 3. Plasticizer polyethylene glycol does not give rise plasticizer, characterized by the breakdown of the surface of the product after coated and undergo rancidity in week 2.

*Keywords:*canna; edible coating; organoleptic; plasticizer

1. Introduction

Packaging of food products is a packaging process with suitable packing materials to maintain and protect food to the consumer so that quality and safety can be maintained [1]. In order for product quality to be maintained, packing and storage is necessary and appropriate. Packaging and storage are two things that cannot be separated in the food industry. In addition, good packaging and storage will extend the self-life of the product.

One of the most commonly used packaging materials of packaging material derived from petrochemical polymers or better known as plastics, is the most widely used packaging material. This is due to various plastic advantages such as flexible, easily formed, transparent, not easily broken, and the price is relatively cheap. However, plastic polymers also have many disadvantages, namely its non-heat resistance, tearability, and most importantly contamination through its monomer transmission to packed material. Another disadvantage of plastic is its non-biodegradable nature, used plastic waste will not be destroyed even if it has been dumped for decades, as a result of the buildup of plastic waste can cause pollution and damage to the environment [2].

Along with the human consciousness of this problem, it developed a type of packaging from organic material, and derived from renewable and economical materials. One type of packaging that is environmentally friendly is edible packaging. The advantage of edible packaging is to protect food products, the original appearance of the product can be maintained, and can be directly eaten and safe for the environment. Edible packaging is grouped into two parts, which serve as an edible coating and an edible film.Edible packaging can be made from several polymers, namely: hydrocolloids (in the form of polysaccharides: cellulose, starch, pectin, etc. and proteins: collagen and gelatin), lipids (fatty and fatty acids) and composites [4]

Some studies that have been done in the manufacture of edible packaging with starch ingredients include the use of jackfruit seed starch as an edible coating on the quality of *dodoljenang* [5]. The use of breadfruit starch as an edible coating on the quality of *dodoljenang* [6].Corn starch as an edible coating for maintaining the quality and saving of tomatoes [7]

The source of starch in Indonesia is actually very much, of which originated from tubers. Canna which is one part of the growing source of starch in Indonesia which is currently not widely utilized [8].Canna plants are quite easy to cultivate both on fertile soil and on barren land and its growth does not require difficult requirements. Canna production is quite a lot

* Corresponding author. Tel.: +62751 7055053; fax: +62751 41152.
*E-mail address:*ikhlas_armin@yahoo.com

in the community especially in rural areas. People still rarely use canna as food. Canna is a tuber that has carbohydrate levels 86,64-87,28% [9]. High levels of carbohydrates in canna have excellent prospects to be developed into edible packaging.

Several studies that have been done using these canna tubers include the manufacture of biodegradable plastic [9] and the manufacture of edible film for packaging *gelamai* [10]. *Gelamai* which is packed with edible film from this canna tubers can last for 1 month, before overgrown with mushroom. But the edible film produced at the time packed to *gelamai* makes the shape of the *gelamai* unattractive.

2. Method

The Making Edible Coating Solution

3 g canna tuber starch is dissolved in 100 mL of aquadest then heated to gelatinating temperature (75-80^{o}C). After gelatinization temperature was achieved, plasticizers were added with various concentrations (0%, 1.0%, 1.5% and 2.0%). After mixing then the solution is heated for approximately 30 minutes.

Application to Gelamai

The edible solution from canna tubers with the plasticizer variation was applied to the *gelamai* by immersion into an edible solution (with variations of 1x, 2x and 3x dipping) then dried in an oven at 60 ° C for 1 hour.

Organoleptic Test

The test is conducted to determine the effect of coating and film on the appearance of the overall taste, aroma and texture of the stored *gelamai*.

Storage Gelamai

Coated and enclosed edible films are inserted into the container and stored for 30 days at room temperature. On days 7, 14, 21, 30, measure a water content test with gravimetric method and rancidity (ThiobarbituricAcid number) was performed using AOCS cd 19-90 (1990) method from *gelamai* to determine its quality

3. Results and Discussion

Organoleptic Test

The organoleptic test is performed to determine the level of panelist acceptance of the resulting *gelamai*. The organoleptic test was performed by 30 untrained panelists with parameters including color, aroma, taste and texture.From organoleptic test that has been done to *gelamai* which have been packed with various edible coating, got the most accepted product of panelist is *gelamai* with edible coating sorbitol 1% as seen in Figure 1 below,

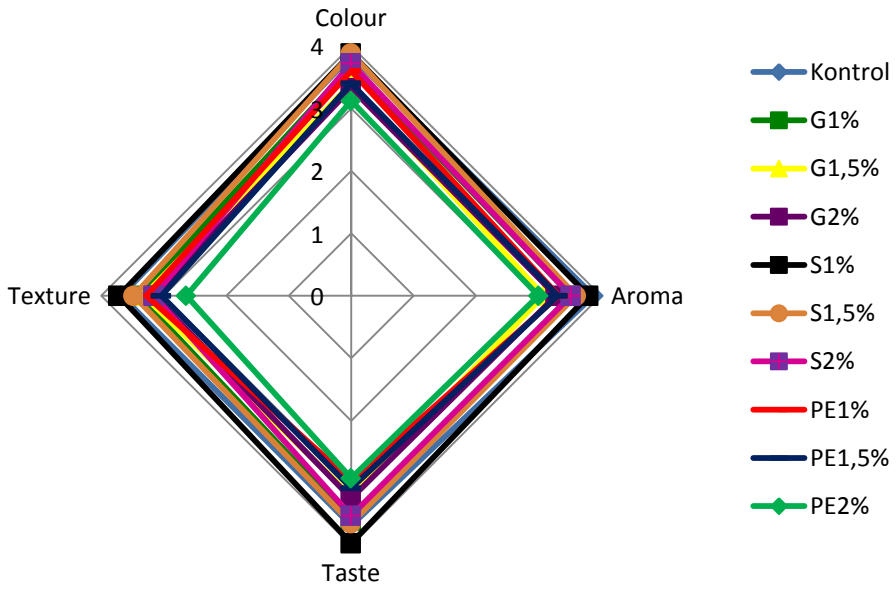
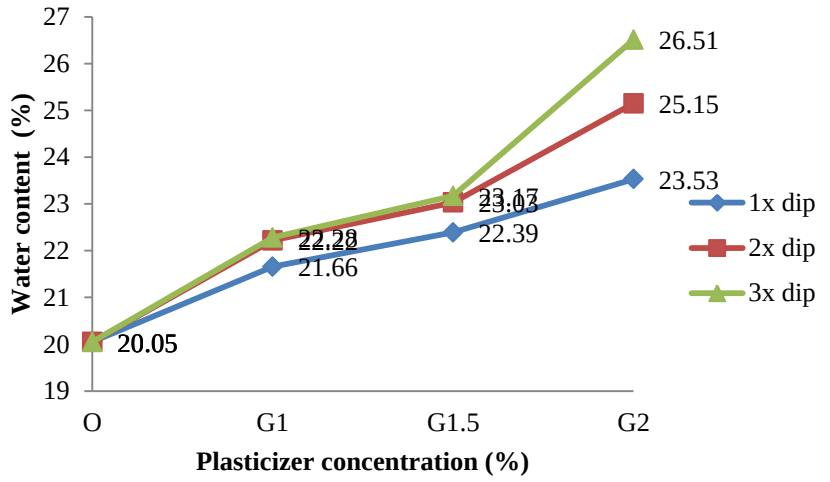


Figure 1. Panelist reception to *gelamai* with edible coating with various plasticizers
(S = Sorbitol, G = glycerol, PE = polyethylene glycol)

Water content

The influence of moisture is very important in the formation of durability of food, because water can affect physical properties or chemical changes. The result test of water content from *gelamai* which have been dicoating can be seen in Picture 2.



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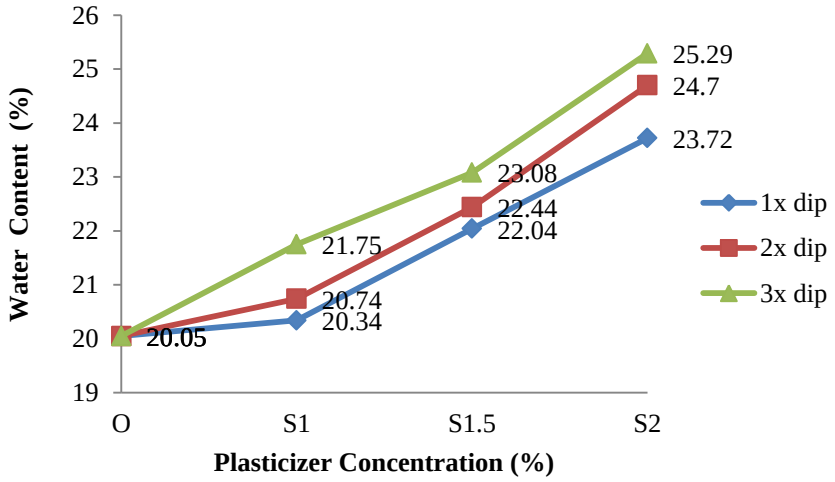

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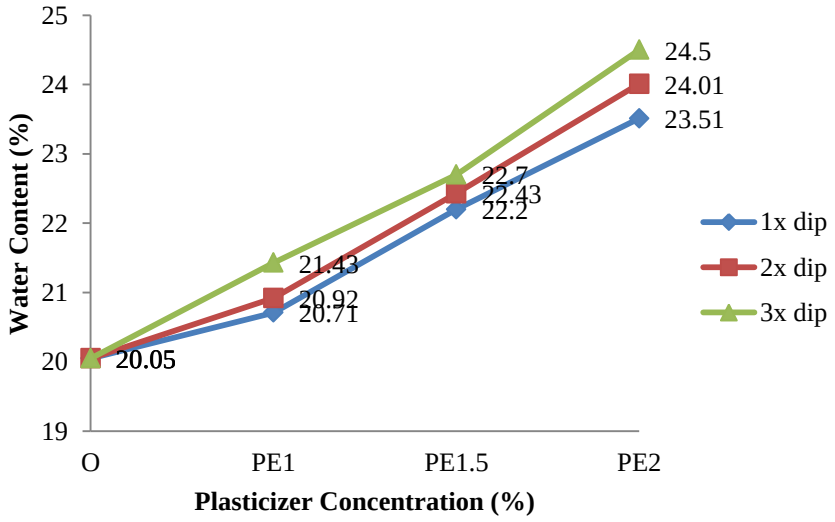


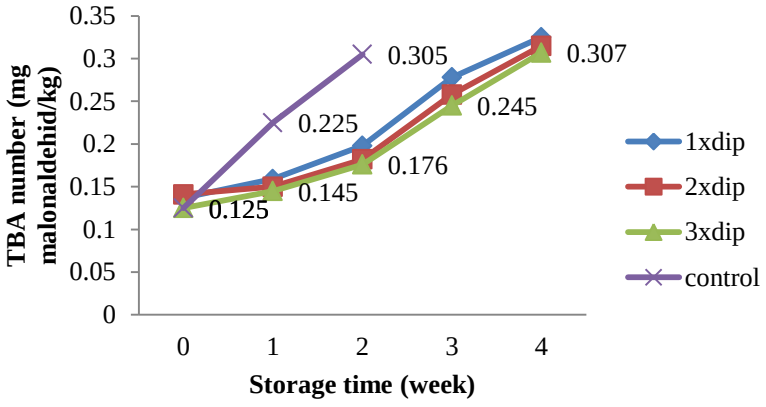
(c)

Figure 2. Graph of Water Content of *Gelamai* (a) coating with edible plasticizer glycerol. (b) Coating with edible plasticizer sorbitol and (c) coating with edible plasticizer polyethylene glycol

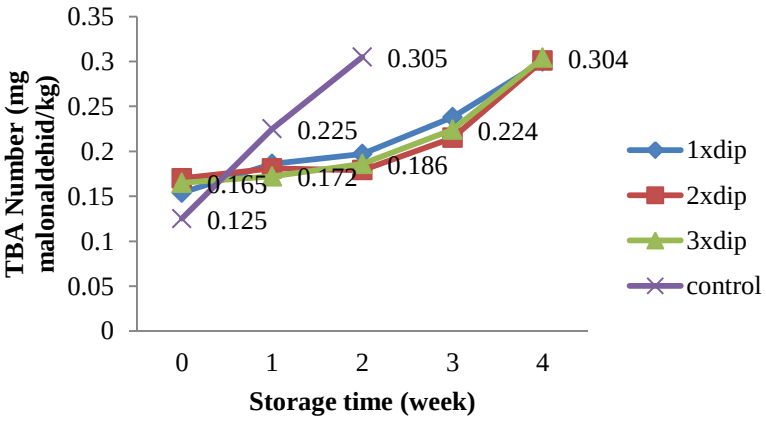
Figure 2 shows that the water content of the *gelamai* increases after coating with edible solution. This increase in water content depends on the thickness of the edible solution after the addition of plasticizer and the amount of coating. The thicker the edible solution, the higher the water content of the *gelamai*, as well as the more coating the higher the moisture content.

Glycerol Plasticizer

Determination of TBA to *gelamai* during storage can be seen in Figure 3.



(a)



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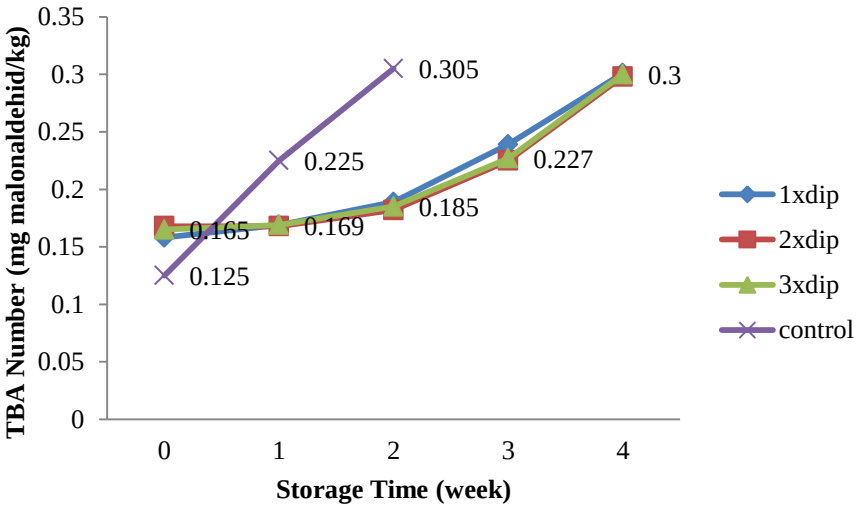


(c)

Figure 3. Graph of Thiobarbituric Acid Content with Edible Coating Glycerol (a) 1% (b) 1.5% and (c) 2%

From Figure 3 it can be seen that the level of TBA from *gelamai* increases during storage, but the increase rate of TBA is slower when compared to the control that has shown rancidity at week 2. From the figure it is also seen that the number of dip did not significantly affect the number of TBA obtained, the plasticizer concentration has an effect on the number of the TBA from *gelamai* as shown in Figure 4.

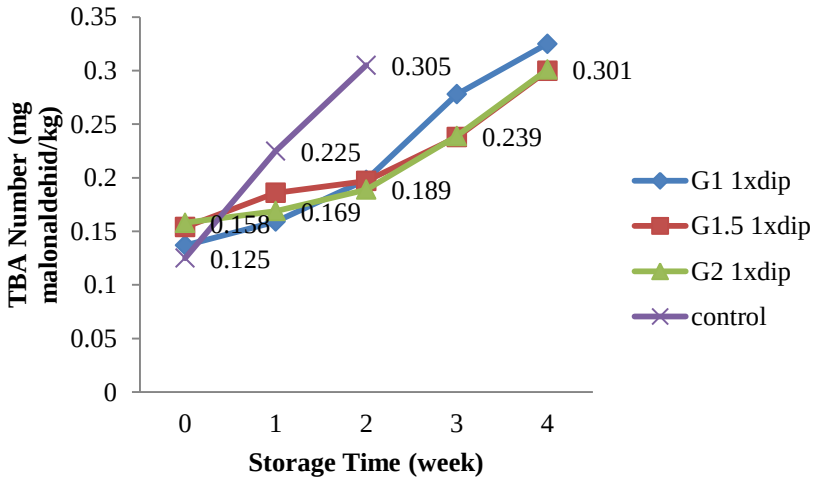
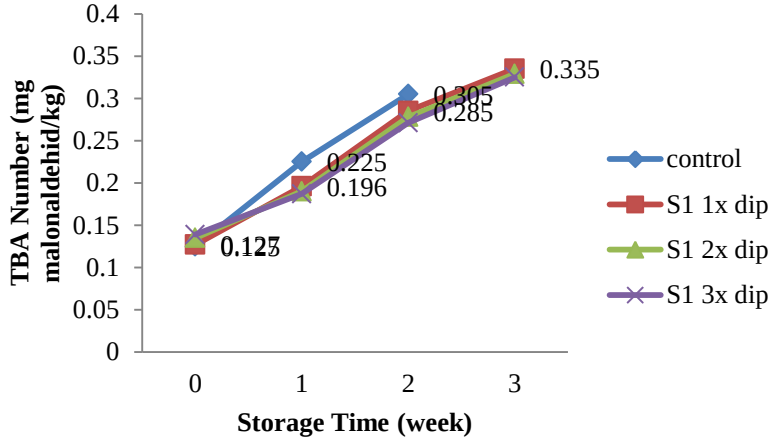


Figure 4. Graph of Thiobarbituric Acid Content of *Gelamai* with various concentrations of Glycerol

Sorbitol Plasticizer

When compared between edible coating and glycerol plasticizer, the value of rancidity with sorbitol plasticizer occurs at week 3 after coating, as shown in Figure 5. This is due to the sorbitol permeability properties of water vapor and oxygen [11] thus accelerating the hydrolysis and oxidation of oils in the *gelamai* to free fatty acids and peroxidecompounds.



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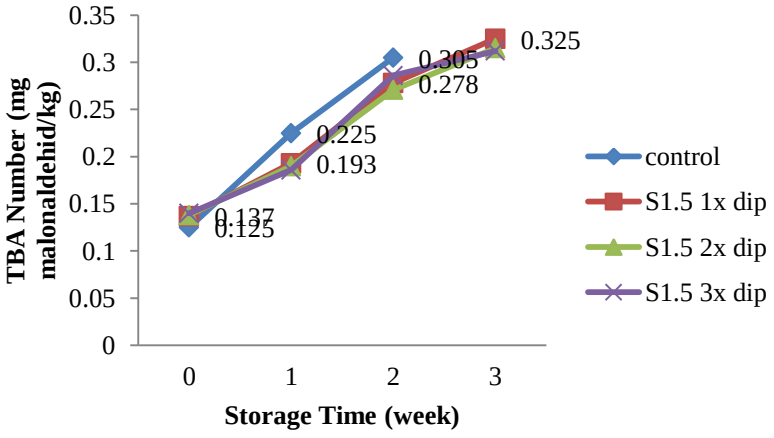

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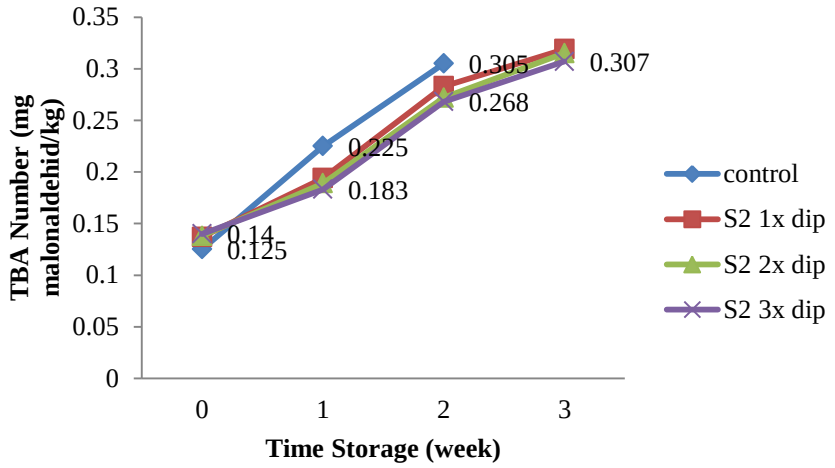
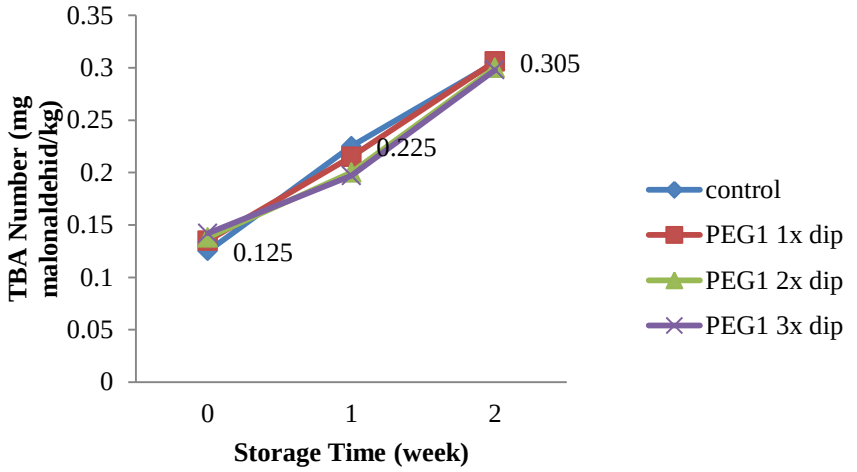


(c)

Figure 5. Graph of Thiobarbituric Acid Content with Edible Coating Sorbitol (a) 1% (b) 1.5% and (c) 2%

Polyethylene Glycol Plasticizer

Edible coating with polyethylene glycol plasticizer, does not provide plasticity addition to the edible coating. This can be seen from the emergence of cracks or cracked on the surface of the *gelamai* coating with this plasticizer. So the selflife of this *gelamai*same with *gelamai*notcoating is about 2 weeks.



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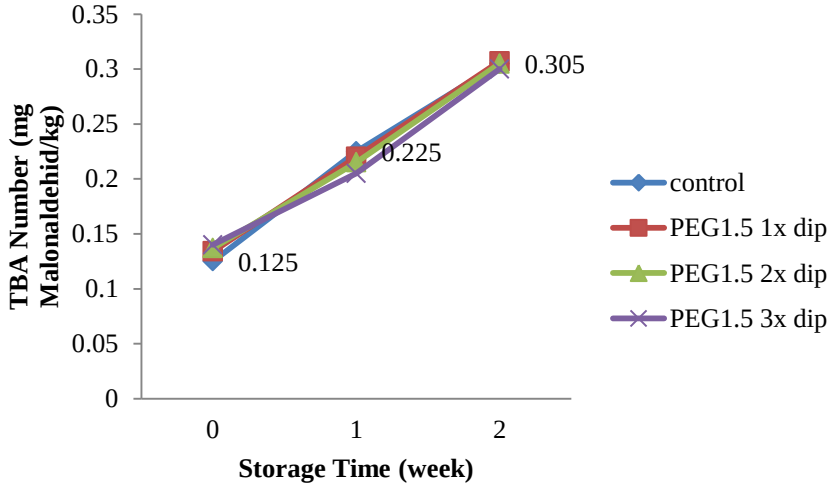

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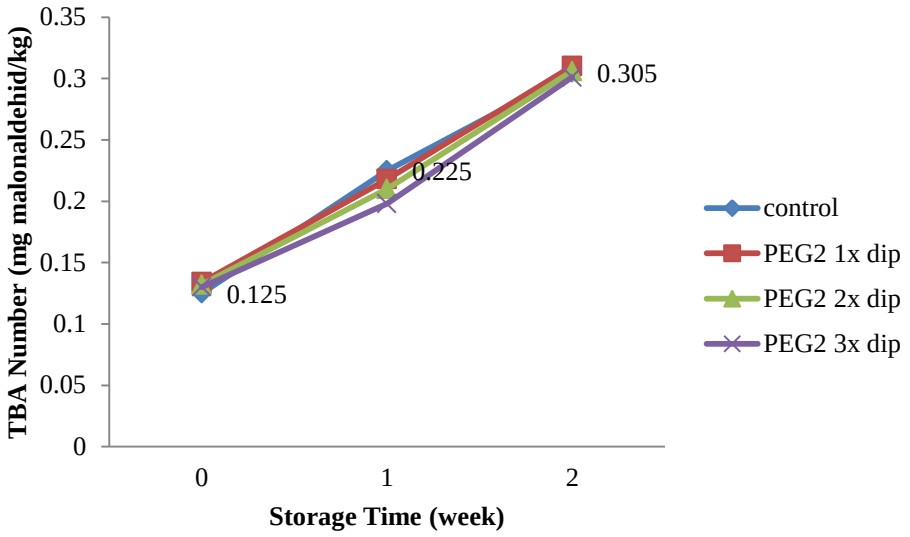

(c)

Figure 6. Graph of Thiobarbituric Acid Content with Edible Coating of Polyethylene Glycol (a) 1% (b) 1.5% and (c) 2%

4. Conclusions

From the research that has been done can be concluded that:

1. Plasticizer gives effect to the viscosity of the resulting edible coating solution.
2. Types of plasticizers and the amount of immersion provide a decrease in the level of panelist preferences in organoleptic tests. Where *gelamai* with edible solution with 1% sorbitol plasticizer get the best reception from panelist.
3. The water content of the *gelamai* is increased based on the type of plasticizer and the amount of coating.
4. Edible coating packaging gives effect to the shelf life of this galamai is marked by decreasing rate of increase of TBA value on the coating *gelamai* compared with control. The control was rancid at 2 weeks, *gelamai* with plasticizer glycerol at week 4 and sorbitol at week 3.
5. Plasticizer polyethylene glycol does not provide an increase in plasticizer, characterized by surface cracking of the product after coated. And rancidity occurs at week 2.

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The Correlation of Biodiesel Physical Properties and Titanium Tetrahedral Coordination in Silica-Titania Prepared by Different Moles Ratio of Titania Precursors

Umar Kalmar Nizar[a], Yohanes Manan Sitanggang[a], Risma Sari[b], Rita Sundari[c], Bahrizal[a],Ananda Putra[a], Latisma DJ[a]*

[a]*Chemistry Department, Universitas Negeri Padang*
[b]*Chemical Analysis Department, Politeknik ATI Padang*
[c]*Mechanical Engineering, Universitas Mercu Buana Jakarta*

Abstract

Palm oil cannot be used directly as biofuel due to its high boiling point and viscosity. For its application as biofuel, the palm oil is converted to biodiesel through transesterification of palm oil and methanol with catalyst addition. This work is related to the synthesis of silica-titania as catalyst in association with titanium tetrahedral coordination and the study of the effect of titanium tetrahedral coordination on biodiesel production from palm oil. A solid state method is used to synthesize silica-titania catalyst applying mole variation of both solid silica and titania. The synthesis products are characterized by FTIR and DR UV-Vis, as well as the fraction of titanium tetrahedral coordination is calculated through deconvolution method of DR UV-Vis spectra. The results show the tetrahedral coordination of titanium increased using both solid silica and titania in the solid state method compared to that using solid titania commercial as precursor in the reaction. The mole ratio of silica and titania of 1:0.5 gave the highest percentage of titanium tetrahedral coordination. The increasing of the fraction of titanium tetrahedral coordination in silica-titania catalyst applied in reaction of palm oil and methanol can reduce the boiling point, viscosity, and density of the oil product.

Keywords: silica-titania, titanium tetrahedral coordination, biodiesel, palm oil, solid state

1. Introduction

Based on several reasons in relation to (i) limitation of fossil fuel natural resources, (ii) current cost of crude oil, and (iii) environmental pollution generated by fossil fuel usage, some research on biodiesel energy have been investigated during recent decades. Biodiesel has been considered as one of alternative fuel energy due its special advantage over common fossil fuel energy. Furthermore, biodiesel has several benefits related to (i) its better lubricating properties compared to that of fossil fuel, (ii) reducing too fast engine exhausted, and (iii) economic factor of engine maintenance (Gaurav, et al., 2016; Ilmi et al., 2017).

Indonesia is a country rich with palm oil and therefore, biodiesel can be produced from palm oil through some treatments. In addition, palm oil can live longer (about 25 years) and resist towards climate problem. According to Axelsson et al. (2012), the application of palm oil for biodiesel production is not reducing the availability of palm oil for consuming need.

It is known that a homogeneous catalyst is required in the reaction of vegetable oil with high free fatty acid content with short chain alcohols. Meanwhile a heterogeneous catalyst is suitable for tranesterification reaction of vegetable oil with low free fatty acid and short chain alcohols such as methanol and ethanol. The homogeneous catalysts such as sulfuric acid, hydrogen chloride, sodium hydroxide, and potassium hydroxide yielded a problem related to separation process of product and catalyst. As a result, a higher cost factor is needed for the more complex separation. In addition to the incomplete separation between biodiesel product and catalyst may generate problem related to engine corrosion (Talebian et al., 2013). The limitation of homogeneous catalyst can be solved by the application of heterogeneous catalyst since the phase of heterogeneous catalyst is different from the phase of biodiesel product. The separation process is more easy and low cost. Moreover, the heterogeneous catalyst is reusable for other reactions (Chouhan et al., 2011).

One of the famous heterogeneous and very versatile catalysts in the group of titano silicate is silica-titania (SiO_2-TiO_2). It is known that the role of titanium tetrahedral coordination is very important in catalytic activity of silica-titania. The formation of titanium tetrahedral coordination via Si-O-Ti bond yields acidity on silica-titania surface caused by different geometrical form and coordination between Si and Ti (Nizar, et.al, 2013). Up to date, the application of surface acidity which occurred as the present of titanium tetrahedral coordination in silica-titania catalyst for biodiesel production has not been reported yet. However, a literature study ever reported a substituted sulfate group of silica-titania as catalyst in biodiesel production. Generally, the catalytic activity of silica-titania and titania sulfate is stronger with 90% achievement of conversion. According to Shao et al. (2013), the increased percentage of biodiesel production is not directly proportional with the increased percentage of sulfate group in silica-titania .

* Corresponding author.
E-mail address: umarjati77@gmail.com

The mole ratio of Si and Ti believed as one of the factors affected the number of titanium tetrahedral coordination in which the mole of Ti must be small equal to Si mole. It was agreed when the mole ratio of titania higher than that of silica, the formation of Si-O-Ti had been blocked by Ti-O-Ti bonding. The presence of Ti-O-Ti bond indicates the formation of titanium in octahedral coordination that means the silica and titania precursors are not reacted. Therefore, the objectives this studies firstly, to investigate the effect of mole ratio of solid precursors to the formation of titanium tetrahedral coordination in silica-titania catalyst. Secondly is to study the effect of titanium tetrahedral coordination to the physical properties of biodiesel production yielded from transesterification reaction of palm oil and methanol.

2. Method

2.1. Materials

Analytical grade of titanium oxide (Acros), silica (Sigma Aldrich), and toluene (Merck) were used in this study for the synthesis of silica-titania catalyst. Palm oil (Bimoli) and methanol (Merck) were used for biodiesel production through transesterification reaction using the proposed silica-titania catalyst.

2.2. Synthesis of silica – titania by solid state method

The silica-titania catalyst is synthesized by reacting solid precursor of silica and titania in toluene using solid state method. In order to obtain the silica-titania catalyst with high percentage of titanium tetrahedral fraction, the mole ratio of titania should be the same or lower than that of silica, thus, the variation of mole ratio using titania of 1.0, 0.50 and 0.25 compared to 1.0 mole of silica. A mixture of silica and titania in toluene was sonicated using ultrasonic apparatus for 1h to obtain homogeneous mixture. Afterwards, the mixture was put in a fumehood for 24h to evaporate toluene. Next, the mixture was calcinated at 450^{o}C for 8h and then the mixture was kept in a dessicator for characterization and biodiesel synthesis (Ningsih, 2015; Nizar et al., 2013; Shao et al., 2013).

2.3. Characterization study of silica-titania catalyst

The FTIR examination was used to determine the chemical bonding in the mixture of silica and titania. The samples were detected in the range of 4000–400 nm^{-1}. The DR UV-Vis investigation was used to determine tetrahedral and octahedral coordination in the sample and also to calculate the fraction of titanium tetrahedral based on UV spectral deconvolution. The samples were analyzed in wavelength range of 200 – 400 nm.

2.4. Silica-titaniacatalyst for biodiesel production

The production of biodiesel was obtained by transesterification reaction of commercial palm oil and methanol in the existence of silica-titania catalyst. The mole ratio of methanol and palm oil was taken to be 6 : 1 and the quantity of catalyst was taken by 10% of the palm oil weight. All components were mixed using a magnetic stirrer and heated for 3h at 65^{o}C. Afterwards, the mixture was cooled followed by separation process of the product, catalyst and excess methanol (Lokman et al., 2016).

The first separation process was conducted to remove catalyst using centrifuging. The second separation process was conducted to remove excess methanol using rotary evaporator at temperature higher than the boiling point of methanol. The biodiesel product was examined by FTIR while the physical properties of biodiesel were determined for its boiling point, viscosity, and density. The prepared catalysts and biodiesel formed are summarized in Table 1.

Table 1. The prepared catalysts and biodiesel product

Sampel	Mole silica	Mole titania	Biodiesel product
TiO_2	-		Bio-T
ST (1-1)	1,00	1,00	Bio(1:1)
ST (1-0,5)	1,00	0,50	Bio(1:0,50)
ST (1-0,25)	1,00	0,25	Bio(1;0,25)

3. Results and Discussion

3.1. FTIR spectra of silica-titania series

Fig.1 shows FTIR spectra of TiO_2, SiO_2, and series of SiO_2-TiO_2 formed by syntheses at wave number range of 4000 – 600 cm^{-1}. Moreover, the main absorption bands of TiO_2 spectrum are detected at wave number 2352 cm^{-1} and 734 cm^{-1} respectively, which indicate vibrations of Ti-O (Ti-O-Ti). The main absorption band of SiO_2 spectrum at wave number of 1058 cm^{-1} indicates asymmetric vibration of Si-O-Si, while the main absorption band at wave number of 803 cm^{-1} indicates symmetric vibration of Si-O-Si (Shao et al., 2013).

The FTIR spectra of SiO_2-TiO_2 show main absorption bands at respected wave numbers of 3668 cm^{-1}, 3429 cm^{-1}, 960 cm^{-1}, and 749.42 cm^{-1}. In general, the FTIR spectra of SiO_2-TiO_2 series are similar and appear as combination spectra of SiO_2 and TiO_2. The absorption bands at wave number of 3668 cm^{-1} and 3429 cm^{-1} indicate stretching vibrations of -OH

from silanol group (Si-OH) or water vapor adsorbed on material surface. The absorption band of –OH detected in the synthesized samples are due to samples which exposed in open air during sample measurement by FTIR. The absorption band at wave number of 749.42 cm^{-1} is suggested the absorption band of Ti-O-Ti. A very weak intensity of vibration band is observed at wave number of 960 cm^{-1}, this absorption band indicates a vibration of Si-O-Ti bonding.The Si-O-Ti bonding was formed due to chemical interaction between SiO_2 and TiO_2 and this bonding is a sign of tetrahedral framework formation in the synthesis of SiO_2-TiO_2 (Kim, et al., 2000; Nizar et al., 2013).

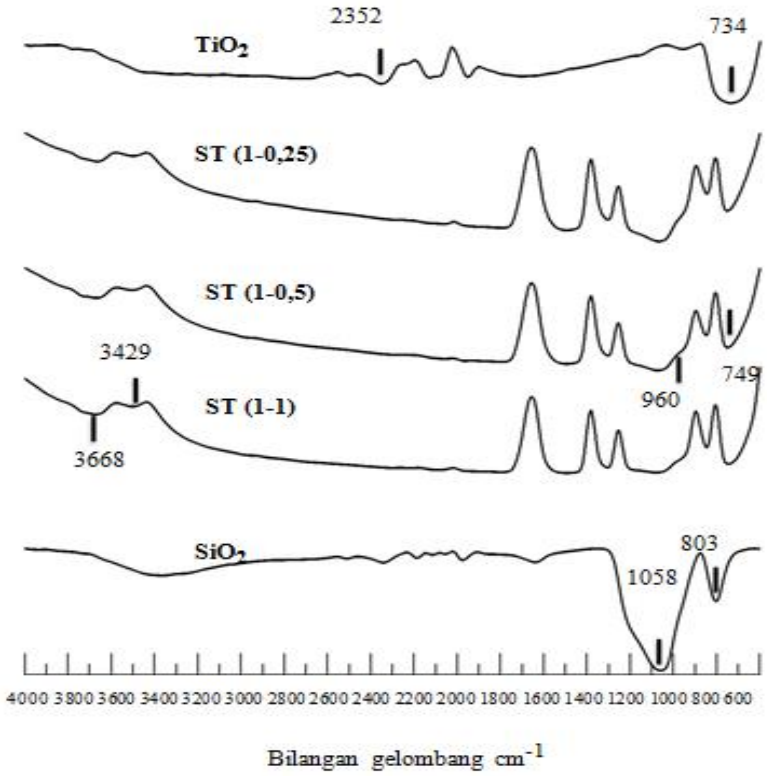
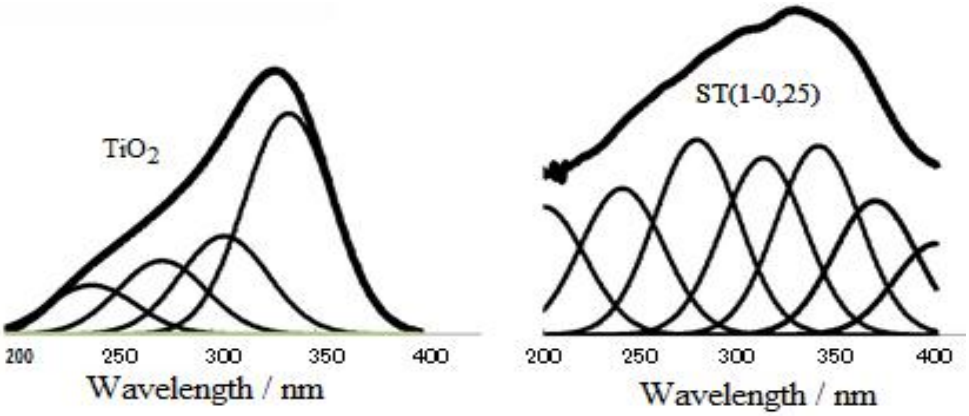


Fig.1. FTIR spectra of respected TiO_2, SiO_2, and SiO_2-TiO_2 series

The absorption band at wave number of 960 cm^{-1} is an expected absorption band because this absorption band is an indicate on of tetrahedral framework formation with the existence of Si-O-Ti bonding (Chen, et al., 2012; Kim, et al., 2000; Nizar et al., 2013). The existence of tetrahedral framework in the synthesis of silica-titania shown by FTIR spectra is more confirmed by justification of absorption band shown by DR UV-Vis examination.

3.2. Deconvolution spectra of DR UV-Vis of silika-titania series

Fig. 2 shows diffuse reflectance spectra of UV-Vis of SiO_2-TiO_2 series and TiO_2. Deconvolution on spectra was examined to investigate the effect of mole ratio of SiO_2 and TiO_2 precursors on tetrahedral framework and to determine the quantity of tetrahedral fraction formed by Si-O-Ti bonding. A literature study reported that at wave length range of 200 - ≤ 270 nm of DR UV-Vis spectra is an absorption range of titanium tetrahedral, while titanium octahedral coordination is observed at wavelength range of ≥270 – 400 nm ((Nizar et al., 2013; Sosnov, et al., 2010).



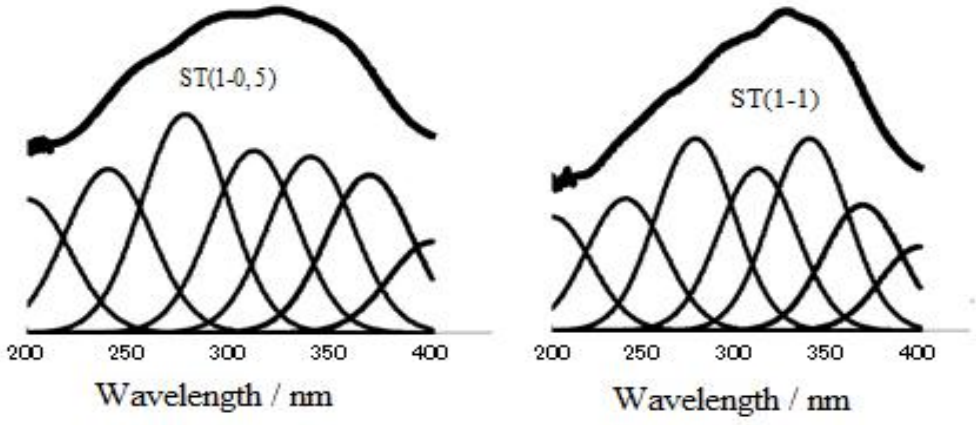


Fig. 2. Deconvolution spectra of DR UV-Vis of SiO_2-TiO_2 series and TiO_2

In general, the SiO_2-TiO_2 catalyst formed on the basis of mole ratios of SiO_2:TiO_2 may have dominant octahedral fraction, however, the catalyst synthesized under this study showed an increase of tetrahedral fraction. The increasing of tetrahedral fraction yielded can be read from Table 2.

Tabel 2. The percentage of titanium tetrahedral fraction on the basis of deconvolution of DR UV-Vis spectra

Sample	Titanium tetrahedral fraction
TiO_2	33, 40
ST(1-0,25)	42,84
ST(1-0,5)	44,70
ST(1:1)	42,05

Based on the results shown at Table 2, the solid state reaction of silica and titania at 450^{o}C can increase the quantity of titanium tetrahedral fraction from 33% to almost 50%. The spectra deconvolution justified a large part of TiO_2 and SiO_2 formed Si-O-Ti bonding. More Si-O-Ti bonding can be formed when the quantity of TiO_2 is lower than that of SiO_2. When the quantity of TiO_2 is higher than that of SiO_2, the titanium octahedral fraction is likely being formed through Ti-O-Ti bonding. However, there is no standard based on the ratio of Si : Ti in the synthesis of silica-titania (Ren, et al., 2008). The results shown by spectral deconvolution of DR UV-Vis is in good agreement with that of FTIR spectra by the appearance of absorption band at wave number of 960 cm^{-1}.

3.3. Application of silica-titania catalyst in biodiesel production

In general, the reaction between palm oil and methanol using a catalyst may produce biodiesel (methyl ester with gliserol as side product) or soap (Alhassan, et al., 2015; Konwar et al., 2015; Lokman et al., 2016). The product may have solid phase if soap is formed. However, the reaction between palm oil and methanol using SiO_2-TiO_2 or TiO_2 have yield a product with liquid phase which indicated the production of biodiesel. The biodiesel product separated by using a centrifuge and rotary evaporator. In order to confirm that palm oil is converted into biodiesel, an examination of physical properties (density, viscosity, and boiling point) on biodiesel product is required. The difference of physical properties between palm oil and the product indicates that palm oil has already converted to biodiesel.Table 3. shows the physical properties of palm oil and biodiesel at room temperature.

Table 3. Physical properties of palm oil and biodiesel at room temperature.

Physical properties	Palm oil (Bimoli)	Biodiesel			Unit
		Bio (1:1)	Bio(1:0,5)	Bio(1:0,25)	
Density	0.905	0.898	0.897	0.899	g/ml
Viscosity	0.090	0.100	0.100	0.100	ml/s
Boiling point	315	290	270	294	^{o}C

Data from Table 2 and Table 3 with respect to titanium tetrahedral fraction can be used to examine the effect of quantity of titanium tetrahedral fraction on physical properties of biodiesel with respect to its boiling point, viscosity, and density. Fig. 3(a) and 3(c) shows increased titanium tetrahedral fraction resulting a decrease in both boiling point and density of biodiesel, respectively. Fig. 3(b) shows increased titanium tetrahedral fraction yielded indifferent values of viscosity of biodiesel. However, based on data in Table 3 with respect to the viscosities of palm oil and biodiesel, the existence of titanium tetrahedral fraction in silica-titania catalyst may change the value of their viscosities.

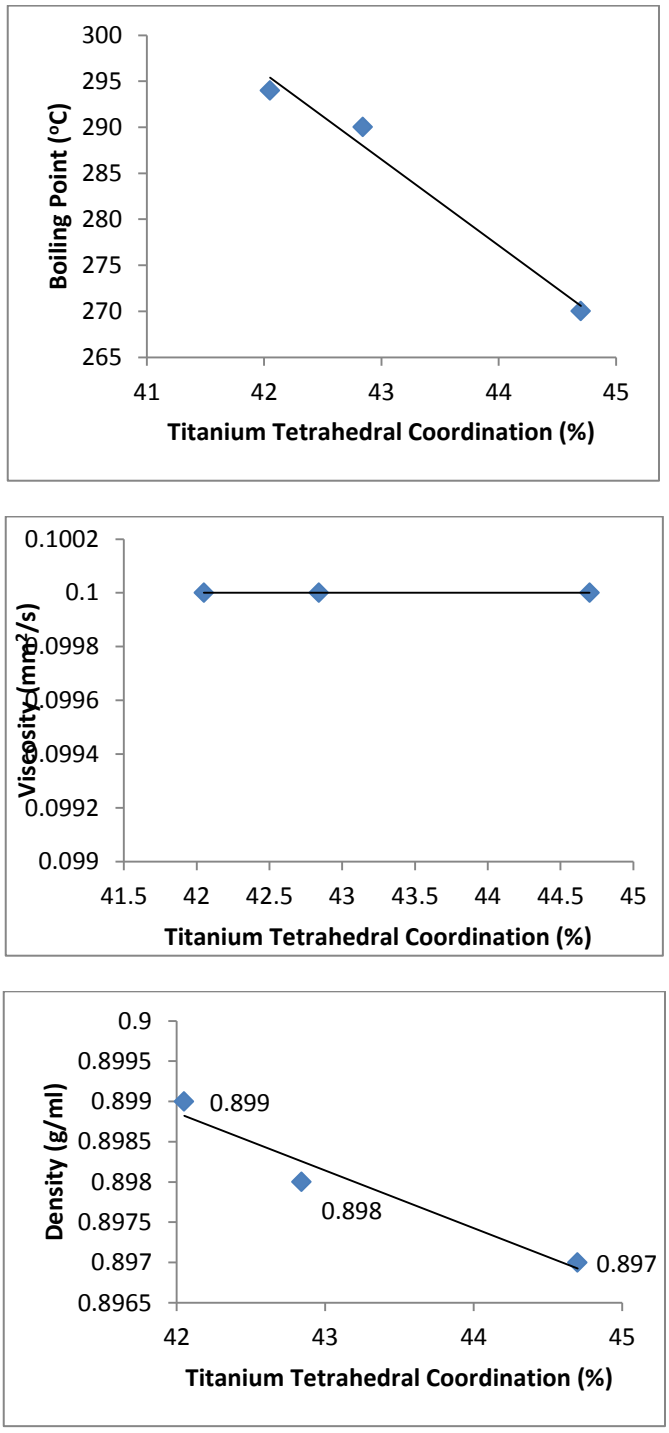


Fig.3. Effect of titanium tetrahedral fraction on physical properties of synthesized biodiesel with respect to boiling point, viscosity, and density.

4. Conclusion

The series of silica-titania catalyst, which is formed through solid state method using solid silica and titania as precursors, is very substantial for transesterification reaction in biodiesel production. This study shows the existence of titanium tetrahedral fraction may improve the physical properties of synthesized biodiesel.

Acknowledgement

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Biosorption of Cadmium and Copper Ions from Aqueous Solution using Banana (*Musa paradisiaca*) Shell as Low-Cost Biosorbent

Edi Nasra[a*], DesyKurniawati[a], Bahrizal[b]

[a]*Analytical Chemistry Laboratory, Faculty of Mathematics and Sciences, UniversitasNegeri Padang, Jl. Prof. Hamka, Air Tawar Padang 25131, Indonesia*
[b]*Inorganic Chemistry Laboratory, Faculty of Mathematics and Sciences, UniversitasNegeri Padang, Jl. Prof. Hamka, Air Tawar Padang 25131, Indonesia*

Abstract

The research of Cd (II) and Cu (II) biosorptionin aqueous solution using banana shell powder has been conducted. Optimization of heavy metal adsorption using banana shell as adsorbent with column method has been investigated. The studies include determination of optimum pH and concentration. The result showed that the optimum condition was at pH = 5, concentration 500 mg/L with adsorption capacity 8.3864 mg/g for Cd (II) and pH = 3,concentration 500 mg/L for Cu (II)with adsorption capacity 7.5975 mg/g. This study shows that banana shell waste can be an important low cost biosorbent for Cd (II) and Cu (II) removal.

Keyword: Biosorption, cadmium (II), copper (II), banana (*Musa paradisiaca*) shell

1. Introduction

Nowadays the pollution of different natural water by heavy metals is a great concern because of the toxic effects on living organisms. Urbanization, industrial development, and heavy traffic lead to contamination of water bodies by heavy metals. [1]

Copper, as one of essential of trace elements used to maintain normal life activities, plays significant rule in many biological processes and systems. However, it is environmental pollutant at high concentration [2,3], and an excess concentration of Cu^{2+} in human body can cause many serious diseases such as Alzheimer's [4], Parkinson's [5] and Mengke's disease [6].

Cadmium is mainly used in Ni-Cd batteries manufacturing, as pigments, stabilizers, fabric coatings, alloys and electronic compounds such as Cadmium Telluride (Cd-Te) as the semiconductor [7,8]. Cadmium is not an essential element for human body. Human can absorb the element of cadmium into the body through breathing or food, while the absorption through the skin is not generally done. The total cadmium absorbed by the body is 2 to 6% ofthe entire cadmium entering through food [7].

Cases of chronic pollution caused by cadmium poisoning have occurred in Japan along the river Jitsu, known as "itai-itai" (it means screaming because of sudden illness). Patients have great disorders of the kidneys, liver and bone which sometimes lead to death. This pollution arises from industrial waste mining cadmium, zinc and lead [7,8].

Due to its important role, a large number of methods have been developed for quantitative determination of metal ions in aqueous solution. Conventional methods for removing metals from aqueous solution include chemical precipitation [9], chemical oxidation and reduction, ion exchange filtration, electrochemical treatment, reverse osmosis, membrane technologies and evaporation. The major disadvantages with conventional treatment technologies are the production of toxic chemical sludge and its disposal/treatment becomes costly affair and is not eco-friendly.

Therefore, removal of toxic heavy metals to an environmentally safe level in a cost effective and environment friendly manner assumes great importance [10-12]. Removal ofCd (II) and Cu(II) from wastewater is crucial and it toxicity for human being is at level of 100-500 mg per day. The World Health Organization in 2006 recommended 2.0 mg/l as the maximum acceptable concentration of copper in drinking water [1,2,7,8].

Thebiosorption has considerable amount of attention as an alternative process to traditional methods and heavy metal removal from contaminated water. Different kind of biomaterials interacts effectively with toxic metals [4]. A long with aforementioned advantages, various functional groups such as hydroxyl, carboxyl, carbonyl, amine in biosorbents have hightaffinity to form metal complexes. Hence, there is a growing demand to find effective, low-cost and locally available biosorbents for the biosorption of heavy metal ions, [10]. Research in the recent years has indicated that some natural biomaterials including agricultural products and by products can accumulate high concentration of heavy metals. Adsorbent generated from these biomass are cost effective and efficient,low cost agricultural product and by products have been reported to be effective in removing toxic metals [14]. Waste Mangostreen shell [14], pomegranate [13], akke apple seed [10], banana, lemon and orange cortex [15], melon seed [16][17], peanut shell [11], tomato waste [18], papaya seed [19] and longan [20].

* Corresponding author.
E-mail address:hardi_rais@yahoo.com

The main objective of this work was to evaluate the adsorption performance of banana shells for removal of Cd (II) and Cu(II) from single aqueous solutions. The effect of solution pH, initial concentration, particle size, amount of biosorbent dose and flow rate in biosorptionwith column method. The banana shells were characterized by FTIR spectroscopy to identify chemical bond type in molecules present in banana shells.

2. Method

2.1 Chemicals and apparatus

All reagents used were of analytical grade obtained from Merck (Darmstad, Germany). In present work, the biosorption experiments were conducted by using stock standard solution (1000 mg/L) of $CuSO_4.5H_2O$ and $Cd(NO_3)_2$from E-merck, HNO_3 65 %, $NH_{3(aq)}$ 25%.The apparatus used were screener Octagon 200 (Endcots, London, England), analytical balance (AA-200 Denver Instrument Company), shaker (Haake SWB 20), pH meter (Denver Instrument Company), FTIR (Bio-Rad FTS 60), and atomic absorption spectrometer (AAS Alpha-4, Analysis 100, London, England).

2.2 Preparation of biosorbent

Bananashells (Fig. 1) were used a biosorbent for sorption ofCu(II) and Cd(II) from an aqueous solution. Banana was collected from local market of Padang City, West Sumatera Province of Indonesia. Banana shells were washed with deionized water remove dirt, sand, clay and particulate materials from the surface. After washing, they were dried under the sunlight. Dried banana shells were cut, ground using crusher, with various particle size range 105 – 425 µm. The banana shells in a solution of 0,01 M HNO_3 for 2 h with 20 g biomass in excess of 80 ml HNO_3 0,01 M, followed by washing thoroughly with deionized water and then air-dried. The biosorbent was dried and ready to use.

Fig. 1. Banana shells.

2.3 Biosorption studies

The adsorption experiments were studied by using dynamic sorption experiments. Powder of banana shells (biosorbent) was implemented in a set of conical flask containing 10 ml of solution containing Cd (II) and Cu(II).The effects of pH (2-6),initial metal ion concentration (100-500 mg/L), biosorbent dosage (0.2-0.5 g), particle size (106-425 µm) and flow rate (1-6 ml/min) were studied. The suspension then filtered and metal ion concentrations in the supernatant solution were measured by Atomic Absorption Spectrophotometer. The optimum conditions for the biosorption of Cd (II) and Cu (II) ion were determined.To determine the amount of Cd (II) and Cu(II) adsorbed by banana shells, the formula used is:

$$Qe = \frac{C_o - C_e}{M} \text{ x } V$$

where C_o is the initial concentration of metal ions (mg/L), C_e, final concentration at equilibrium state (mg/L), M is biosorbent mass(g) and V is volume solution (L).

2.4 Fourier Transform Infrared Spectroscopy analysis

For the IR studies, 5% (w/w) of dried banana shells were pressed to form KBr disc. The FTIR spectra were recorded in the range of 4000-450 cm^{-1} spectral range using a Bio-Rad FTS 60 instrument. A total of scans were averaged for each sample with resolution of 2 cm^{-1}.

3. Results and Discussion

3.1 Characterization of biosorbentMusa paradisiaca

3.1.1 FTIR Analysis

FTIR is an important analytical technique, which detects the vibration characteristics of chemical functional groups existing on the surface of adsorbent [22]. Furthermore, it provides information on binding mechanism and possible functional groups involved in the interaction with metal ions [23]

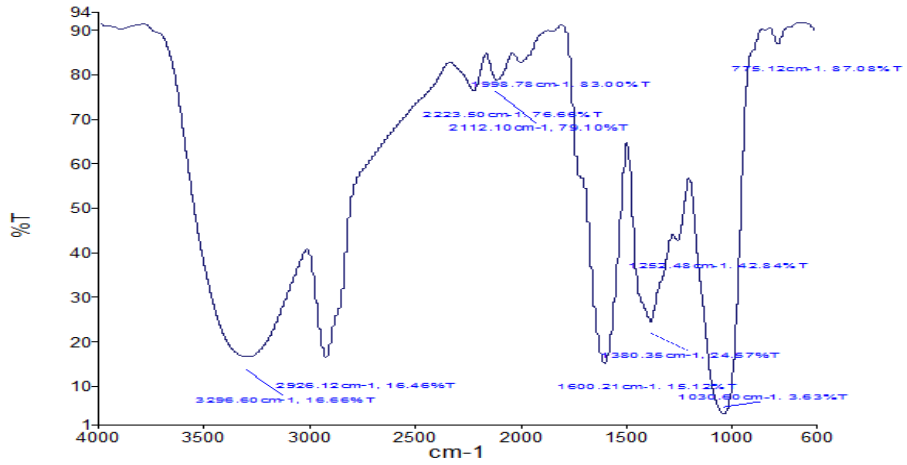

Fig. 2.FTIR spectrum of banana shells.

FTIR characterization was carried out to analyze the major functional group which exists in the biomass. The broad and intense peak at 3296.60 cm^{-1}ranging from 3600 to 3200 cm^{-1}, was assigned to the stretching of – OH groups due to inter- and intra- molecular hydrogen bonding of polymeric compound such as alcohols and carboxylic acid. At 2926.13 cm^{-1}, C-H stretching. The 1600.21 cm^{-1} (a) peak was a carboxyl stretch in ester.

3.2 Effect of pH solution

The pH of solution had a significant impact on the removal of heavy metals since it determined the surface change of the adsorbent has carboxylate. Fig.3. shows the maximum biosorption of Cu (II) occurred at pH 3 with biosorption capacity mg/g. There was a decrease in biosorption capacity with the pH increase from 3 to 6. Biosorption of metal ions decreased because of increasing of competition with H^+ ion for active biosorption sites at lower pH. Similar results were shown by [21] in the removal of Pb^{+2} also got the optimal pH for biosorption as 3. Gupta et al in [21] used bassage, fly ash a sugar industry waste material for the removal of Pb(II), the optimum pH 3.

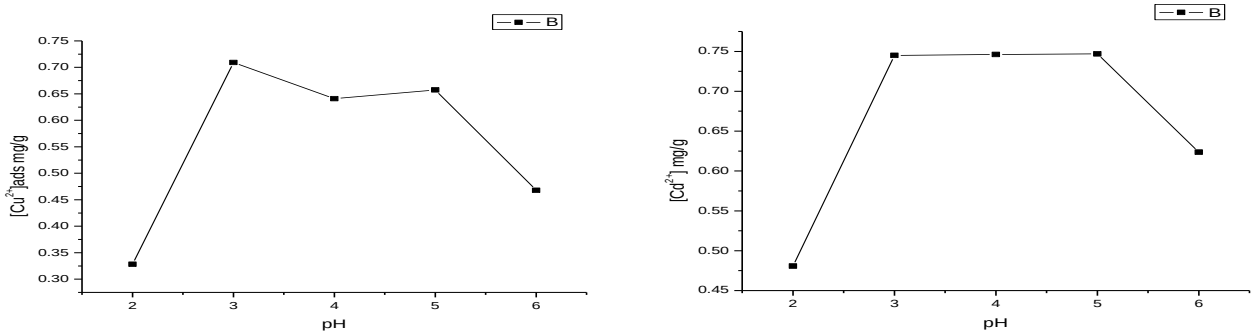

Fig 3. Effect of pH solution on Cu (II) and Cd (II) adsorption by banana shells.

Fig. 3 shows the metal ions uptake in the solution of cadmium nitrate and copper nitrate, as a function of pH. In the experimental system, Cu^{2+} remains the dominant species below pH 3 and Cd^{2+} belowpH. Beyond this pH, solid cadmium hydroxide and copper hydroxide is thermodynamically the most stabile phase.

3.3 Effect of initial metal ion concentration

The heavy metal ionsbiosorption capacities of banana shells as a function of the initial concentration of Cd (II) and Cu (II) ion within the aqueous solution were studied. The amount of metal ions adsorbed per unit mass of banana shell increased with an increased in initial concentration of Cd (II) and Cu (II) ion. At the lower concentrations, all metal ions present in the solution would interact with the binding sites and thus facilitated 100 % biosorption. At concentrations adsorption, sites took up the available metal ions more quickly. However,at higher concentrations metal need to diffuse to biomass surface by intra-particle diffusion and more hydrolyzed ion will diffuse at slower rate [21]. The maximum biosorption capacity of Cd (II) per gram of banana (*Musa paradisiaca*) shells were calculated at 8.3864 mg or mg/L metal solution and adsorption capacity of Cu (II) were calculated at 7.5975 mg/g banana shells.

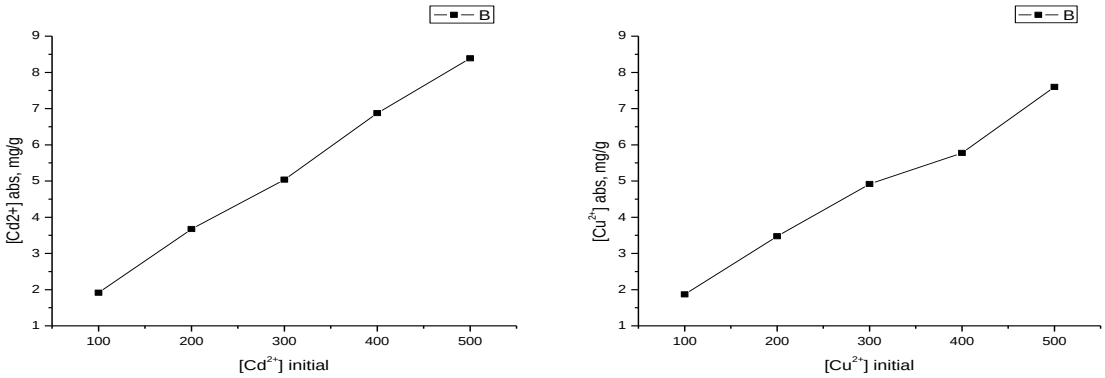

Fig. 4. Effect of concentration of Cd (II) and Cu(II) solution on adsorption by banana shells.

3.4 Adsorption isotherm studies

An adsorption isotherm describes the relationship between the amount of adsorbates taken by the adsorbent and the adsorbates concentration remaining in solution. This isotherm was derived from equilibrium constant of the interaction of adsorbate with adsorbent [22].In this research, the equilibrium data for biosorptionprocess of Cu (II) ions on banana shells evaluated by the Freundlich and Langmuir isotherm models. Fig. 7 described some information related to biosorption processof Cu (II) ions on powder of longanshells and seeds. Fig. 7 shows the comparison between the Langmuir and Freundlich regression coefficients. It was observed that the experimental data fitted the Langmuir isotherm model best. The model Freundlich was far from unity while the Langmuir isotherm model was closer to unity [23].

4. Conclusion

The results demonstrate that banana shells are the effective biosorbents to remove Cd (II) and Cu (II) from aqueous solution. Cd (II) and Cu(II) were removed in column experiments. Biosorption process was affective by pH 3, initial concentration 500 mg/L for Cu (II) with adsorption capacity 7.5975 mg/g banana shells for Cu and pH = 5, initial concentration 500 mg/L with adsorption capacity 8.3864 mg/g banana shells for Cd (II) . The equilibrium data fitted well to Langmuir isotherm with R^2 =0.9984. The study revealed that banana biosorbent could be used as adsorbent for the removal of other heavy metals on large scale.

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Thermal Degradation of Modified Phenol-Formaldehyde Resin with Sodium Silicate

Muh. Wahyu Syabani[a*], Indra Perdana[b], Rochmadi[b]

[a]*Department of Rubber and Plastic Technology, Politeknik ATK Yogyakarta*
Jl. Ring Road Selatan, Panggungharjo, Sewon, Bantul, Yogyakarta 55188, Indonesia
[b]*Department of Chemical Engineering, Universitas Gadjah Mada*
Jl. Grafika 2, Yogyakarta 55281, Indonesia

Abstract

Phenol formaldehyde (PF) is thermosetting polymer that is widely used in many applications, including as an adhesive in wood industry.Modification using sodium silicate has been successfully improving the curing temperature and bonding strength. But, it's important to studies phenol formaldehyde thermal stability, since its main application were using high temperature. In this work, the thermal stability of modified phenol formaldehyde was studied using thermogravimetric analysis (TG/DTA) at heating rate of 10^{o}C/min to understand the step of the degradation process. In addition, the ash content was determined at 1000oC in order to compare the thermal stability of the PF resin samples. The amount of sodium silicate was varied in the range of 0% to 25% (w/w) in terms of sodium silicate to phenol. The experimental resultsindicate that modified PF resin has improved thermal stability in comparison with conventional PF resin. The thermogravimetric curves showedfour stage of the phenol formaldehyde thermal decomposition. The presence of sodium silicate can increase the crosslink density that improves the thermal stability at temperature lower than 700^{o}C. However, at themperature higher than 700^{o}C the Si-O bonding were easier to break than the methylene and methylene ether bond that lead to faster decomposition in phenol formaldehyde for higher sodium silicate concentration.

*Keywords:*phenolic resin; thermal stability; wood; adhesive; sodium silicate

1. Introduction

Phenol formaldehyde (PF) is one of the most common synthetic resins that used in a wide area of application. This resin known as an important adhesive in wood panel industry [1,22] and also used in coatings and advanced composite matrice in aerospace and electronic industries [2]. The resin offer some advantages such as high temperature resistance, high char yield and solven resistant [3,20].PF resin with improved thermal and pyrolysis characteristic are desirable in composite for thermo-structural application [21]. But, this resin also has some disadvantageous nature, such as moderate brittleness and evolution of volatile substances in condensation-cure reaction [20].Therefore, thermal degradation are important topic to be researched, including here is their heat resistance and thermal stabilisation. The making process of this resin has remained unchanged for some times. For example, wood adhesive is usually made of resol-type phenol formaldehydewith F/P molar ratio higher than one and in basic condition. The most common basic catalyst used for the resin preparation is sodium hydroxide [4].Several studies have been done to investigate modified resin thermal degradation using thermogravimetric analysis (TG).TG measures weight change as a function of temperature and/or time [23]. For instance, the thermal degradation of lignin-modified resin [2], the influence of titanium and silicon on the resin oxidative degradation [5], non isothermal degradation of phenolic triazine [16]and the thermal stability of natural fibre and phenolic resol[6].The decomposition process of phenolic resin is usually accelerated by the number of dihydroxy phenyl methylene group [17] and also the high oxygen content of phenol [16].

In the recent years, phenol formaldehid modification using silicon-containing chemical has been studied in order to modify the thermal properties [19]. Polymerization of phenol formaldehyde using SiO_2 nanocomposite gives better thermal stability and flame retardant [7]and also increasing the hardness [8]. Other worksreported that silicon carbide [9] and vinyl triethoxylane [10] can also be used as phenol formaldehyde modifiers.Another alternative of silicon-containing chemicals that has potential as modifier is sodium silicate. In our previous study, the addition of sodium silicate into phenol formaldehyde gaves higher crosslink density, thus gave improvement in lowering the curing temperature, activation energy and increasing the bonding strength. However, the effect of sodium silicate dosage on the thermal degradation which is important in the application that needs high thermal resistance has not been reported. For instance, for wood based composite, this information is useful in determining the temperature in which wood structure no longer have structural integrity [23].

This paper presents the study to gives better thermal resistance of PF resin using sodium silicate as modifier. The resin was made of 37% formaldehyde, phenol and sodium silicate. The effect of sodium silicate dosage on the thermal degradationwas investigated using Thermogravimetric/Differential Thermal Analysis.

* Corresponding author.

2. Method

2.1. Materials

The Phenol (Merck), sodium hydroxide (Merck), 37% aqueous formaldehyde (Merck), aquadest and sodium silicate (Sigma-Aldrich) were analytical pure purchased from commercial resources.

2.2. Preparation of PF resin

The resin was synthesized by batch polymerization with a molar ratio of phenol to formaldehyde of 1:1.5, following Wang's methods [11]. Phenol, aquadest and sodium silicate were mixed and stirred in a flask. After heated to 80^{o}C, formaldehyde was added dropwisely into the mixture, then the mixing was continued for 4 hours. The resulting resin was then dehidrated for 2 hours at 60^{o}C in vacuum conditionresultingina viscous solution.The amount of sodium silicate to phenol was varied at certain value.

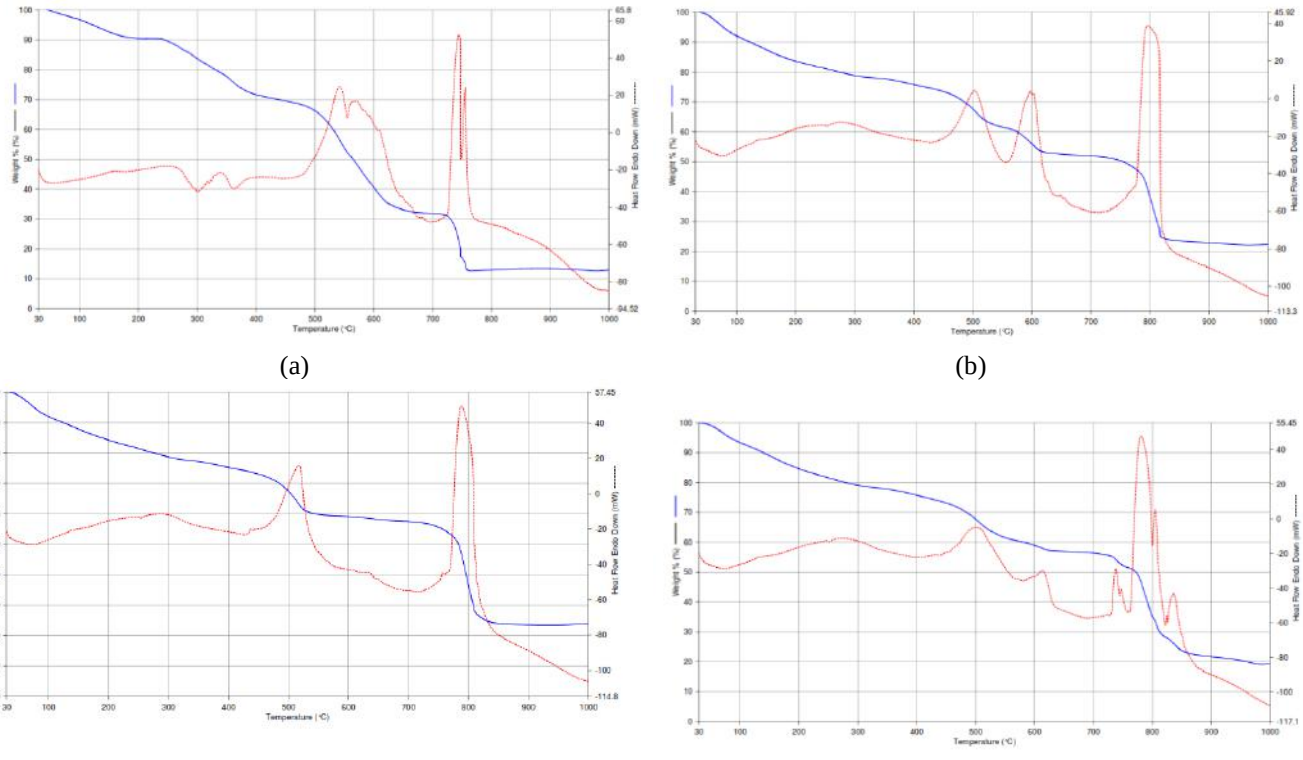
Each sample for thermal analysis was dried for 30 minutes in an oven at 100^{o}C and then crushed using mortar. The sampel was weighed 5.0 mg then placed onto the sample pan. Thermogravimetric/Differential Thermal Analysis (Perkins TG/DTA Diamond Series) was used to characterize the heat flow and mass loss during heating. The Perkins PYRIS software was used for data collection and analysis. The program was set to a heating rate of 10^{o}C/min in atmospheric condition.In order to confirm the repeatibility and authenticity of the generated data for all considerated cases, the experiments were repeated two times at every sample. The observed deviation were very little.

2.3. Research Variables

The research variables consists of dependent variables and independent variables. The dependent variables included the polymerization temperature 80^{o}C, initial pH 11 and F/P ratio 1.5. The independent variable is sodium silicate concentration. Resin modification were done using sodium silicate as modifier with a variation of 0%, 6.25%, 12.5%, 18.75% and 25% (w/w) of sodium silicate to phenol mass ratio.

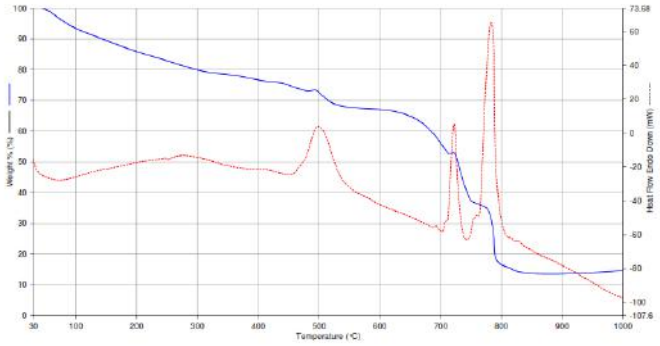
3. Results and Discussion

In this research, we focused on the thermal stability of the PF resol resins under oxidative atmosphere. The measurement of the amount and the velocity of the sample mass loss as function of the temperature in controlled atmosphere are used primarily to determine the oxidative stabilities of materials as well as their compositional properties [2]. The thermalgravimetric methods can analyze materials that exhibit mass loss due to decomposition, oxidation and volatile materials losses (such as small particle and moisture) [2,24]. Therefore this methods are very often used to analyze materials that applied or processed in high temperature. The TG/DTA curve for each sample are presented in fig. 1.



(a) (b)

(c) (d)



(e)

Fig.1. TG curveof the PF with variation0; 6.25; 12.5; 18.75; 25 %(w/w) respectively

The degradation of resol resin were shown in theTG curve obtained with a heating rate of 10 ^{o}C/min. Fig.1 shown that in general there are 4 steps of the phenolic resin weighted loss. In the first steps, heating a pre-cured resin to curing temperature gives us steady lossof the volatile and low molecular weight materials such as phenol and solven [23] and also some monomers [2], followed by water and formaldehyde loss evolving from the resin during processing [13,24]. The substances will beliberated at lower temperatures due to the results of the methylol groups condensation reaction [12, 17]. The small exothermic up peak that emerged in the range of 90-180^{o}C are the curing temperature[23,24]. Since the exothermic heatflow of the curing process is lower than the endothermic evaporation, the overall curve would showing the endothermic down peak. For the PF resin without sodium silicate addition, this step occurs in temperature up to 220^{o}C. But, the PF resin with sodium silicate addition the range is slightly higher, upto 300^{o}C. It is clearly showed that all the modified phenolic posses better thermal stability in comparisson to the convensional resole resin. The mass loss of the modified PF resin (20-22%) are higher than the convensional (10%) since the water and formaldehyde released in condensation reaction are also higher.

The second stage resulted from the degradation of the polymer. The lower molecular weight component of the polymer degrade faster to the higher molecular weight polymer component [23]. We found from the TG curve, that more sodium silicate added, the mass loss were lesser. This facts indicates that the resin with 25%(w/w) sodium silicate addition has oligomers and polymers with higher molecular weight. The higher molecular weight probably occurs because of sodium silicate easy to make network structure [14]. Therefore, sodium silicatecan easily make bond with the phenol formaldehyde [13] thus give more complex polymer with higher molecular weight.It is well known that the mass loss of phenolic resin during post curing is 15% in average [2], the analyzed PF resins showed mass losses on the range of 12-17%, which is still in accordance with the literature on thermal degradation of phenolic resins.

The third stage of degradation is due to the thermo oxidation of the resin [2]. There is always a thermo-oxidative process during degradation of the system in both air and inert atmosphere [16,18]. It is obvious since the source of the oxygen is not only from the atmosphere, but also form the phenol itself. This steps istake places at 550 upto 700^{o}C, during this step the modified PF resin were degraded with the mass loss were lesser than 15% compared to convensional PF resin that have 37% losses. Themain reaction is the breakage of the aromatic rings that releases gaseous substances, i.e. CH_4, H_2, CO, CO_2 and other low molecular weight chemicals [13,15]. TG curve in fig 1 shows that higher sodium silicate added gives better thermal stability because of crosslink density and probably conductive resistances.The sodium silicate could blocked the heat conduction thusprevent the thermal degradation [13].

Table 1. Ash content of the PF resin

Sodium silicate addition (% (w/w))	Ash content(%)
0	12.65
6.25	22.20
12.50	24.27
18.75	19.43
25.00	14.05

The last step occurs at temperature higher than 700^{o}C, where it gives highest weight loss for the modified PF resins. Lower sodium silicates added gives lower weight loss, because the crosslink made by sodium silicate is not as strong as the methylene and methylene ether crosslink.Other workssuggest that the –Si-O- bond energy was higher than the –C-C- bond energy [13], thus the thermal degradation were faster.Initially, the degradation of silica network structure was restricted by intermolecular hydrogen bonding at lower temperature [19], but the restriction will dissapeare when the phenolic resin start to degrade at higher temperature.Finally, overall thermal stability can be indicated from the ash content, which is higher value indicates that a polymer is more thermally stable [2]. Form the table 1, the ash content at 1000^{o}C of the modified PF resin are higher than the conventional PF resin.

4. Conclusion

The mass loss during thermal decomposition of modified phenol formaldehyde resol resin have been studied in oxidative atmosphere using thermogravimetry. The TG curve shows that the addision of sodium silicate has significant effect into thermal stability. It was established that with the increase in sodium silicate percentage the PF resin exhibits high thermal stability on temperature below 700^{o}C since sodium silicate easy to make network bond.It was also conclude that for temperature higher than 700^{o}C, modified PF resin decompose faster because the crosslink made by sodium silicate are weaker than the methylene bridge.While this study provides important insight into the degradation mechanism of the resin, it would useful to made further study in kinetics method in their degradation.

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Characteristics of Gayo Coffee's Chemical Compound Based on Different Roasting Condition – An Explorative Study

Dedy Rahmad[a], Dian Hasni[b*], Murna Muzaifa[b], Novi Safriani[b]

[a]*Polytechnic ATI Padang, Jl. BungoPasang- Padang, West Sumatera – Indonesia*
[b]*Department of Agricultural Product Technology- Syiah Kuala University, Darussalam, Aceh, Indonesia*

Abstract

Roasting is an industrial coffee processing which has heavy contribution towards formation of coffee flavor. This heat treatment modifies the aroma precursor in coffee bean through Maillard reaction and Stecker Degradation. Conventionally, roasting is done by contacting the green bean with hot air in short time. However several producing countries have different techniques of roasting, such as torrefacto whisch defined as roasting with additional ingredients. This work aims to investigate the effect of two roasting conditions (conventional and torrefacto) towards Gayo coffee (Arabica and Robusta varieties) which being sold commercially and laboratory experimented. The measured chemical compounds are moisture (%), ash (%), lipid (%), protein (%) and carbohydrate with two repetitions. The results showed that both commercial and experimental roasted coffee powders are meeting the SNI requirements for moisture and ash contents, where commercial product has higher amount of these compounds. To be conclude with, Arabica and Robusta coffee from Gayo Highland have differences and chemical compounds and it also varies based on the roasting process.

Keywords: torrefacto; roasting; Arabica; Robusta; Maillard, Gayo Highland.Introduction

1. Introduction

Gayo Highland has been acknowledged as single origin coffee since successfully claimed its Geographical Indication in 2010 [1]. The highland is ultimate production area for Arabica coffee in Indonesia which has largest plantation area and superior quality. As global demands for this single origin coffee increases [2] many attempts has been made towards Gayo coffee quality improvements especially towards cupping quality in green bean [3, 4].The attempts are done based on thoughts that coffee cupping quality is a manifestation of complex process of harvesting, semi-wash process and roasting. During this long chain the chemical compounds of coffee cherries modified as it changed in to green bean and roasted bean [5].

Roasting ultimately has large contribution in the formation of coffee flavor which produces coffee as pleasurable brewed drinks [6]. Roasting enables coffee bean to release the volatile compounds, which produces the complex cupping quality as the roasting degree varied based on certain condition [7]. During roasting which the maximum temperatures are 210-230^{o}C [8], the bean cells are ruptured since beans are directly exposed with the heat, dried up most of moisture contents and released the aromatic compounds [9] which counted more than 900 volatile compounds mainly formed during this process [6]. As results, the physical appearance of coffee bean is changed dramatically, and consists of carbohydrates, protein fragments, lipids, less moisture contents, caffeine, trigonelline and melanoidins as results of Maillard reactions [8,9].

In Gayo Highland farmers also planted Robusta varieties in lower elevation area which mainly consume by local citizen in Aceh regions, whilst Arabica mainly considers as export commodity [5]. As local consumption, coffee is roasted in special way named as torrefacto, where the 10-15% of sugar is added during roasting [6]. Torrefacto claimed as roasting techniques which enable to cover the defects of coffee and produce heavy, creamy and sweeter brewed drink. This project aims to explore the changes of Gayo coffee based on its varieties (Robusta and Arabica) in different roasting techniques (conventional and torrefacto). As torrefacto method is commonly used by commercial roaster in Banda Aceh, this research also has objective to compare roasted coffee which are commercially sold and laboratory experimented.

2. Methods

2.1. Materials

This research used commercial and experimental samples. The commercial sample, both for Robusta and Arabica varieties are bought from several coffee shops in Banda Aceh districts. On the other hand,for experimental samples, materials used in this research are Gayo Arabica green bean variety Gayo 1, planted at 1200-1440 m.a.s.l in Aceh Tengah district and Gayo Robusta variety S 88, planted at800 m.a.s.l. For commercial samples, it is roasted and bought one day prior to analyses. The commercial samples are then mixed in order to have homogenous samples In order to have reliable data, the moisture contents of green bean is counted based on AOAC [10].

* Corresponding author. Tel.: 62 852 7041 0214
*E-mail address:*hasni_dian@unsyiah.ac.id

Table 1. Moisture contents of raw material (green bean)

Moisture Contents (%)	
Arabica Gayo 1 (from farmers)	13.05
Arabica GayoMultivarieties	12.82
Robusta S 88	10.05
Robusta Multivarieties	9.80

2.2. Procedures

Conventional commercial roasting used hot air drum roaster where the coffee bean is roasted at 160-180^{o}C for 7-8 minutes then chilling out in the conveyor for another 10-15 minutes. For *torrefactocommercial roasting*, coffee bean is mixed with 15% of sugar then is roasted at 160-180^{o}C for 7-8 minutes then chilling out in the conveyor for another 10-15 minutes. *Laboratory experimented conventional roasting* used drum air Didacta Italia roaster, while coffee bean is roasted at 175-180^{o}C for 7-8 minutes, chilling out in cylinder bath for another 10 minutes. For *torrefacto,* sugar is added after the bean roasted at drum air roaster, by adding 15% of sugar, then mix manually above gas stove.

Fig. 1. Drum air roaster for commercial purpose (left); Didacta Italia drum roaster (right)

2.3. Samples preparation

The roasted bean is grounded at 20 mesh and stored in vacuum container. The process should be done one day prior to analysis. Then the measured chemical compounds are moisture contents, lipids, protein fraction, ash followed AOAC, whilst carbohydrate contents measured by difference.

3. Results and Discussion

Arabica varieties in Gayo Highland are commonly processed by semi-wash methods. This method consists of ripe-red cherries picking, washing and screening in floatation tank, pulping and drying up to 40% moisture contents, wet hulling and drying up to 12-13 % moisture contents. Based on the moisture contents of raw material as can be seen in Table 1, the commercial samples used multi-varieties which has 12.82% moisture contents, whereas variety Gayo 1 as laboratory experiment sample as 13.05%. On the other hand, Robusta which treated by dry process, commonly reported to have lower moisture contents since the cherries are directly dried start from the beginning as can be seen in Table 1.

However,these slightly lower differences of moisture contents could not be seen in commercial coffee roasted for both varieties. But the moisture contents are considerably differs based on commercial and experimental. Table 2 shows that based on commercial and experimental roasting, commercial has higher value of moisture then experimental roasted coffee even for the raw material commercial coffee has lower moisture contents. This is might be an effect of different amounts of coffee being roasted in one batch roasting process. The commercial roasting has 10 kg of green bean for one batch roasting whilst the experimental only has 3 kg for one batch roasting. Since the experimental has fewer amounts,makes the surface area is larger,that might be possible for hot air to make larger contact with coffee bean. However, all of coffee samples fulfilled the SNI 01-3542-2004 [11] for grounded coffee, which stated moisture contents should be blow 7.00%.

Table 2. Arabica Gayo chemical compounds based on method of roasting

Chemical Compounds (%)	Robusta				Arabica			
	Commercial Roasting		Experimental Roasting		Commercial Roasting		Experimental Roasting	
	Conventional	Torrefacto	Conventional	Torrefacto	Conventional	Torrefacto	Conventional	Torrefacto
Moisture	6.95	6.59	1.60	1.60	6.17	6.80	4.00	3.20
Ash	4.95	4.96	5.00	5.0	3.62	3.88	4.00	4.50
Lipids	5.05	5.37	5.15	5.54	6.25	6.25	7.36	7.36
Protein	12.97	13.92	16.79	18.67	14.17	14.12	8.04	8.04
Carbohydrate	69.17	12.97	71.96	69.19	68.99	68.95	76.60	76.60

Roasting is heat treatment process where the bean has direct contact to the hot air [12]. Drum roaster as the most common tools used in industries is preferable since it grants homogenous color and quicker in process. This equipment also allows the roaster master to modify the time and temperature variation for each roasting degree. Then roasting temperatures can vary between 180-240^{o}C for 8 to 15 minutes which classifies roasting at three degree levels, which are light, medium dark. Light roasting produces sweet, cocoa, and nutty aromas whereas medium roast converts coffee with more complex aroma and dark roast is contributed to ashy, burnt and roasted characteristics. Later it also reported that medium roasting, as used in this research enables to point out the regional characteristics of single origin coffee [13, 14]. The evaporation of free and bound water started at the first phase of roasting, while the chemical changes mainly occurred at the end phase of roasting [8].

As evaporation of free and bound water started at the first phase of roasting, the chemical changes mainly occurred at the end phase of roasting. As the bean temperature reached 130^{o}C, caramelization of sucrose and browning occurs, and beans are swelling. Later, when temperature reached above 180^{o}C all non-volatile compounds such as carbohydrate, lipids, protein and minerals participate simultaneously, the compounds degraded into low and high molecular weight such as melanoidins and protein [8, 15]. Protein content of Arabica is slightly lower than Robusta [16] for both green and roasted coffee bean [8]. As can be seen as well in Table 2 Arabica has protein range between 8.04-14.17% and in Robusta, protein is in the range 12.97-18.67%. The protein and other nitrogen containing compounds are reacted with carboxyl group reducing sugars in which so called Maillard reactions and caramelization, forming out melanoidins and small fraction of nitrogen which stated to be responsible for coffee flavor [13, 17]. For coffee with torrefacto roasting, most of sample has higher protein contains than conventional roasting.

From Table 2, it can be seen that mineral or ash contents are varied between 3.62 to 5.00%. Arabica green bean reported to have 3.2-4.2% of ash contents where Robusta ash contents are between 4.4-4.5%. Moreover the roasted bean for both Arabica and Robusta reported to have ash contains between 4.5-4.7% [8]. Mineral in coffee mainly consists of potassium, and manganese, iron and cupper are available in smaller amounts. These minerals are functioned as catalyst biochemical reaction during roasting [13]. Last is carbohydrate, which is in roasted bean majorly presents as arabinogalactans, mannan, glucan and cellulose [18]. The small amounts of carbohydrate also presents as sucrose and reducing sugars [8]. The carbohydrate is responsible for the sweetness and releasement of volatile compounds in Maillaird and caramelization reactions [13]. For coffee with torrefacto roasting, the sugar is added to mask the negative flavors and produce coffee with dark brown color, intense aroma and strong taste and bitterness, and has flavor of roasty, burnt and intensive caramel. This is an impact of sugar addition, the pyrazines, furans and pyridines are formed out in larger amount than conventional roasting [6]. In this studies, most of experimental roasting produced high amount of carbohydrate, this is might be occurred due to the amount of water released in experimental roasting is higher than commercial one.

4. Conclusion

Taking everything into consideration it can be stated that quality of coffee as brewe drink is manifestation of all process involved from farm to cup. Roasting is an industrial process which evaporate the moisture contents, transform the non-volatile compounds i.e. protein and carbohydrate through Maillard reaction in order to release volatile compounds or forming out the aromatic compounds such as melanioidins, pyrazines, furans and pyridines. The intensive research should be done to explore and investigate the specific chemical compounds whichare reported to have important contribution of coffee cupping quality such as chlorogenic acids, trigonelline, melanoidins and others.

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Characterization of Mobile e-Nose for Halal Detection Device

Pharmayeni[a], Zulhamidi[a*]

[a]*Politeknik ATI Padang, Bungo Pasang Street, Padang 25171, Indonesia*

Abstract

Electronic Nose (e-nose) is an instrument used to detect odor or aroma. The system is built on gas sensor arrays known as electronic olfactory systems, because e-noses have the ability to mimic the workings of the human sense of smell. Since the output of this e-nose system is a signal, the signals represent patterns representing each of the scents so they can be applied for identification, comparison, quantification and aroma-based classification applications. In this study an e-nose was made to detect alcohol content in food / beverage using MQ-3 gas sensor connected ADC ADS1256 on Raspberry Pi and send its data directly to database server on Raspberry Pi. E-noses and servers are located on a wireless computer network. In the detection results obtained alcohol detection results with the detection of sensors in a standard solution of 200 ppm produces an average voltage detection of 1.6 Volts.

*Keywords:*e-nose, raspberry pi, halal detection;

1. Introduction

Alcoholic foods / beverages are strictly prohibited in Islam, even in very small amounts it would be illegal [1]. However, detection of ethanol content that is naturally occurring, or is intentionally added in food processing, is permissible if the amount is sufficient to not cause toxicity. The permissibility of ethanol is based on the concept of Al Istihlak (assimilation or consumption), which if a small prohibited substance is mixed with the dominant permitted substances and the prohibited substance loses all its attributes such as taste, color and odor, this substance loses qualification to impure [2]. In general, 0.5% ethanol levels are allowed in foodstuffs [3], but acceptable limits for food products differ for different countries and organizations. Most halal certification bodies receive small amounts of inherent alcohol, generally less than 0.1% and sometimes up to 0.5%. The Islamic Food and Nutrition Council of America (IFANCA) organization received a rate of 0.1% [1]; MajlisUlama Indonesia, 1% [4] and Thailand, does not exceed 1.5% in the final product by natural fermentation. On the other hand, JAKIM Malaysia does not state the allowable level, while Brunei Standards for Halal Foods does not even permit the use of alcohol-based carriers. This consistent limit of ethanol for halal certification of food products has proven to be one of the issues that can affect the growth of global halal markets. This encourages the need to set global standard limits that apply to all countries and halal certification bodies.

Electronic Nose (e-nose) is an instrument used to detect odor or aroma. This system is built on a gas sensor array known as electronic olfactory system because e-nose has the ability to mimic the work of the human sense of smell. Since the output of this e-nose system is a signal, the signals represent patterns representing each of the scents so they can be applied for identification, comparison, quantification and aroma-based classification applications. In addition, e-nose also uses the basic pattern recognition pattern (pattern recognition) resulting from a series of gas sensor array as a method of analysis. Identification of electronic nose analysis can also be done through Artificial Neural Network (ANN) such as Backpropagation (BP) and some other ANN method. From some researches on e-noses that have been conducted among others are in the field of food (food) such as see rapid test of the quality of aromatic rice [5], Beverage [6], black tea classification [7], and Environment [8]. Based on its type electronic nose (e-nose) is divided into two types namely direct and indirect [9]. Direct (direct) E-nose model is e-nose with direct aroma-capture model to the sample, the measurement is done on direct system of steady state value achieved by the sensor. E-Nose on a direct aroma pickup system by way of exposing the sensor directly to the sample test object. The advantage of e-nose with direct model is that the sampling is very easy and the distance between sensor and aroma is very close. However, the weakness in this system there is still interference from the air-air aroma around so that the sensor readings are still disturbed. While the indirect system model of aroma through the airflow brought from the sample room. In the e-nose system of this indirect model, the test sample is placed in the sample chamber and the resulting aroma comes from the sample chamber. the resulting aroma in the sample chamber is brought to the sensor by utilizing the airflow through a hose and valve hose regulated by its use. The advantage of e-nose indirect system is the influence of other aromas that come from outside can be minimized. While the weakness of this indirect model is the sample preparation stage which is longer than in the direct model [9]. During this time electronic nose indirect system is used to detect samples with volatile compounds such as alcohol, after the new volatile compound is readable by the gas sensor. Alcohol are volatile compounds.

* Corresponding author. Tel.: +62751 7055053; fax: +62751 41152
*E-mail address:*zulhamidi@gmail.com

2. Method

2.1 Tools and Devices

There are some tools dan devices used in this reseach, such as :

a. Raspberry pi
b. Alcohol sensor or MQ-3 sensor
c. Database Website server
d. Alcohol content materials
e. ADC ADS 1256 24 bit
f. Wireless acces point Xiaomi
g. Personal Computer for Control
h. Power supply
i. Structure

2.2 Work Procedure

The work procedures for this research are :

a. Assemble / fabricate e-nose by pairing MQ-3 sensor on ADC ADS 1256 which is then connected to #1 Raspberry pi, then synchronized.
b. Created a program to control e-nose using #1 Raspberry Pi with Python Programming Language .
c. Characterization of e-nose device with alcohol content materials

3. Results and Discussion

3.1. Fabricated Mobile e-nose

The tested of fabricated mobile e-nose while used alcohol content material yields voltage ± 1.6 Volt see figure 1.

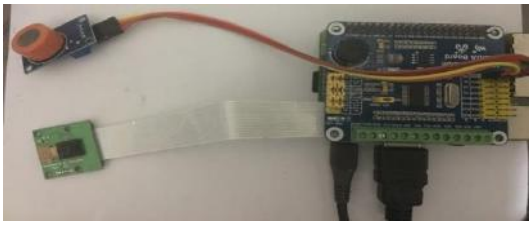

Figure 1. Fabricated Mobile e-nose

3.2. Characterization of Mobile E-Nose

MQ-3 sensor in no alcohol state has voltage of 1.5 Volts.The sensor is calibrated by using standard alcohol solution with a content of 0.4mg / L or equivalent to 200ppm. The sensor generates a voltage of: 1.6 Volts and continues to rise up to a voltage of 1.7 Volts when held close to alcohol content material as we can see at Table 1.This sensor can work on a range of alcohol content of 0.05mg / L to 10mg / L.

Table 1 : Tested e-nose with alcohol content materials

Number of test	Voltage (Volt)
1	1.602
2	1.610
3	1.623
4	1.607
5	1.650
6	1.645
7	1.676
8	1.648
9	1.689
10	1.692

From the results of the research at Table 1 above, an electronic nose with the following characteristics of the MQ-3 sensor as a sensor to detect the level of alcohol associated to ADC ADS 1256 as an analog signal converter into digital. Raspberry Pi is installed with ADC ADS 1256 so it functions as aquisition data that converts and collects data of alcohol content (where volatile compounds released by detected alcohols) become potential difference data or voltage data. The increase in readable voltage indicates the alcohol content read by the MQ-3 sensor. Previously the MQ-3 sensor was first characterized so that it was found that with a standard solution of 200 ppm would result in a 1.6 Volt voltage.

4. Conclusion

It has been fabricated and built a mobile e-nose and data transmission system on the ADC ADS 1256 that is connected to Raspberry Pi. Detection results with the detection of sensors in a standard solution of 200 ppm yields a 1.6 Volt detection voltage

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A Linear Programming Model for Hybrid Corn Seed Cultivation Planning

Jonrinaldi[a]*, Alexie Herryandie[a], Rahmatul Aulia[a]

[a] *Department of Industrial Engineering Andalas University, Campus Limau Manis, Padang 25163, Indonesia*

Abstract

This paper proposes a modelof hybrid corn seed cultivation planning system that can help for decision making in a certain period. This paper develops a linear programming models to find the optimal solution of hybrid corn seed cultivation planning. The model developed is tested at PT Citra Nusantara Mandiri (PT CNM) that produce hybrid corn seed in West Sumatra cooperating with PT Pertani (Persero). The model developed has decision variables that are land allocation of each area for each variety and total cost of hybrid corn seed cultivation planning. The model then is solved using Software Lingo 16.0. The model developed has been verified and validated. Sensitivity analysis is also performed to see the effects of changing parameter values to the optimal solution such as contract volume, land availability, and seed productivity. This sensitivity analysis is useful for PT CNM and other companies to control and manage those three parameters in order to achievean optimal hybrid corn seeds cultivation planning.

Keywords: hybrid corn seed; linear programming model; cultivation planning; land allocation; seed productivity

1. Introduction

Corn as one of potential and strategic food commodities. Its development is focus to animal feed in addition to food diversification. The need for corn continues to increase in line with increasing population and increasing demand for food, animal feed and industrial fuel. Until 2015, the national corn production has not yet fulfilled the domestic corn requirement. This can be seen from the huge amount of corn imports and increase every year. In 2012, Indonesia's corn imports reached 1.92 million tons, while in 2013, 2014 and 2015 respectively 3.2 million tons, 3.37 million tons and 3.5 million tons. The volume of corn import is inversely proportional to the volume of corn export in 2012, 2013, 2014, and 2015 respectively 70.86 thousand tons, 20.49 thousand tons, 44.84 thousand tons, and 250.97 thousand tons. The trend of export and import volume of Indonesian corn is presented in Figure 1.

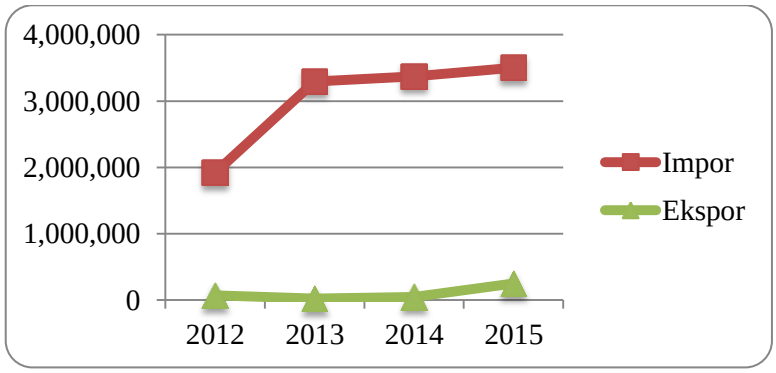

Figure 1 Export and Import volume of Indonesian Corn
(Ministry of Agriculture, 2015)

PT CNM's business activities started with a contract agreement with PT Pertani (Persero). Then proceed with the production process of hybrid corn seed consisting of two stages namely cultivation stage in the field and post-harvest process stage. Then, corn seeds are distributed to PT Pertani (Persero) warehouse in various regions in Indonesia. The trend of the number of PT CNM corn seeds contracts is presented in Figure 2.

* Corresponding author. Tel.: +62751-72479; fax: +62751-72566.
E-mail address: jonrinaldi772000@gmail.com

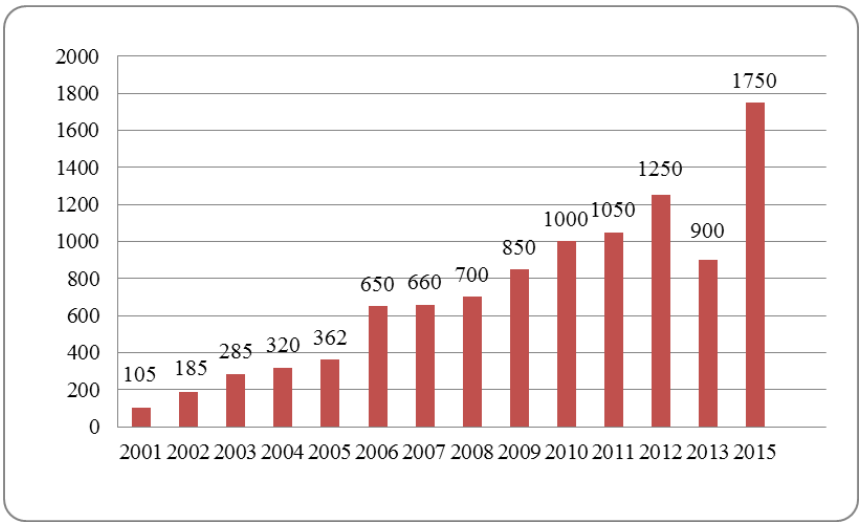

Figure 2 Recapitulation of the contracts of PT CNM with PT Pertani (Persero) (PT CNM, 2016)

The high volume of corn seeds contract makes the management system of seed production in PT CNM increasingly complex. According to Field Managers, there are several factors that affect the realization of corn seed production such as seed productivity that depends on natural factors such as climate that can be anticipated by arranging planting schedule and harvesting of corn seeds, cultivation of controlled cultivation factor with application of technology and good cultivation. In addition, the realization of seed production is also influenced by the area of captive land. The increased volume of corn seeds contract resulted in increased demand for corn seed cultivation areas.

PT CNM has currently not been able to fulfill the contract with PT Pertani (Persero) on time. Based on interviews with Field Managers, it is known that in fact there is still potential land and not yet utilized by PT CNM for cultivating corn seeds. The lands are spread in several regencies/ cities in West Sumatera such as Solok Regency, Solok City, South Solok Regency, Tanah Datar Regency, Dharmasraya Regency, and other areas. The company certainly needs a systematic planning for the potential land use, especially planning concerning the cost aspects of corn cultivation by considering the agreement of purchase price of corn seeds from PT Pertani (Persero) to PT CNM. The cost of corn cultivation consists of seed costs, labor cost of dettaselling (male wage removal rate), harvesting cost, crop purchase cost, and male cutting cost (compensation cost for harvested crops). With the difference of potential land location, the cost of corn cultivation between locations also varies.

Thus, the problem of not fulfillment of the contract is not due to the unavailability of land that can be utilized. However, the company has not yet optimized the utilization of potential land. Therefore, systematic corn planning for PT CNM is required to optimize potential land utilization by considering the cost of corn seed cultivation that must be incurred by PT CNM.

2. Formulation of the Model

Formulation of hybrid corn seed cultivation planning model based on linear programming model approach consists of:

a. Determination of decision variables
   X_{ij}: land area per nagari $i \in I$ for each variety $j \in J$

b. Determination of objective function

The aim of hybrid corn seed cultivation planning model is to minimize corn seed cultivation breeding cost at PT CNM. The cost of hybrid corn seed cultivation consists of seed costs, labor cost of dettaselling, male cutting compensation cost, purchase cost of harvest, and the cost of transporting the harvest from cultivation area to factory. The formulation of each cost of hybrid corn cultivation costs is as follows:

Seed cost

Seed cost is obtained from multiplication of seed price per kg with seed requirement per hectare and captive cultivation area. Here is the cost formulation of seeds in a hybrid corn seed cultivation system.

$$\text{Cost of seed} = \sum_{i \in I} \sum_{j \in J} X_{ij} \; Bb \; Kb \qquad (1)$$

Labor cost of detta selling

This cost is derived from the multiplication of labor wages with labor requirements per hectare and the area of captive land. Here is the cost formulation of dettaselling labor in a hybrid corn seed cultivation system.

Labor cost of dettaselling = $\sum_{i\in I}\sum_{j\in J} \boldsymbol{X_{ij}}\ \boldsymbol{Lc_i}\ \boldsymbol{Kt}$ (2)

The cost of malecutting compensation

The cost of malecutting compensation is obtained from the multiplication of malecutting cost per hectare with the area of captive land. Here is the cost formulation of male cutting compensation in a hybrid corn seedling cultivation system.

Compensation cost malecutting = $\sum_{i\in I}\sum_{j\in J} X_{ij}\ Bm$ (3)

The cost of purchasing the corn crops

This cost is derived from the multiplication of the cost of purchasing the corn crops with the productivity of each region's harvest per variety and the area of captive land. Here is the formulation of the cost of purchasing the crop.

Purchase cost of harvest = $\sum_{i\in I}\sum_{j\in J} X_{ij}\ Bhp_j\ P_{ij}$ (4)

Cost of transporting corn crops

The cost of transporting the corn crops is obtained from the multiplication of the cost of harvesting and the productivity of each area per variety and the area of captive land and divided by the capacity of the truck used. Here is the formulation of the cost of transporting the crop.

The cost of transporting the crops = $\sum_{i\in I}\sum_{j\in J} \frac{X_{ij}P_{ij}}{Ct} Bap_i$ (5)

Based on the formulation of each cost of hybrid corn seed cultivation, total cost is obtained by summing all costs of cultivation as follows:

$$Min\ Z = \left\{\left(\sum_{i\in I}\sum_{j\in J} X_{ij}\ Bb\ Kb\right) + \left(\sum_{i\in I}\sum_{j\in J} X_{ij}\ Lc_i\ Kt\right) + \left(\sum_{i\in I}\sum_{j\in J} X_{ij}\ Bm\right) + \left(\sum_{i\in I}\sum_{j\in J} X_{ij}\ Bhp_j\ P_{ij}\right) + \left(\sum_{i\in I}\sum_{j\in J} \frac{X_{ij}P_{ij}}{Ct} Bap_i\right)\right\} \quad (6)$$

c. Determination of constraints

Some constraints of hybrid corn seed cultivation planning model are as follows:

- Constraints to ensure that the cultivation lands per nagari $i \in I$ for each variety $j \in J$ do not exceed the availability of lands on nagari *i* and greater or equal to zero.

$$\sum_{j\in J} X_{ij} \leq X_i \qquad \forall\ i\ \in I \quad (7)$$

$$\sum_{j\in J} X_{ij} \geq 0 \qquad \forall\ i\ \in I \quad (8)$$

- Constraints to ensure that the production of hybrid corn seeds of each variety is greater or equal to the number of contracts of each variety. Production is obtained from the multiplication of cultivation lands per nagari $i \in I$ for each variety $j \in J$ with productivity $j \in J$ and shrinkage of yields worth 0.48.

$$\begin{aligned} &\sum_{i\in I} X_{ij}\ P_{ij}\ Shp\ \geq\ D_j \qquad \forall\ j\ \in J \\ &\sum_{i\in I} X_{ij}\ P_{ij}\ 0.48\ \geq\ D_j \qquad \forall\ j\ \in J \end{aligned} \quad (9)$$

- Constraints to ensure that the value of cultivation area per nagari $i \in I$ for each variety $j \in J$ d is positive value.

$$X_{ij}\ \geq 0 \qquad \forall\ i\ \in I, j\ \in J \quad (10)$$

3. Results and Discussion

Cultivation of hybrid corn seeds at PT CNM requires systematic planning to fulfill contracts from PT Pertani (Persero). Contracts can be fulfilled by utilizing the potential land available in the cultivation area. Utilization of potential land would require planning especially in terms of cost planning. This is applicable because the difference in land leads to differences in the cost of captive cultivation. By modeling the corn cultivation system at PT CNM, potential land allocation plots in cultivation areas for each variety of hybrid corn seed can minimize the cost of captive cultivation.

Then, sensitivity analysis can be performed. Sensitivity analysis is used to determine the conditions and risks that may arise in the implementation of captive cultivation. Sensitivity analysis aims to see whether the model is sensitive to model parameter changes. This analysis is performed by changing the value of model parameters consisting of changes in the coefficient of constraint function such as the productivity of the seed of each variety per region and the value of the resource *i* is the availability of land and volume of contract.

Changes in model parameter values were performed with a certain percentage of ± 5% and ± 10%. Changes in parameters such as land availability (≤ 10 Ha) at a percentage of ± 5% and ± 10%, will result in a small change of objective function of the dual price value. This is performed because the parameter value has not reached 1 unit or 1 Ha. Then, the percentage change of parameters both land availability, contract volume and seed productivity are presented.

Based on sensitivity analysis both one parameter change and two model parameters, it was found that the model that has been proposed is not sensitive to changes in parameters, either contract volume parameters, land availability, and seed productivity. In other words, changing those parameters does not significantly impact the total cost of cultivation costs. However, PT CNM should be able to plan and control the change of model parameters in fulfilling the contract with PT Pertani (Persero).

The volume of hybrid corn seed contracts will affect the planning of the production of hybrid corn seeds. The volume of contracts can be achieved if the area of planted land and crops is in accordance with the planning. The realization of cultivation land area depends on cooperation with farmer breeder. Thus, it is necessary to have a plan that can increase the interest of farmers in doing the hybrid corn seed cultivation. The company has attracted farmers in several ways such as free seeding, the dettaselling labor cost of the company and the costs of malecutting compensation. However, it will be more attractive to farmers, if PT CNM can establish other policies such as increased cost of purchasing corn crops to farmers' breeders. When compared with other food commodities such as rice, the cost of purchasing corn crops is still low. Therefore, PT CNM needs to raise the cost of purchasing the crops to farmers.

The volume of the contract can be met if the number of crops in accordance with the estimation or planning. The number of crops is related to the productivity of the seeds produced. PT CNM should continue to improve the productivity of seedlings by making various efforts such as quality control of seeds to be planted, improving the procurement of production facilities and management of good corn cultivation through the application of technology and on-site supervision on a continuous basis so that farmers catch all breeding procedures, especially in terms of care of corn crops

4. Conclusion

This research has proposed a hybrid corn seed cultivation planning model using linear programming method. The output of the model is the optimal potential land allocation with minimum total cost of captive cultivation. Hybrid corn seed cultivation planning model can also determine the production capability of corn seeds owned by PT CNM.Hybrid corn seed cultivation planning model is already verified and valid based on the numerical example given. The sensitivity analysis has also been performed. It found that the proposed model is not sensitive to parameter changes such as changes in contract volume parameters, land availability and seed productivity. However, PT CNM must keep controlling the change of parameters. For further research, it is necessary to develop an integrated information system on a hybrid corn cultivation planning system. The system can also be developed with other purpose functions such as minimization of the achievement of the volume contract.

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Implementation of Preventive Maintenance in Production Machine with Age Replacement Model in PT XYZ

Taswir Syahfoeddin[a*], Indra Yusuf R[b]

[a,b]Politeknik STMI, Central Jakarta, 10510, Indonesia

Abstract

Reduce the amount of damage time injection molding machine during production, required preventive maintenance maintenance system with age replacement model. The result of data processing and analysis of critical injection molding machine problem is Toshiba 220 Ton with damage time 2,195 minutes during July to December 2016. Toshiba 220 Ton injection molding machine obtained four spare parts which are damaged is screw, oil seal, and nozzle and hydraulic, where the nozzle has a high frequency of damage. The replacement time according to the age replacement model for spare-part nozzle is 52 hours (3 working days) and inspection time four times a month. Increased reliability spare-part nozzle, equal to 0.4244 or 42.44% from the previous 0.35 to 0.50.

Keyword: Preventive Maintenance, Age Replacement, Injection Molding

1. Introduction

Injection molding machine has an important role for the production process, because the injection molding machine of raw materials is processed into finished product that has added value. Continuous use of machines used can be dead or damaged. Dead or damaged engine problems related to maintenance and replacement of machine spare parts.

2. Method

2.1. Maintenance

Maintenance is an activity to maintain or maintain plant facilities and equipment, and make any necessary repairs, adjustments or replacements to obtain a satisfactory condition of production operation, as planned. In addition, according to Stephens maintenance is all the activities necessary to keep the system and all components work properly [1]. According to Corder maintenance is a combination of various actions taken to keep an item in, or to fix it until, an acceptable condition [2]. With the maintenance activities are expected all facilities and machines owned by the company can be operated in accordance with the plan. Treatment has a very decisive role in the production activities of a company concerning the smoothness or congestion of production.

2.2. Purpose of Maintenance

1. The ability to produce can meet the needs in accordance with the production plan.
2. Maintain quality at the right level to meet what is needed by the product accordingly and uninterrupted production activities.
3. To help reduce unnecessary usage and deviations and keep the capital invested in the company for the specified time in accordance with the company's policy on the investment.
4. To achieve the lowest level of maintenance costs possible, by carrying out maintenance activities effectively and efficiently.
5. Avoid maintenance activities that may endanger the safety of workers.
6. Conduct a close cooperation with other major functions of a company; in order to achieve the main objectives of the company is the level of profit or return of investment as possible and the lowest total cost.

2.3. Preventive Maintenance

Preventive Maintenance is generally done based on data damage in the past. Implementation of preventive maintenance on a regular basis so unexpected events that can disrupt the smoothness of the production process can be minimized. This preventive maintenance activity is very important because its utility is very effective in facing the production facilities which belongs to the 'Critical Unit' group. If preventive maintenance is implemented on the critical component then the maintenance task can be done with intensive planning for the unit concerned, so that the production plan can be achieved with the production of larger in a relatively shorter time.

* *Corresponding author*

In practice according to Assauri preventive maintenance conducted by a factory company can be distinguished on [2]:

1. Routine maintenance is a routine maintenance and maintenance activities performed on a daily basis. For example, routine maintenance activities are cleaning of facilities or equipment, lubrication or checking the oil, as well as checking the contents of the fuel and possibly warming up the machines for a few minutes before being operated throughout the day.
2. Periodic maintenance is the maintenance and maintenance activities performed periodically or within a certain period. Periodic maintenance is done by using the length of working hours of the machine or production facility as a schedule of activities, such as one hundred hours of machine work once and so on. So, the nature of the maintenance is fixed periodically or periodically

2.4. Reliability

Reliability is the probability that a component or system can operate according to the desired function for a given time when used under predetermined operating conditions. The reliability value is between 0 - 1, where the value 0 means reliability is very low and the component cannot be used. While the value 1 indicates high reliability. In order to determine reliability in operational relation, a more specific definition is needed, i.e. a description of non-confusing and observable failures, identification of time units, and observed systems must be in normal environmental and operating conditions.

2.5. Downtime

According Nakajima (1998) downtime is divided into two namely, based on equipment failure and setup and adjustment. Equipment failure with examples such as damage and setup adjustment with examples such as mold replacement on injection molding machines. Downtime is the time when a unit can no longer perform its function as expected. This may occur when a unit experiences problems such as engine damage which may interfere with the performance of the engine as a whole including the quality of the resulting product or its production speed so as to require a certain time to restore the function of the unit to its original condition (Ebeling, 1997).

2.6. Damage Curve

This section describes the curve showing the pattern of instantaneous rate of damage that is common to a product known as the curve of the tub (curve) because of its shape. The system that has a function of this rate of damage at the beginning of the cycle of its use decreases the rate of damage (premature damage), followed by the rate of near-constant damage (wear life), then increases in damage rate (over the life). Curve shape can be seen in the following figure:

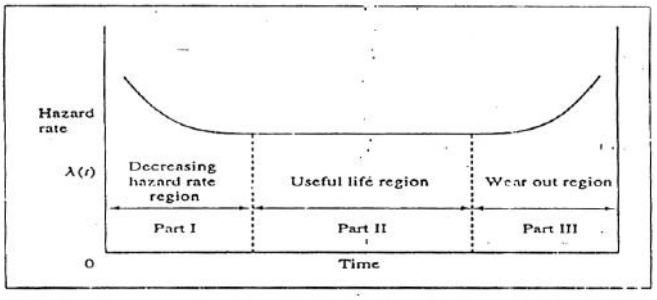

Fig 1. Bath Tub Curves
(Source: Ebeling, 1997)

Each time period has certain characteristics determined by each rate of damage that is:

1. Early Failure or Early Damage
   This area is often referred to as the Burn-in period. In this period the rate of deterioration decreases with time. Damage occurring at this time may be caused by several causes according to (Dhillon and Reiche, 1985):
   a. Unqualified quality control.
   b. Substandard material and labor performance.
   c. Errors arising during assembly.
   d. Human errors such as installation and set up.
   e. Packing error and material handling methods.

If there is damage, then replaced with a new product, then reliability will increase again. Damage to this phase can be satisfied with Weibull distribution.

2. Chance Failure or Useful Region or Normal Operation

This time period is marked by a constant rate of damage. This matterindicates that the instantaneous rate of damage will not increase with increasing component life, and the probability of damage to the component at any time is the same. Consequently, in an area of unexpected damage usually caused by sudden loading of magnitude beyond the capability of components or other extreme conditions. Some of the reasons causing damage to this phase according to Dhillon and Reiche (1985) are:

a. Unexplained damage causes.
b. Human error and natural damage.
c. Damage is inevitable, even with the most effective practical treatment measures though.

3. Wear Out Failure or Wear Out Period

This time period is marked by a sharply increasing rate of damage, due to deteriorating equipment conditions. This increase indicates the end of useful life of the product will begin to be in line with the worsening condition of the product. When a device has entered this phase, preventive maintenance should be taken to reduce the occurrence of more fatal damage. Some of the reasons causing damage to this phase according to Dhillon and Reiche (1985) are:

a. Inadequate care.
b. Fatigue due to wear caused by usage.
c. Fatigue due to age.
d. Overhaul error.
e. The occurrence of corrosion.
f. The design of life is short.

2.7. Determination of Optimal Prevention Replacement Time Interval With Machine Downtime Minimization

Preventative replacement is done to avoid cessation of the machine due to component malfunction. To perform this treatment action, it is necessary to know the time interval between the optimal replacement (tp) actions of a component so as to achieve maximum minimization of downtime.

1. Block Replacement

In this model, the replacement action is performed at a fixed time interval. So this model aims to determine the optimal preventive replacement time interval (tp) between replacement prevention to minimize downtime per unit of time. This model allows for replacement within the adjacent time period, where newly installed components after replacement damage must be replaced again at the time of arrival of preventive replacement times. The block replacement model can be seen in the following figure

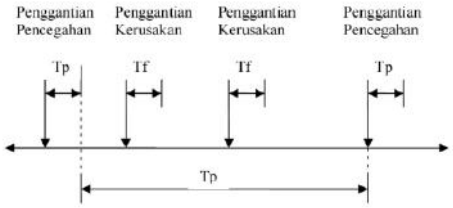

Fig 2. Block Replacement Model
(Source: Jardine, 1995) [4]

2. Age Replacement

In this model, the precautionary action is taken when the operation has reached the specified age, i.e. at tp, if in time interval tp no damage occurs. If the system is damaged before tp, then the replacement is done as a corrective action. The calculated life expectancy of tp starts from the beginning again with reference to the start of operation of the system again after the corrective maintenance measures are performed. The age replacement model more details can be seen in the following figure:

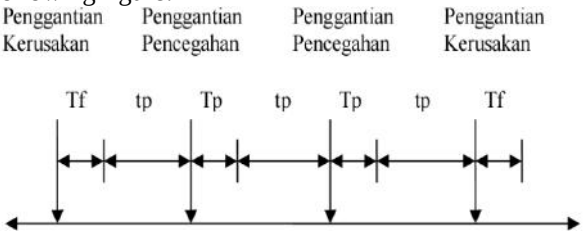

Fig 3. Model Age Replacement
(Source: Jardine, 1995) [4]

3. Result and Discussion

After conducting the data collection process, the next step is to perform data processing based on data that has been collected with the appropriate data processing methods.

3.1. Determination of Injection Molding Machine is Frequently Damaged

In this research will be discussed about the damage data on the injection molding machine, because the machine is a machine that serves as a converter from raw materials into products. Damage to injection molding machine can be seen in the following table

Teble 1. Damage Injection molding machine

No.	Machine	Total Damage (Minutes)	% Damage	% Cumulative Damage
1	Hattian 350 Ton	1.095	19,31	19,31
2	Toshiba 220 Ton	2.195	38,71	58,02
3	Futashin 100 Ton	1.175	20,72	100
4	JSW 100 Ton	1.205	21,25	79,28
Total		**5.670**	**100,00**	

Determination of critical machine is done based on the amount of total damage. Based on the largest total damage, injection molding machine Toshiba 220 Ton as the machine that experienced the highest damage of 38.7% during the period July to December 2016. Toshiba injection molding machine 220 tons will be done next data processing.

Selection of Frequent Spare Parts

The following is spare part damage on Toshiba 220 Ton injection molding machine. There are four spare parts that have been damaged in the period July to December 2016. Each of the damage spare parts on Toshiba 220 Tons injection molding machine can be seen in the following table:

Table 2. Damage of Spare Parts Injection Molding Machine

No.	Name Spare part	Frequency Damage	Total Damage (Minute)	% Damage	% Cumulative Damage
1	*Screw*	1	225	10,25	40,77
2	*Oil Seal*	9	670	30,52	30,52
3	*Nozzle*	25	1.170	53,30	94,07
4	*Hydraulic*	1	130	5,92	100
Total		**36**	**2.195**	**100,00**	

Selection of critical spare parts is done by making Pareto diagrams. From this Pareto diagram, it will show the most frequent spare part damage from July to December 2016. Pareto diagram for damage to spare parts injection molding machine Toshiba 220 tons can be seen in the following figure.

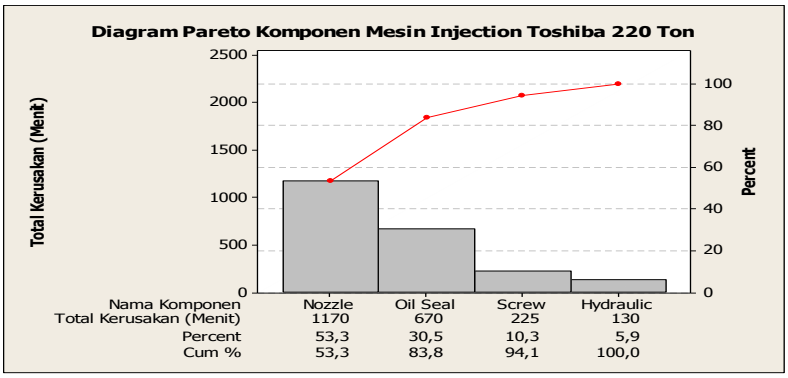

Fig 4. Pareto Diagram Damage Spare Parts Injection Molding Machine

Based on the Pareto diagram, it can be seen that the most dominant spare part damage that occurred on Toshiba 220 tons injection molding machine for six months from July to December 2016 was spare part nozzle (53.5%) and spare part oil seal (30.5%) then for both spare parts are selected for further calculation. On screw and hydraulic spare parts are not continued on the next calculation because the frequency of occurrence for each spare part only once.

Preventive Maintenance for Spare part Nozzle

At this stage will be done calculations that begin with the determination of critical spare part. Calculations are based on data collected during July to December 2016.

In the nozzle spare part, the time to fix the damage that varies with the longest time is 4 hours and the fastest is 0.167 hours, while the interval distance between the greatest damage is 215 hours, while the smallest is 12.83 hours. From the calculation it can be explained that at time t = 55 there is a replacement then R (t-nT) or prevention value will be close to 1 and the value of n will increase for each replacement and on average damage 74.27 reliability of 0.3482 or 34, 82% at the time without prevention and after the prevention of reliability obtained by 0.496 or 49.6%. From these results obtained that an increase in reliability of 42.44%

3.2. Critical Injection Molding Machine Analysis

Determination of critical injection molding machine based on the biggest downtime (damage) time during July-December 2016. In Pareto diagram injection molding machine Toshiba 220 tons has the largest percentage of 38.71% with a time of damage of 2295 minutes, then for Toshiba 220 tons.

Critical Spare-part Analysis on Injection Molding Machine

Damage to the injection molding machine Toshiba 220 tons consists of four spare parts, namely screw, oil seal, nozzle, and hydraulic. Determination of critical spare-part on Toshiba 220 ton injection molding machine is done by using Pareto diagram. Selection of critical spare parts is based on the time of damage and percentage. The selected spare-part is a nozzle with a break time of 1.170 minutes (53.3%).

3.3. Time to Failure (TTF) and Time to Repair (TTR)

Damage and repair data from July to December 2016. Injection molding machines are used in one day for sixteen hours and five days a week. The longest breakdown time for the nozzle spare-part is for 215 hours and the fastest damage time is 12.83 hours. At the time of the use of injection molding machine for spare-part nozzle there is the longest improvement that occurred on October 10, 2016 with a repair time of 240 minutes or 4 hours. Repairs lasted long due to unavailability of spare-part in the event of damage so that repair is waiting for the availability of spare-part nozzle. The fastest improvement for 10 minutes or 0.167 hours, the cause of the damage is the clogging of nozzles by objects that do not melt during heating

3.4. Analysis of Replacement Calculations With Age Replacement

The calculation of time interval of prevention turnover is done to find out how long the time interval of critical spare part is needed until the spare part must be replaced again. It aims to minimize the downtime (damage) that occur. The calculation of time interval for prevention is done using the age replacement model, where this model takes into account the optimal life of a spare-part. In the TTF data the distribution for each spare-part is lognormal and normal. Based on the main characteristics of spare-part damage if it is in lognormal distribution and normal then it will enter in IFR characteristic (Increasing Failure Rate). On these characteristics spare-parts need to be held preventive replacement. Spare-part Nozzle replacement time interval for 52 hours.

3.5. Analysis of Interval Inspection Calculation

The calculation of time interval checking aims to anticipate the occurrence of spare-part damage suddenly, so if found spare-part condition that is not good immediately can be done replacement to prevent things that are not desirable. This inspection process is part of the treatment action, because through this inspection process, the spare-part can operate optimally because the condition is checked periodically. Based on the calculation results obtained that spare-part nozzle examination conducted four checks each month. Examination is done based on several provisions that exist, among others, the amount of damage that occurred, the average time of repair and the length of time for each inspection activity set by the company.

3.6. Reliability Analysis (Reliability) With Preventive Maintenance And Without Preventive Maintenance

Reliability (reliability) is the probability of a spare-part or system to be able to operate in accordance with the desired function for a given period of time when used under prescribed conditions. (Ebeling, 1997). In addition to the increased availability rate, it is expected also with the Preventive Maintenance then the reliability level (reliability) of engine spare-parts can increase, the reliability level will be better when close to 1, which means the spare-part can operate optimally under the conditions set. The process of calculating this reliability differs based on the distribution that accompanies the machine's failure time data. Increased reliability spare-part can be seen in the following table:

Table 3. Reliability Table Before and After Preventive Maintenance during MTTF

Spare-part Critical	Reliability Before Preventive Maintenance (R (t))	Reliability After Preventive Maintenance (Rm (t))	Increase (%)
Nozzle	0,34822	0,49600	42,44%

R (t) is spare-part reliability before preventive maintenance is performed, while Rm (t) shows spare-part reliability after preventive maintenance. Based on the Reliability Table Before and After Preventive Maintenance At MTTF, it can be seen that after the preventive maintenance, when the spare-part enters MTBF, the reliability level tends to increase for all critical spare parts, this is because the spare parts have the damage characteristic with increasing rate (IFR). Can be seen that the level of reliability increased by 42.44% for nozzle when applied preventive maintenance by applying a good maintenance schedule the company will get some other advantages that the level of reliability of critical spare-part will increase, and extend the life of the spare-part.

4. Conclusion

Can be drawn his conclusions

1. The critical injection molding machine is the Toshiba 220 Ton injection molding machine with a break time of 2,195 minutes during the period July to December 2016, and four spare parts were damaged: spare-part oil seal, nozzle, screw and hydraulic. Based on the frequency of spare-part damage is a nozzle that has a large damage frequency.
2. The replacement time according to age replacement model for spare-part nozzle is 52 hours (3 working days) and inspection time for spare-part nozzle is four times in a month.
3. Increased reliability occurs in the nozzle spare-part, which is equal to 0.4244 or 42.44% from the previous reliability of 0.34822 to 0.496.

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Proposed Pricing of Tea Leaf in PTPN VI Unit Danau Kembar with Simulation System Approach

Irna Ekawati[a]*,Lisa Nesti[b]

[a,b] *Politeknik ATI Padang, Jl Bungo Pasang Tabing, Padang, 25171, Indonesia*

Abstract

PTPN VI Unit Danau Kembar is a government company that processed tea leaf into orthodox black tea. Tea leaf are produced from their own gardens and plasma gardens. Tea produced will be sold through auction process at Jakarta Tea Auctions every week. The selling price of tea at the auction tends to change every week while the purchase price of tea leaf does not always change. This causes PTPN VI Unit Danau Kembar at risk of losses. This study proposes a reactive price determination of tea leaf and is based on the selling price of black tea in an auction every week. The proposed model is modeled using a simulation system approach using promodel software. The proposed model shows that PTPN VI can avoid the risk of loss because the percentage of profit is set at the beginning. As a consequence, the pricing of tea leaf from farmers is changing and reactive depending on the selling value of black tea.

*Keywords:*blacktea, PTPN VI, tea leaf, pricing, simulation.

1. Introduction

The increasingly complex consumer demand and changes in international trade rules have affected the supply chain system of Indonesian tea industry, such as the development of supply chain traceability era [1] whereby tea industry actors are required to make changes in the operating system to compete with global tea industry players. Tea industry players must be able to deliver their products with the right quality and quantity in accordance with the demand, sustainable, timely and cheap price. Supply chain integration is a difficult task because of differences in conflict of interest and is a dynamic system that evolves over time [2]The level of complexity will be seen when the decision-making process is done. Conflicts of interest will occur in accordance with the different needs motives of stakeholders.

In general, tea supply in Indonesia is produced by (1) independent farmers, (2) large private plantations and (3) state plantations known as PT. PTPN VI produces black tea with which it will be sold in Jakarta Tea Auction through auction process [3]. Tea sold during the auction will be exported or further processed by the downstream products industry such as fast tea beverage factory and so on. Furthermore, in Indonesia there are also many independent tea farmers who produce tea leaf with longer flow chains (through small collectors, large collectors) to be processed into more downstream products. In addition to PTPN and independent farmers, there are also large private plantations where they usually have a black tea or green tea processing factory.

PT. Perkebunan Nusantara VI Unit Danau Kembar is a company which is a State Owned Enterprise having address at Jorong Street Jayu Kenagarian Batang Barus, Gunung Talang Subdistrict, Solok Regency with total area of about 569.18 Ha. Organizational structure of the company, this company is one unit of production from PTPN VI based in Jambi. The company produces black tea with Orthodox system through the process of picking, forging, rolling, fermentation, drying, sorting to packing. The raw materials of tea processed in PTPN VI come from own plantation (main farm) and plasma farm.

As partner of PTPN VI Unit Danau Kembar (hereinafter referred to as PTPN VI) plasma farmers sell tea leaf to PTPN VI at a price set by PTPN VI Pusat in this case PTPN Jambi. Tea produced by PTPN will be auctioned at Jakarta Tea Auction organized by PT. Kharisma Pemasaran Bersama (PT. KPB) which is also a subsidiary of PTPN in Indonesia. In the tea product auction process, PTPN VI Unit DanauKembar is represented by PTPN VI Jambi will follow the auction every Wednesday every week. Further information on the auction results (tea and purchase quantity) will be delivered to PTPN VI Unit Danau Kembar where in this case the buyer will pick up the tea directly through the fleet organized by a third party. Meanwhile, the flow of tea purchase money will be delivered to PTPN VI Jambi so that in this case PTPN VI Unit Danau Kembar units only manage the finances associated with production activities.

As the actors in the tea flow supply chain described above, farmers, PTPN VI Unit Danau Kembar and PTPN VI Pusat (Jambi) should be together so as to generate mutual benefits and produce a steady supply of good performance. Farmers in this case as providers of raw materials are considered to have a low bargaining position because they have to accept the purchase price set by the PTPN VI. Meanwhile PTPN VI in conducting its business activities cannot be separated from the risk of losses due to the resulting black tea sold by the auction system. When the auction price is below the cost of production then the company suffered losses or vice versa. Whereas according to [4] suggested the scope of supply chain management research not only assess the problem of efficiency but also should be directed to examine the problem of justice among actors involved in a supply chain

*Corresponding author ; phone : +62751 7055053; fax: +62751 41152
Email : irna_e@yahoo.com

2. Method

The proper design of a dynamic problem (changing over time) can be done using system dynamics [5]. System dynamics is an approach that uses a perspective based on information feedback and delays to understand the complex behavior dynamics of physics systems, biological systems and social systems. In addition, system dynamics is a modeling approach based on systemic thinking and dynamic modeling principles [6]. The main assumption in the system dynamics paradigm is that the phenomenon of the decision-making process is an assembly of causal loop structures. The system approach is a way of solving the problem that begins with the identification of the existence of a number of needs so as to produce an operation of the system that is considered effective. The system approach is generally characterized by the following two things: to find all the important factors that exist in getting a good solution to solve the problem, and made a quantitative model to help the rational decision [7].

This research was conducted to focus on the black tea industry supply chain in West Sumatra with PTPN VI Unit Danau Kembar as focal firm. The data obtained is the result of interview with PTPN VI. This study will illustrate the current conditions in which the leaf prices are not reactive to the selling price of black tea. A proposal system is provided where the pricing of tea leafdepends on the sale price of the proceeds. By using simulation with dynamic system approach (Sterman, 2000) using Powersim [7]. The steps taken are

a. Simulation of existing condition
   The steps taken are:
   1. Describe the existing condition of tea supply chain.
   2. Describe the variables and parameters involved
      - Leaf tea from main farm (kg/week)
      - Leaf tea from plasma farm (kg/week)
      - Prosessed leaf tea (kg/week)
      - Black tea production (kg/week)
      - Leaf tea purchasing price (Rp/kg)
      - Input output ratio of tea production
      - Range of selling price of black tea in 16 types (Rp/kg)
      - Estimation of production cost (Rp/kg)
      - PTPN VI Unit Danau Kembar profit (Rp)
   3. Determining the causal relationship between variables in c*ausal loop diagram*
   4. Formulating mathematical equation involve variables in*causal loop diagram.*
      - $\text{Prosessed leaf tea} = \text{Tea leaf from main farm} + \text{Tea leaf from plasma farm}$
      - $\text{Black tea production} = \text{Prosessed leaf tea} * \text{Input output ratio of tea production}$
      - $\text{Selling price of black tea} = \sum(black\ tea\ in\ type\ i * price\ of\ type\ i)$
      - $\text{Margin} = \text{Selling price of black tea} - \text{production cost}$
   5. Create a stock flow diagram and input all variables values using*Powersim Studio Academic*
   6. Running simulation and analyzing the output of simulation
   7. Analyze the performance of the existing supply system and identify change of improvement

b. Simulation of proposed condition
   The steps taken are:
   1. Setting the proposed improvement objectives according to the analysis of the existing conditions
   2. Establish decision variables within the proposed system
   3. Describe the variables and parameters involved
      - Leaf tea from main farm (kg/week)
      - Leaf tea from plasma farm (kg/week)
      - Prosessed leaf tea (kg/week)
      - Black tea production (kg/week)
      - Leaf tea purchasing price (Rp/kg)
      - Input output ratio of tea production
      - Range of selling price of black tea in 16 types (Rp/kg)
      - Estimation of production cost (Rp/kg)
      - Target of profit (%)
   4. Determining the causal relationship between variables in c*ausal Loop Diagram*
   5. Formulating mathematical equation involve variables in*Causal Loop Diagram*.
      - $\text{Prosessed leaf tea} = \text{Leaf tea from main farm} + \text{Leaf tea from plasma farm}$
      - $\text{Black tea production} = \text{Prosessed leaf tea} * \text{Input output ratio of tea production}$
      - $\text{Selling price of black tea} = \sum(black\ tea\ in\ type\ i * price\ of\ type\ i)$
      - $Leaf\ tea\ purchasing\ price = \left(\frac{\frac{Selling\ price\ of\ black\ tea}{1+margin} - * production\ cost}{black\ tea\ production}\right)$
   6. Create a stock flow diagram and input all variables values using *Powersim Studio Academic*

3. Results and Discussion

This study, comparing the two current conditions and proposed conditions. In this paper will be presented development of proposed model. The determination of the price of tea leaf of farmers determined real time based on the value of tea sales the previous week. It aims to have a fairer profit if the price of tea sales rises or just the opposite. PTPN VI as a company under the government can set the desired company margin to further be used as a basis in calculating the purchase price of raw materials (tea leaf) to farmers. Determination of this margin can reduce the risk of companies experiencing losses if the selling price of tea fell. The consequence of this proposal, all parties especially KPB and PTPN VI agree and willing in disclosure information to PTPN VI Unit Danau Kembar and farmer in the openness of tea sale price. Description of proposal system described above is poured on causal loop diagram in Fig. 1.

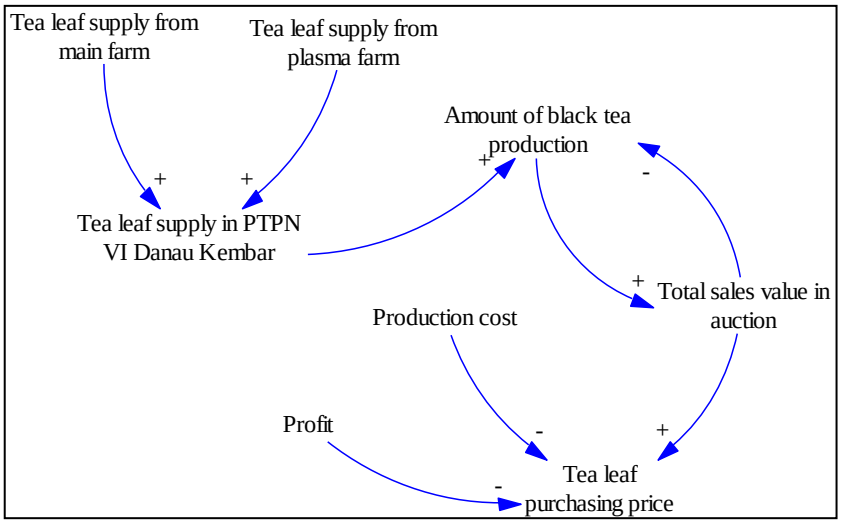

Fig. 1. Causal loop diagram

Based on the causal loop diagram in Fig. 1 and the value of variabel from observation and interview,then formed a stock flow diagram using Powersim Studio Academic software in Fig. 2.

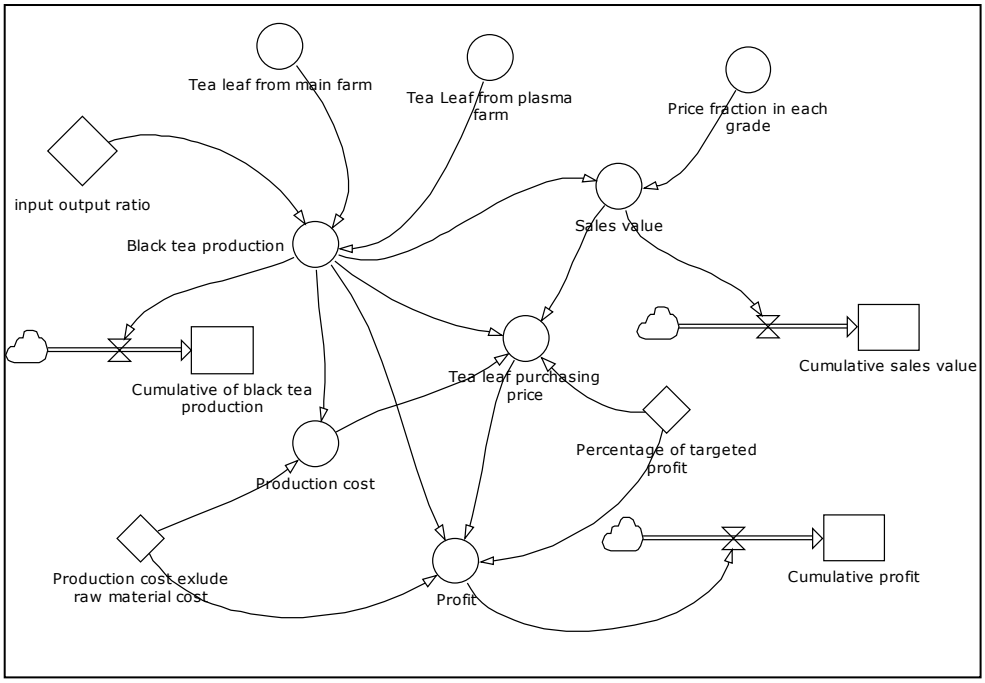

Fig.2. Stock flow diagram

The simulation runs with time interval from 1st of January to 1st September with time step 1st week with consideration of tea sale auction process every week. The output the existing and proposes simulation model presented at Fig. 3a and 3b.

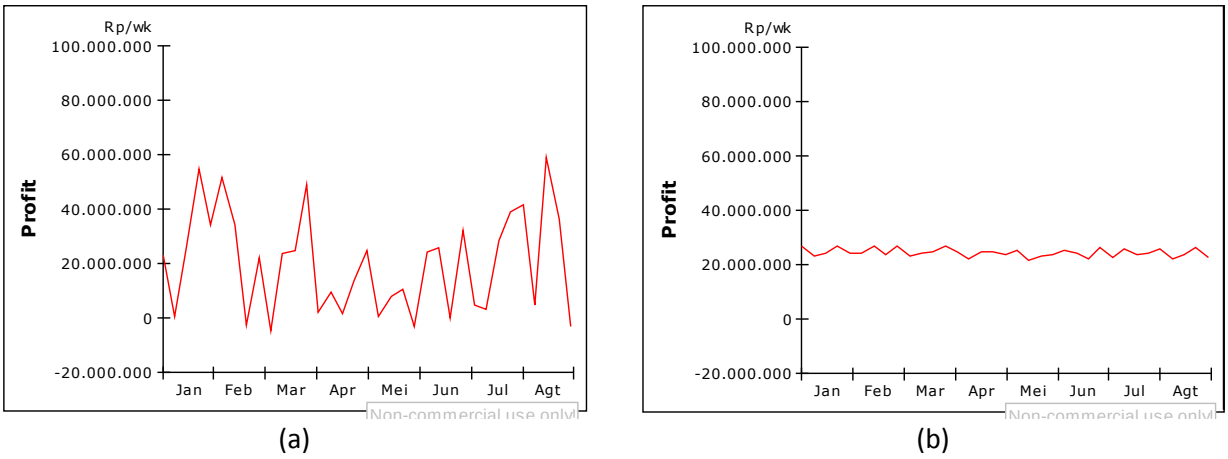

Fig. 3. Simulation Output of (a) existing condition and (b) proposed condition

Fig 3(a) shows that the current condition of PTPN VI is experiencing fluctuating profits due to fluctuating tea sales prices at the auction while the price of tea leaf is not reactive to the selling price. In the proposed system, PTPN VI sets the target margin margin. Based on these targets then set the purchase price of tea leaf to farmers. This system benefits PTPN VI because it can avoid the risk of loss as illustrated in Fig. 3(b) even though tea sales price fluctuates.

4. Conclusion

This study discusses one of the existing tea supply chain system in West Sumatera especially involving PTPN VI Unit Danau Kembar. Tea produced is a type of orthodox black tea that supplies raw materials derived from the main farm and plasma farm to be sold at auction every week. The price of tea purchased to farmers is determined by PTPN VI Jambi and not too reactive to the price of tea sales. Meanwhile PTPN VI has the potential to lose if the auction price is below the production price. The research proposes a system that requires price openness of sales to tea industry actors, especially to farmers and PTPN VI Unit Danau Kembar. The purchase price of the proposed tea leaf depends on the value of tea sales each week that the determination is also influenced by PTPN's desired margin. With this system is expected PTPN VI avoid loss because the value of profit set at the beginning.

Acknowledgements

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Quality of Kahwa's Leaves Hard Candy in Terms of Food Chemistry

Malse Anggia[a*], Ruri Wijayanti[b]

[a,b]*Agricultural Industrial Technology, Dharma Andalas University*

Abstract

Kahwa's leaves hard candy is known as one of the very popular food products by the community with variety of form and taste. The purpose of this research is to produce hard candy from kahwa's leaf extract which can be a healthy snack. Since the activity of antioxidant and polyphenols will provide good health effects for the body. Moreover, this will increase the utilization of kahwa's leaf. The stages of this research start with making of kahwa leaf extract, making hard candy, chemical analysis (moisture content, ash content, antioxidant, and polyphenol). The results showed that the moisture content 1,54 % - 2,06 % and the ash content 0,06% - 0,41% and the content of antioxidants and polyphenols is 40,61%-78,52% dan 720 – 1423,33 mg GaE/gram. This results imply that kahwa's leaves hard have met Indonesian National Standard (SNI)..

Keywords: Kahwa's leaves, Hard candy, antioxidant, polyphenol

1. Introduction

The coffee leaves known as "kahwa leaves" were used as traditional drinks in Tanah datar Regency. This traditional beverage known as "aia kahwa". The appearance of this beverage looks similar with tea but has different flavor. Aia Kawa is much preferred by the rural population. The recipe were derived from the descendants of their respective (Based on Community survey results in the Sungai Tarab District of Tanah Datar).

Previous research related to kahwa's leaves still scarce in number. One of the research including the making of tea leaves kahwa-cassiavera by Anggia (2011). The Hard candy product from Kahwa's leave extract is expected to develop product from kahwa leaf and food diversification. Candies derived from Kahwa leaf extract can be used as a healthy snack that provides a good effect for health with the presence of antioxidant activity in snacks. Some of the advantages of hard candy production from Kahwa leaf are, for example, the unnecessary addition of the dye due to the extract from the leaf kahwa has an attractive and quite strong brown color. In addition, the candy products from kahwa leaf extract have a distinctive flavor and aroma so there is no need for additional flavor.

"Aia Kahwa", a traditional drink made by boiling kahwa leaves, is usually treated in a certain way before the boiling process is done. Some treatments such as drying the leaves under the sun, warming over the embers until a fragrant aroma occurs. "Aia Kahwa" have a bitter taste, fresh and delicious, and has a distinctive aroma. Fragrant aroma is caused by changes in the content of coffee leaves due to heat treatment such as changes in carbohydrates, amino acids, essential oils, tannins and kaffeine (Baikal, 2007).

Candies are processed food products that are solid, made from sugar or sugar mixtures with other sweeteners with or without the addition of other food stuffs and food additives that are permitted, and has a hard structure (National Standard of Indonesia, 2008). The temperature used to make the candy so that the moisture content reaches about 3% is 150^{o}C. The technique of making candy with satisfactory durability lies in the production process with minimum moisture content and with very little tendency to crystallize (Buckle et al., 1987). The results of study by Srimarlinda (2010) showed that more higher temperature used for making hard candy, the hardness will higher and lower moisture content

2. Method

2.1. Raw Material Selection

The main raw materials used are kahwa's leaves obtained from farmers' gardens in Nagari Pasie Laweh, Sungai Tarab, Tanah Datar, West Sumatra. Kahwa leaves are then sorted according to requirements.

2.2. Extracting Process

After finished in sorting, then kahwa leaves roasted until the fragrant aroma occurs and the color of the leaves turns to dark brown. The roasted leaves are then extracted. The comparison of kahwa leaf extraction was used with a ratio of 1:10 with water.

2.3 Inverted Sugar Making

The process in making inverted sugar following Wahyuni (1998) as follows: 200 grams of sucrose dissolved in 90 ml of water and added 1% citric acid concentration (2 grams) then heated to 100 ° C for 20 minutes. Then controlled pH with 33.3% NaOH until it reaches pH 5. this process will produce 200 ml of inverted sugar.

** Corresponding author*
email : malse.a@unidha.ac.id

2.3. Hard Candy Production

The process of making this hard candy is guided by the way of Srimarlinda (2010), with the following work order: First, 200 grams of sugar (sucrose) plus 20 ml of water. Second, apply kahwa leaf extraction (according to treatment) and then add 50 ml of inverted sugar while heated until the final heating temperature reaches 150^0C (note, if put into water, the extract will be in the form of yarn sheet and can be broken). Third, after heating and then cooled to 60 °C. Then, add the leaf syrup of kahwa according to the treatment. After that, put in mold to harden. Remove the hard candy from the mold when it is completely hardened.

2.4. Research sites

This research was conducted in Laboratory of Agricultural Industrial Technology, Dharma Andalas University and Laboratory of Agricultural Technology Production, Andalas University.

2.5. Research design

The design used was Completely Randomized Design (RAL) with 5 treatments and 2 replications. If there were significantly different at the 5% level, a follow-up test will be perform using Duncan's New Multiple Range Test at 5% level.

For Treatment: A: Add 20 ml kahwa leaf extract, B: Add 30 ml kahwa leaf extract, C: Add 40 ml kahwa leaf extract, D: Add 50 ml kahwa leaf extract, E: Add 60ml Kahwa leaf extract

2.6. Observation

Observations made were: moisture content, ash content, antioxidants and polyphenols.

3. Results and Discussion

3.1. Moisture Content

Moisture content analysis results obtained from the hard candy leaves of kahwa can be seen in Figure 1

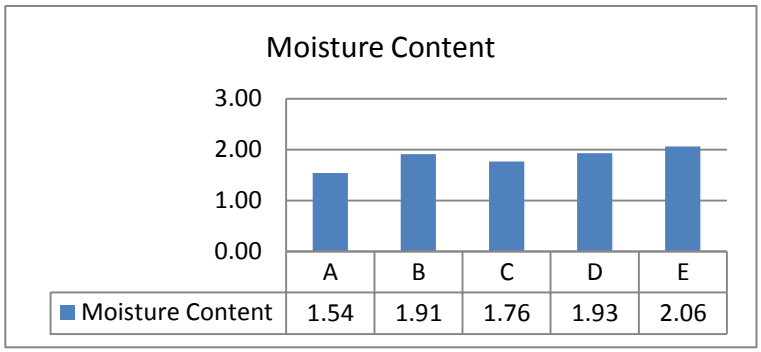

Fig 1. Moisture content of Kahwa Leaf Hard candy

The results of laboratory analysis showed that the average water content of hard kahwa leaves ranged from 1.54 - 2.06%. moisture content is very influential on the quality of hard candy, because the quality of hard candy associated with water content. Based on SNI 3547.1: 2008, maximum moisture content of hard candy, is 3.5%. based on this standard, the moisture content of hard candy kahwa meets the quality requirements. Based on the results of analysis of variance, the addition of leaf kahwa extract not give a real effect on the hard candy water content produced.

Table 1. Duncans New Multiple Range Test at 5% level

Perlakuan	%
A. Adding 20ml kahwa leaf extract)	1,54 a
B. Adding 30ml kahwa leaf extract)	1,91 a
C. Adding 40ml kahwa leaf extract)	1,76 a
D. Adding 50ml kahwa leaf extract)	1,93 a
E. Adding 60ml kahwa leaf extract)	2,06 a

3.2. Ash Content

Ash content is very useful as a parameter of nutritional value of foodstuffs because it is a test to determine mineral materials (inorganic) (Sudarmadji, et.all, 1989). The higher levels of minerals contained in a foodstuff can cause damage to the intestines and human digestive disorders. The results of Ash Content obtained from hard candy leaves of kahwa can be seen in Figure 2

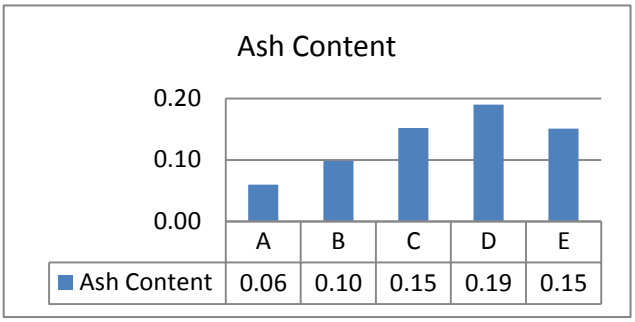

Fig 2. Ash content of Kahwa Leaf Hard candy

Based on the results obtained that the ash content obtained from hard candy leaves kahwa 0.06% -0.19% Compared with the quality requirements of ash content of SNI 3547.1: 2008 of hard candy is maximum 2.0%, then ash content from hard candy kahwa leaves qualify. This indicates that the raw materials of inverted and sucrose sugar used in making hard candy leaves of kahwa, have sufficient ash content for the requirements of making hard candy so that the resulting ash content meets the quality requirements.

The result of Analysis of variance showed that the addition of kahwa leaf extract did not give significant effect to hard candy ash content.

Table 2. Duncans New Multiple Range Test at 5% level

Perlakuan	%
A. Adding 20ml kahwa leaf extract)	0,06 a
B. Adding 30ml kahwa leaf extract)	0,10 a
C. Adding 40ml kahwa leaf extract)	0,15 a
D. Adding 50ml kahwa leaf extract)	0,19 a
E. Adding 60ml kahwa leaf extract)	0,15 a

3.3. Antioxidant Levels

The Results of antioxidant levels obtained from the kahwa leaf hard candy can be seen in Figure 3.

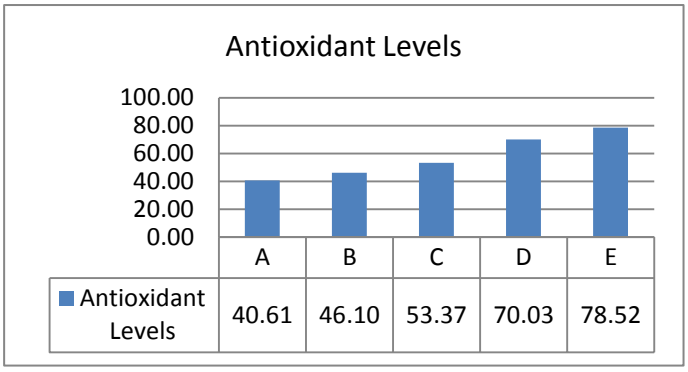

Fig 3. Antioxidant Level of Kahwa Leaf Hard candy

Based on the results of the study found that antioxidant data on hard candy from kahwa leaves was 40.61 - 78.52%. From these results it can be said that the leaves of kahwa have the potential to inhibit the free radical of DPPH. The ability of these antioxidants is also related to the chemical compounds found in the leaves of kahwa. Based on research by Anggia (2011) the tannin level on the leaves of kahwa is 6.4%. The tannins in the leaves of kahwa may be antioxidants, but there is also the possibility of other components that are antioxidants. Tanin is a secondary metabolite compound that is known to have several properties such as astringent, antidiare, antibacterial and antioxidant (Desmiati, et al 2008 in Malanggia, et al 2012). Also expressed by Hagerman (2002) that tannin serves as a biological antioxidant.

Table 3. Duncans New Multiple Range Test at 5% level

Perlakuan	%
A. Adding 20ml kahwa leaf extract)	40.61 a
B. Adding 30ml kahwa leaf extract)	46.10 ab
C. Adding 40ml kahwa leaf extract)	53.37 ab
D. Adding 50ml kahwa leaf extract)	70.03 bc
E. Adding 60ml kahwa leaf extract)	78.52 c

3.4. Polyphenol Levels

The content of Polyphenols in each extract is expressed as the equivalent of gallic acid or Gallic Acid Equivalent (GAE). GAE is a common standard for measuring the amount of phenolic compounds present in a material (Mongkolsilp et al., 2004). Based on the results of the research, it is known that the content of polyphenols in hard candy from kahwa leaves is 720 - 1423.33 mg GaE /gram

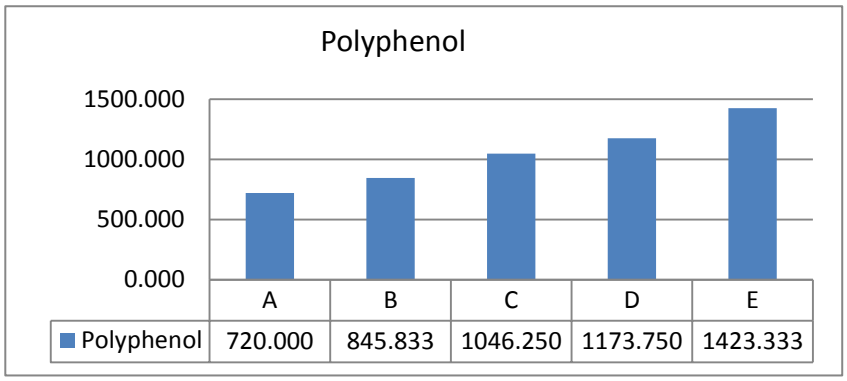

Fig 4. Polyphenol Levels of Kahwa Leaf Hard candy

The results of the analysis of variance at 5% level showed that, the addition of kahwa leaf extract gave no significant effect to the antioxidant on hard candy

Table 4. Duncans New Multiple Range Test at 5% level

Perlakuan	Mg GaE/ gram
A. Adding 20ml kahwa leaf extract)	725.833 a
B. Adding 30ml kahwa leaf extract)	853.889 a
C. Adding 40ml kahwa leaf extract)	955.278 a
D. Adding 50ml kahwa leaf extract)	1205.833 a
E. Adding 60ml kahwa leaf extract)	1409.722 a

One chemical component belonging to polyphenols in the leaves of kahwa is tannins. Tanin is a chemical compound belonging to a polyphenolic compound (Deaville et al., 2010). Dianawaty and Ruslin (2015) added that the classification of phenol compounds contained in plants is simple phenol, benzoquinone, phenolic acids, acetophenone, naphthoquinone, xanton, bioflavonoid coumarin, stilben, tyrosine derivatives, hydroxy cinnamic acid, flavonoids, lignans and tannins

4. Conclusion

A brief summary should be given for the principal conclusions of the work. Hard candies from kahwa leaves that are studied show good quality because they have fulfilled SNI 3547.1: 2008 seen from the content of moisture content, ash content. Antioxidant data on hard candy from kahwa leaf is 40,61 - 78,52% while polyphenol content in hard candy from kahwa leaf is 720 - 1423,33 mg GaE / gram. From these results can be said that hard candy produced is a hard candy that gives good health effects because it contains antioxidants and polyphenols, because kahwa leaves have the potential to inhibit the free radical DPPH. The ability of antioxidants is also related to the chemical compounds found in the leaves of kahwa is tannin which is classified as polyphenols. Further research is needed such as hardness level testing on hard candy and testing with appropriate temperature and time variations to obtain better hard candy texture.

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The Competitiveness of Crude Palm Oil in West Sumatra in The Domestic and The World Market

Lisa Nesti[a], Firwan Tan[b]

[a]*Polytechnic of ATI Padang,Bungo Pasang Tabing Padang, 25171, Indonesia,*
[b] *Departement of Economic, Andalas University,Limau Manis, Padang 26163, Indonesia*

Abstract

Indonesia should increase its competitiveness to get benefit from Asean Economic Community, especially CPO (crude palm oil) commodity which prospective future market is predicted to be still prospective which is marked by world demand for CPO is still high until now. This study examines the competitiveness of CPO in West Sumatera Province from 2000 to 2016 in Indonesian market (domestic) and the word market from 2000 to 2015 using RCA (Revelead Competitive Advantage) index analysis. The result of the research shows that the CPO of West Sumatera in Indonesian market (domestic) which shows the value of RCA index> 1 means that the export value of CPO of West Sumatera has competitiveness while the value of Index RCA CPO of West Sumatera in world market is got value of RCA index average equal to 1,2 which show value of RCA> 1 mean export of CPO in West Sumatera still have competitiveness above average world CPO, although if seen RCA index each year there is a value of RCA<1.

Keywords: competitiveness, CPO, RCA, West Sumatera.

1. Introduction

According to the World Economic Forum said that in 2015 Indonesia's competitiveness in ASEAN level 37 and are ranked in the bottom three neighboring countries, namely Singapore, which is ranked second, Malaysia ranked 18 and Thailand ranked at 32. However, Indonesia still outperformed the Philippines, who is ranked 47, ranked 56th in Vietnam, Laos ranked 83, ranked 90 out of Cambodia, and Myanmar in the ranking of 131. Indonesia must improve its competitiveness to be able to benefit from the Asean Economis Community. We know that the ASEAN countries on average producing and consuming agricultural products are almost identical, so that there will be competition between countries of the exporter to supply the importing countries the same one

For West Sumatera province which is still dominated by agriculture, forestry and fishery as field the main effort with contribution to GDP amounted to 23.10% of West Sumatra in 2016 and specialized for plantation sub-sector contributed a total of 6.57% (BPS, 2017). it can be said that the plantations in West Sumatra has the potential for a sizeable competitiveness and CPO*(*crude palm oil)is one of the final products of processing of fresh fruit bunches (FFB) of palm oil before being exported to the world market. Export of CPO has managed to donate foreign exchange amounted to 33.6% in 2015 with a value of CPO in 2016 amounted to US $ 17.8 billion, up 8 percent compared to the previous year's US $ 16.5 billion. The market outlook is still predicted prospective CPO future characterized by global demand for palm oil is still high enough, it can be used by Indonesia to increase its CPO production supported by the availability of oil palm land continues to increase each year, the availability of relatively cheap human resources and oil maintenance costs are still relatively low.

Several studies on the competitiveness of palm oil commodities have been done, such as Zulkifli (2000) which states that the Indonesian and Malaysian palm oil exports is inelastic and slow to respond to changes in prices that occurred *(time lag)* and only influenced by the level of CPO production. Purwanto (2002) states that global CPO prices showed a negative response to the increase in exports and positive impact on imports, further of influence the world price of crude palm oil to export prices, import and domestic prices of each of the main exporters and a major importer in general are also positive and inelastic, Primitive (2012), stated that Indonesia's CPO exports is inelastic to changes in Indonesia's CPO production in the short term but elastic in the long run. If the CPO production rise 10 percent, the export of CPO rise 7,01 per cent in the short term and 12,44 percent rise in the long term. Lowering the export tax Indonesian CPO exports. The rupiah exchange rate against the USD has positive influence on Indonesia's CPO exports. Asrini (2013) conducted a study to do research on the competitiveness of Indonesian crude palm oil commodities in 2001-2012 stated that Indonesia's CPO export competitiveness to the Japanese market and Autralia. Other research on the analysis of the competitiveness of Indonesian palm oil on the international market in 1999-2014 using RCA index states that Indonesian CPO has the greatest comparative advantage in the international market compared to Malaysia and Thailand (Turnip et.al, 2016).

According Rifin (2012) determinants of competitiveness of Indonesian CPO exports dam Malaysia is the ratio of the price, the export tax differences, refined palm oil export ratio and the ratio of the exchange rate effect on CPO. Research conducted by Sari (2015) RCA of CPO Indonesia to prove the main export destination country Indonesia has a comparative advantage. The purpose of this study was to analyze the CPO export competitiveness of West Sumatra in the domestic market and in international markets in 2000-2016 by using Index RCA (Revealed Comparative Advantage).

** Corresponding author ; phone : +62751 7055053; fax: +62751 41152*
email : lisa_nesti@yahoo.com

2. Method

The approach used in this study is a qualitative and quantitative approach to the data source in the form of primary and secondary data. The primary data obtained through interviews with the Indonesian Palm Oil Association (Apkasindo), secondary data obtained from relevant government agencies, such as West Sumatera Plantation Office, Department of Food and Horticulture resistance, Department of Industry, Trade and cooperative Prov , West Sumatra, BPS, Ministry of Industry and also through the review of the literature. This Research using RCA analysis. Sample in this study using time series data starting in 2000-2016 to study variables that comprise: CPO export value of West Sumatra (US $), the value of total exports of western Sumatra (US $), Indonesia's CPO export value (US $), value Indonesia's total exports (US $), the world's CPO export value (US $) and the total value of world exports (US $).

The analysis calculation used is the analysis of *Revealed Comparative Advantage* (RCA). RCA is used for measuring the export competitiveness of a region / country so it can know the comparative advantages of a commodity in a region / country. Competitiveness analysis itself has been formulated by Balassa (1965) in the RCA method.Index RCA calculated in the formulation:

$$RCA = \frac{X_{ij}/X_j}{X_{iw}/X_w} \quad (1)$$

where Xij indicates the value of exports of commodity i by country j, Xj indicates the value of total exports by country j, Xiw shows the value of total exports of commodity i world and XW show the value of exports the world's total. If the value of index RCA> 1 then export commodity is said to have a competitive edge over the competitiveness of the world average, while if the RCA index <1 then an export commodity is said to have a competitive edge competitiveness below the world average.

3. Results and Discussion

Competitiveness is the ability of companies, industries, regions, countries, or regions to generate revenue factors and factors of relatively high employment and sustainable to face international competition. Export competitiveness is a picture of the level of competitiveness of industrial exports in the world market by looking at the magnitude of the market share in the world. A country or region will have a competitive edge in the form of comparative advantage if the state or the region capable of producing and exporting goods or services at a cost which is relatively cheaper than the country or the region to import goods and services from other countries. West Sumatra province will have a competitive advantage if the comparison between the export value of *crude palm oil (CPO)* and the total export value in the region is greater than the domestic market and international market. To determine whether the province of West Sumatra has had a comparative advantage represented by RCA index. See Table 1.

Table 1. RCA Index of CPO In West Sumatera In The Domestic Market

Years	Value of West Sumatera CPO Export (USD)	Value of West Sumatera Export (USD)	Value Of Indoesia CPO Export (USD)	Value of Indonesia Export (000 USD)	RCA
2000	26.770.199	229.630.107	1.326.398.000	62.124.000	5,46
2001	26.026.130	208.180.000	1.227.165.000	56.320.900	5,74
2002	86.611.008	307.849.000	2.348.638.000	57.158.800	6,85
2003	130.213.755	377.277.000	2.719.304.000	61.058.200	7,75
2004	219.559.755	594.956.000	3.944.457.000	71.584.600	6,70
2005	278.074.610	731.189.000	4.344.303.000	85.660.000	7,50
2006	345.204.890	1.074.134.000	4.139.286.000	100.798.600	7,83
2007	622.691.326	1.512.799.000	8.866.445.000	114.100.900	5,30
2008	1.068.800.714	2384.568.000	14.110.229.000	137.020.400	4,35
2009	648.400.180	1.344.257.000	11.605.431.000	116.510.000	4,84
2010	1.024.675.222	2.214.774.000	15.413.639.000	157.779.100	4,74
2011	1.204.095.951	303.181.5000	19.753.190.000	203.496.600	4,09
2012	903.179.353	2.363.583.000	22.451.089.000	190.020.300	3,23
2013	654.718.937	2.209.012.000	17.667.471.000	182551800	3,06
2014	696.414.714	2.105.610.000	19.555.633.000	175980000	2,98
2015	678.810.248	1.748.010.000	17.360.395.000	150366300	3,36
2016	571.498.745	1.708.280.000	18.100.000.000	145186200	2,68
Total	9.185.745.737	24.145.923.107	184.933.073.000	2.067.716.700	
Mean	540.337.985	1.420.348.418	10.878.416.059	121.630.394	5

Competitive advantage is achieved when a company Region implement low cost strategy, which makes it able to offer a product that has the same quality with similar products but with a lower price than its competitors. From Table. 1 obtained index value RCA CPO West Sumatra in Indonesia market (domestic) every year from 2000 to 2016 were on average demonstrate the value of index RCA> 1 means that the value of exports of CPO West Sumatra province has high competitiveness in the domestic market, where the value of the highest RCA in 2006 with a value of 7.83 and the lowest in 2016 with a value of 2.68. So it can be said that the province of West Sumatra has a comparative advantage to compete in the domestic market.

Table 2. RCA Index of CPO In West Sumatera In The Word Market

Years	Value of West Sumatera CPO Export (USD)	Value of West Sumatera Export (USD)	Value of Word CPO Export (USD)	Value of word Export (000 USD)	RCA
2000	26.770.199	229.630.107	14.063.000	48.017.790	0,40
2001	26.026.130	208.180.000	16.793.000	47.355.807	0,35
2002	86.611.008	307.849.000	18.438.000	49.382.508	0,75
2003	130.213.755	377.277.000	19.910.000	59.401.306	1,03
2004	219.559.755	594.956.000	22.201.000	75.849.333	1,26
2005	278.074.610	731.189.000	24.545.000	87.090.000	1,35
2006	345.204.890	1.074.134.000	29.000.000	101.310.000	1,12
2007	622.691.326	1.512.799.000	30.048.000	120.230.000	1,65
2008	1.068.800.714	2384.568.000	37.143.000	131.600.000	1,59
2009	648.400.180	1.344.257.000	38.243.000	105.550.000	1,33
2010	1.024.675.222	2.214.774.000	38.854.000	123.010.000	1,46
2011	1.204.095.951	303.181.5000	39.024.000	143.380.000	1,46
2012	903.179.353	2.363.583.000	45.530.000	144.960.000	1,22
2013	654.718.937	2.209.012.000	43.269.000	149.480.000	1,02
2014	696.414.714	2.105.610.000	46.569.000	149.950.000	1,06
2015	678.810.248	1.748.010.000	47.616.000	134.820.000	1,10
Total	8.614.246.992	22.437.643.107	511.246.000	1.671.386.744	
Mean	538.390.437	1.402.352.694	31.952.875	104.461.672	1,13

Furthermore, if you want to know the CPO export competitiveness of West Sumatra province on the world market can be done by calculating the value of RCA index CPO West Sumatra province on the world market (see Table.2). The index value RCA annually during the 2000 to 2015 obtained by RCA varied, but on average RCA> 1 means that the export of CPO in the province of West Sumatra still have a competitive edge over the average CPO world, even if on the index RCA respectively each year there are worth RCA <1. In 2000-2002 resulted in RCA <1 means that in that year the export of CPO West Sumatra province have low competitiveness in the world's CPO export market, but in 2000 -2015 generate RCA> 1, it means that in that year the export of CPO Sumatra west began to show competitiveness in global CPO export market. So in general it can be said that the export of CPO West Sumatra province already has a comparative advantage in the export market CPO world, only to be enhanced competitiveness so that in the next few years the export of CPO In Sumatera West had index value of RCA that every year more than one.

The value of RCA CPO West Sumatra in the Indonesian market (domestic) and the world market show that export CPO West Sumatera average price competitive high enough each year, until now Indonesia respectively ranked first world as the largest producer of CPO and country CPO export the most widely abroad.

4. Conclusion

Power CPO export competitiveness in West Sumatra can be seen from the RCA index value is generated. CPO market of West Sumatra in Indonesia (domestic) every year from 2000 to 2016 shows the index value RCA> 1 means that the value of exports of CPO West Sumatra have competitiveness on the export competitiveness of the average Indonesian. While the value of RCA index CPO West Sumatra in world markets RCA index values obtained annually during the 2000 to 2015 average of 1.2 which indicates RCA> 1 means that the export of CPO in the province of West Sumatra still have a competitive edge above the mean the world CPO price, even if on the RCA index each year there are valuable RCA <1.

Although the results of the analysis of RCA of CPO in West Sumatra who stated that CPO exports in West Sumatra has a fairly high competitiveness in both the domestic market and in international markets, but utilization is still not optimal. Therefore, proposed several attempts to optimalize CPO production in the province of West Sumatra thus better able to compete with other provinces in Indonesia and also in the world

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Supply Chain System of Tea Industry in West Sumatera

Peni Shoffiyati[a]*, Irna Ekawati[b]

[a,b]*Politeknik ATI Padang, Jl Bungo Pasang Tabing, Padang, 25171, Indonesia*

Abstract

This study discusses one of the existing tea supply chain systems in West Sumatra especially involving PTPN VI Danau Kembar Solok. The study aims to look at the flow of the tea industry supply chain in West Sumatra, and the performance of the supply chain. This research uses SCOR method. The results showed that the actors of the tea industry supply chain in West Sumatra are farmers, cooperatives, PTPN VI Danau Kembar Solok, Joint Marketing Office (KPB), exporters and local consumers, and end consumers. There is a flow of material, information and money to each of the supply chain actors. Supply chain performance can be concluded through supply chain reliability performance attributes, supply chain responsiveness, supply chain agility, supply chain cost and supply chain asset management..

Keywords: tea industry ; supply chain ; SCOR method

1. Introduction

Tea supply in Indonesia is generally produced by (1) independent farmers, (2) large private plantations and (3) state plantations known as PT. Perkebunan Negara (PTPN). PTPN produces black tea which will be sold in Jakarta Tea Auction through auction process. The tea that sold during the auction will be exported or further processed by the downstream products industry such as fast tea beverage factory and so on. Furthermore, in Indonesia there are also many independent tea farmers who produce tea leaves with longer flow chains (through small collectors, large collectors) to be processed into more downstream products. In addition to PTPN and independent farmers, there is also a large private plantation where they own a green teaor black tea processing factory. PT. Perkebunan Nusantara VI Tea Garden Danau Kembar Unit is a company which is a State Owned Enterprise (BUMN) having its address at Jorong Street Kayu Jao Kenagarian Batang Barus, Gunung Talang Subdistrict, Solok Regency with an area of about 569.18 Ha. According to the organizational structure of the company, this company is one unit of production of PTPN VI based in Jambi. The company produces black tea with Orthodox system through the process of picking, forging, rolling, fermentation, drying, sorting to packing. The raw materials of tea processed in PTPN VI come from own plantation (core garden) and plasma plantation.

As partner of PTPN VI Danau Kembar Unit (hereinafter referred to as PTPN VI) plasma farmers sell tea leaves to PTPN VI at a price set by PTPN VI Center in this case PTPN Jambi. Tea produced by PTPN will be auctioned at Jakarta Tea Auction organized by PT. Kharisma Marketing Bersama (KBP) which is also a subsidiary of PTPN in Indonesia. In the tea product auction process, PTPN VI Danau Kembar Unit is represented by PTPN VI Jambi will follow the auction every Wednesday every week. Further information on the auction results (tea and purchase quantity) will be delivered to PTPN VI Danau Kembar where in this case the buyer will pick up the tea directly through the fleet organized by a third party. Meanwhile, the flow of tea purchase money will be delivered to PTPN VI Jambi so that in this case PTPN VI Danau Kembar Unit only manage the finance associated with production activities. As the actors in the tea flow supply chain described above, farmers, PTPN VI Danau Kembar and PTPN VI (Jambi) should be together so as to generate mutual benefits and produce a steady supply of good performance. Based on the above problems research aims to see the flow of tea supply chain in West Sumatra, and the performance of the supply chain.

2. Method

This research activity is centered on PTPN VI Danau Kembar Unit as one of the actor of supply chain besides also doing research on entity related to PTPN VI Danau Kembar Unitwhich is farmer and PTPN VI Jambi. The study was conducted from December 2016 to July 2017. Data collection was conducted using two methods namely secondary data collection method and primary data collection method. Description of the flow of the tea supply chain includes tea planting system, tea purchasing system to farmers, tea sales system and tea delivery system to consumers. The supply chain performance is measured using Supply Chain Operation Reference (SCOR) method. With SCOR method, the performance of a supply chain is measured from 5 (five) aspects or attributes, namely supply chain reliability, supply chain responsiveness, supply chain agility, supply chain cost, and supply chain asset management.

* Corresponding author phone : +62751 7055053; fax: +62751 41152
Email : peni_rey@yahoo.com

3. Results and Discussion

3.1. Flow Chain of Tea Supply in West Sumatra

Supply chain system at PT. Nusantara VI Danau Kembar Unit, it is necessary to know the mapping of the supply chain from upstream to downstream. The mapping of the supply chain starts from farmers to consumers. Figure 1 is a mapping of the tea supply chain of PT. Perkebunan Nusantara VI Danau Kembar Unit. The supply chain process is a process whereby the product is still raw (in the form of wet leaves), semi-finished products and finished products (in black tea) are obtained, packed and sold through various facilities connected by the chain along the flow of products and materials. It shows that the supply chain system is the coordination of the material flow, the flow of information and financial flows among the participating supply chain actors. The description of the material flow, the flow of information and financial flows in the supply chain system of the tea industry in West Sumatra are as follows:

1. Material flow

a. Farmers
   Farmers of plasma at PT. Perkebunan Nusantara VI Danau Kembar Unit supplies raw materials (fresh shoots), where the company needs farmers as their pickers. The picking done by the farmers is found in two places, namely in the core garden and plasma garden. In the process of picking the farmers go to the garden at 07.00 and come home at 16.30. The picking is performed twice, the morning picking for fresh shoots weighing at 11.00 and the second picking shoots for weighing at 15.30. Picking done by farmers can be with machines and scissors. The comparison of the speed between machines picking and scissors is 1 person to 25 people. Before the picking, farmers need to be given guidance how the picking procedures that meet the standards and quality that have been set. Then the tea that has been picked up by the farmer then sold through the cooperative.
b. Cooperative
   Tea that has been picked by the farmers is then collected to the cooperative.The cooperative conduct transactions with PT. Perkebunan Nusantara VI Danau Kembar Unit.
c. Factory
   Afterwards, from the cooperative then the tea leaves are transported to PT. Perkebunan Nusantara VI Danau Kembar Unit, then will be processed at the factory through the production process from the process of receiving shoots to the packaging and storage process before it is finally marketed. Processing of tea shoots can be up to two days, because the several processing station that must be passed, the fresh shoot receiving station, shrivelled station, drop station, rolling station, fermentation station, drying station, sorting station, quality analysis and last packing station.
d. Joint Marketing Office (KPB)
   The results of tea processing will be sold by auction system or also called the auction market system in KPB (Joint Marketing Office) in Jakarta. The auction process is done in order to give impact to the improvement of efficiency, orderly administration and transparency (transparency). management of natural resources. Usually, the process of auction of tea result of PTPN VI Danau Kembar Unit is held every Wednesday every week of local exporter / buyer. Tea marketing destinations are Germany, UK, Australia, United States, Middle East, Singapore, and countries of the former Soviet Union. Nowadays export capacity is 80-85 percent. For export products shipments is performed through Belawan and Tanjung Periuk Ports, while tea for local delivery is delivered via Teluk Bayur Port.
e. Consumer
   After the delivery of tea products both export and local to the consumer, then the consumer can use as they need.

2. Information Flow

One of the key factors to optimize supply chain is to create an easy and accurate flow of information among supply chain actors. With the achievement of coordination of supply chain between actors, each supply chain practitioner will not experience shortage of goods and will not have excess goods too much. The flow of information that occurs in the supply chain is described in Table 1.

Table 1. Flow of information available on the Tea Supply Chain

Supplier Chain	Information Flow
Farmers	• Need tea price information from cooperatives Provide information on the amount of tea supply to the cooperatives
Cooperative	• Need info of tea price from PT. Perkebunan Nusantara VI Unit Danau Kembar • Provide information on the amount of tea supply to PT. Perkebunan Nusantara VI Unit Danau Kembar
PT. Perkebunan Nusantara VI Danau Kembar Unit	• Provide tea price information to cooperatives • Requires information on the quantity of tea auction proceeds to be delivered to domestic and overseas consumers from the Jakarta Joint Marketing Office (KPB)

Joint Marketing Office (KPB) Jakarta	• Requires previous PO information Requires information on where to send tea
Local consumer (domestic tea packaging factory)	• Requires information on the amount of tea auction proceeds to be sent by the expedition Requires price information on auction results
Non-local consumers (Exporters)	• Requires the tea PO information to be sent abroad • Requires information on where to send tea

3. Financial Flows

In addition to material flow and information flow, the flow that occurs in the supply chain system is the flow of money. In Table 2 describes the flow of money that occurs in the supply chain system.

Table 2. Flow of Currency in Tea Supply Chain

Supplier Chain	Financial Flow
Farmers	Sales proceeds based on realization price of selling tea
Cooperative	The proceeds of the sale based on the realization price of tea from the Joint Marketing Office (KPB)
PT. Perkebunan Nusantara VI Danau Kembar Unit	Purchase costs based on the realization price of tea purchase
Joint Marketing Office (KPB) Jakarta	• Purchase costs based on the realization price of tea purchase • Sales proceeds based on realization price of packaged tea
Local consumer (domestic tea packaging factory)	• Purchase costs based on the realization price of tea purchase • Sales proceeds based on the exported realization price of tea exported

The purchase price of tea by the factory from the cooperative is determined by PTPN VI which is around Rp 1,805 to Rp 2,205 / Kg (average Rp 2.050 / kg). The price tends to be constant (unchanged) and is not directly affected in real time by the price of tea at auction. When the price of tea supply in CDE decreases, it is possible PT. Perkebunan Nusantara VI Danau Kembar Unit suffered losses due to auction proceeds below production costs. However, because PT. Nusantara Plantation VI Danau KembarUnit is a BUMN so losses have no effect on employee's salary, They just will not get a bonus if the company is losing money. The results of the auction winner, announced at the Joint Marketing Office (KPB) Jakarta which is adjusted to the desired demand for tea grade. KPB then issued a PO to PT. Perkebunan Nusantara VI Danau Kembar Unit to prepare tea delivery to the winner of the auction. Furthermore, the auction winner will send an expedition to transport tea which has been packaged by PT. Perkebunan Nusantara VI Business Unit Twin Lake.

3.2. PTPN VI Supply Chain Performance Analysis Using SCOR Attribute

Based on the system that has been described, it will be analyzed the performance of supply chain by using 5 (five) performance attributes that are supply chain reliability, supply chain responsiveness, supply chain agility, supply chain cost and supply chain asset management.

a. Supply chain reliability
   PTPN VI is considered good enough in marketing its products because the system occurs in the flow of tea is a push system (push system) where the resulting tea is offered in an auction system so that the number of requests that come will not be higher than the offered tea. A challenge faced today is how to improve the quality of tea so as not to lose competition in the market and higher appreciated at the time of auction.
b. Supply chain responsiveness for order fulfillment
   Tea sold at auction process will be delivered to the consumer through a third party. The third party will pick up tea to the factory. In this case PTPN VI is responsible for delivering the tea in accordance with the PO of the auction result
c. Supply chain agility and flexibility
   In running the business process PTPN VI considered enough to solve the problems of production such as the implementation of production processes on schedule, supply management, to problems with other parties involved. For example, PTPN VI always maintains an inventory of finished materials as a precautionary measure if the goods are returned by consumers due to certain conditions.
d. Supply chain cost
   The main cost that arises between farmers, PTPN VI Danau Kembarand consumers is the cost of purchase. PTPN VI issues the purchase cost of tea leaves to the farmers in accordance with the price set by PTPN VI. Meanwhile, PTPN VI is considered not able to optimize its profits considering the process of selling tea done by auction.

e. Supply chain asset management
The current asset management is done in organizational structure by PTPN Indonesia

4. Conclusion

Supply chain actors include farmers, cooperatives, tea processing plants, CDEs and end consumers. The supply chain flow of each actor consists of material flow, the flow of money and the flow of information. Based on the system that has been described, it has already conducted analysisof the performance of supply chain using 5 (five) performance attributes that are supply chain reliability, supply chain responsiveness, supply chain agility, supply chain cost and supply chain asset management. In general it can be concluded that the flow of tea supply chain in West Sumatra is considered sufficient for the five criteria of SCOR method.

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Installation of Turbine Ventilators and Lighting Systems to Improve Occupational Health and Safety in The *Randang Kacang* Industry, West Pasaman

Candrianto[a*], Silfayona[b]

[a,b]Departement of Agro Industry Logictic Management, Polytechnic ATI Padang

Abstract

Randang Kacang is an industry which is part of food processing industry. This industry is still a SME (Small Medium Enterprise).SME Randang Kacang is a growing industry, make by consumer order. Besides SME *Randang Kacang* is also able to provide manpower, as means to facilitate the production process. This utilized manpower to expedite the process of production. The production process is carried out in the room that have higher temperature. And the production room that has not had alighting system, workers can lead to carelessness causes accidents, so that workers are not comfortable in working. Therefore we need an increase in Occupational Health and Safety. So workers can work comfortably, healthy and safe during the production process. In this researched need to perform the installation of the turbine ventilator, aiming to stabilize room temperature in the production room, according to the Indonesian National Standard (SNI). Including to design of artificial lighting systems. Utilized TL bulbs (flourescent) in some point in the production process rooms to avoid the worker accidents. Installation of turbine ventilator performed at the top of the roof. At the top of the roof installed 2 turbine ventilator which has a diameter of 60 cm. Turbine ventilator can absorb 200% more air temperature. To reduce lack of lightening systems utilized 18 watt Philips Light bulbs (fluorescent) in 28 points according to SNI.

Keyword : Accident, Turbine Ventilator, SNI, Lighting Systems.

1. Introduction

SME *Randang Kacang* is a growing industry, make by consumer order. Besides SME *Randang Kacang* is also able to provide man power, as means to facilitate the production process. To improve production, workers must be able to operate and run production well. This is taking into account the quality standards of beans that have been determinate by SME *Randang Kacang*, and also must pay attention to safety and health, in order avoid work accidents.To facilitate and increase production well, workers must be able to operate and run production well. This taking into account the quality standard of beans set by SME *Randang Kacang*

Carelessness of workers often occurs during the production process. The high number of work accidents that occured on SME *Randang Kacang* thus making workers feel uncomfortable with the work they do. The handling of the accident problem should be done as soon as possible. Because potential dangerous work accident can cause losses. In addition to preventing, at least can reduce accidents. Therefore warranty is required in safety and health, safety and health is a thing that must be realized in work, so that workers feel comfortable, safety and healthy in work.

Notes that the current condition SME *Randang Kacang* in has high temperature that exceeds NAB in the production room and not for in door lighting system so it will lead to work accidents for workers. Workers feel uncomfortable in working with an accident that occurred.

Constraint by SME RandangKacang, view from the current conditions, such as :

1. Temperature in production space is high, exceeds the thresholds value. Temperature measurement using a room thermometer.
2. Production space and storage room is not found lighting, just depend on sunlight during the daytime.
3. To anticipate accidents that not of lighting systems, SME *Randang Kacang* conduct indoor lighting, measurements using LUX Meter.

Table 1. Work Accident Data at SME *Randang Kacang* in West Pasaman

No	Type of accident	Times/year
1.	Burns fingers	15
2.	Burns hand to elbow	1
3.	Sprained (hand)	24
4.	Sprained (legs)	5

Based on the above work accident data, the reasearcher is interested to conduct aims on SME *Randang Kacang* it in the title “Installation of Turbine Ventilators and Lighting Systems to Improve Occupational Health and Safety in *the Randang Kacang* Industry, West Pasaman”

* Corresponding author phone : +62751 7055053; fax: +62751 41152

Attention to the description above can be formulated problem in this research is the temperature in the production room at SME *Randang Kacang* is higher than the threshold value and Not of indoor lighting system at SME *Randang Kacang*.This research focuses on the hight temperature in the production room and not of in door lighting system, while in the storage warehouse if the door is opened then the heat in the storage space will be reduced and the lighting will be good.

According to the background and the formulation of the problem then As for the aims is conducting the installation of turbine ventilator to stabilize the temperature in the production room of SME *Randang Kacang* and designing a good lighting system on SME *Randang Kacang*.

2. Method

2.1. Type of Research

Type of survey research that aims to make comparison or evaluation and describes an ongoing of research certain period of time.

2.2. Site of Research

SME *Randang Kacang* in Kampung Melayu Nagari Talu, Talamau District, West Pasaman

2.3. Variable

Based on the problem identification then that included in the research variable is temperature of production room and lighting system in production room.

2.4. Data Source

Obtained from the collection of data in the form of measurement of temperature and lighting in the room.

2.4.1.Installation of Turbine Ventilators

Based on measurement made in the production room, this space can generate high heat, excess the threshold value based on applicable legislation and may cause workplace accidents for workers. To overcome the hazards caused by heat can use turbine ventilator. Turbine ventilator used does not use electricity, but by wind aid. Installation of turbine ventilator mounted on the slope of the roof or on the roof top position.

The temperature measurement is done by hanging the room temperature tool for 2 -5 minutes around the room to be measured, then the mercury or alcohol used as a thermometer filler will expand or shrink in accordance with the measures air heat, so the air temperature in the room can be read in a thermometer scale.

Turbine ventilator used in SME *Randang Kacang* made from aluminum material with the diameter 60 cm, volume 312 m^3, paired 2 turbine ventilator, turbine ventilator can absorb heat 70-90 m3 per hour so temperature in room and outside temperature is same.

Turbine ventilator capable of sucking hot air more than 200 %, so that workers more comfortable in work area and avoid accident caused by indoor heat

The formula determines the amount of ventilator required in the area SME *Randang Kacang* :

$$amount\ of\ turbine\ ventilator = \frac{volume\ of\ room}{suction\ capacity\ x\ time\ of\ circulation} \quad (1)$$

2.4.2. Lighting System Design

SME *Randang Kacang* requires a lighting system. If seen in the initial state, SME Randang Kacang does not have a lighting system yet. Lighting uses only sunlight. Therefore is necessary to measure the lighting using LUX meter. Lighting in the production room can cause an accident. This is due to the dark conditions of the factory, and makes us difficult for the workers to require bright lighting. The design of the lighting system is the installation TL fluorescent bulbs with a Philips brand spread evenly in the workspace or place of the production process.

Installation of a light bulb with length of 10 meters x width of 8 meter will produce maximum illumination. Watt amount used is 18 watt and place to some point. To determine the points of placement of light bulbs can be determined from the strong lighting, the area of the room and by knowing the total lumens of lights, light factors, utilization factors and the number of lights in one point. According to SNI 04-0225-2000, the maximum lighting power for office or industrial space is 15 watts/m2. it can be determined that the amount for 18 watt obtained at 6,3 watts/m2, is still within the limits specified by the Indonesian National Standard (SNI).

3. Results and Discussion

Based on the analysis of the result of the previous data processing can be analysed as follows :

3.1 Installation of Turbine Ventilator

Based on measurement made in the production room, this space can generate high heat, excess the threshold value based on applicable legislation and may cause workplace accidents for workers. To overcome the hazards caused by heat can use turbine ventilator. Turbine ventilator used does not use electricity, but by wind aid.

Turbine ventilator used in SME *Randang Kacang* made from aluminum material with the diameter 60 cm, volume 312 m^3, paired 2 turbine ventilator, turbine ventilator can absorb heat 70-90 m3 per hour so temperature in room and outside temperature is same. Turbine ventilator capable of sucking hot air more than 200 %, so that workers more comfortable in work area and avoid accident caused by indoor heat in ventilator.

With length : 13 m, width 8 m for turbine ventilator with diameter 60 cm then turbine suction capacity is a 30 m^3/minute and choose time circulation 10 minutes :

$$\textbf{\textit{amount of turbine ventilator}} = \frac{312\ m^3}{30\frac{m^3}{minute}\ x\ 10\ minute} = \mathbf{1.04}$$

So for each volume of SME *Randang Kacang* needed 1,04 turbine ventilator and made 2 turbine ventilator.

3.2 Lighting System Design

Lighting in the production room can cause an accident. This is due to the dark conditions of the factory, and makes us difficult for the workers to require bright lighting.The design of the lighting system is the installation TL fluorescent bulbs with a Phillips brand spread evenly in the workspace or place of the production process.

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According to SNI 04-0225-2000, the maximum lighting power for office or industrial space is 15 watts/m2. it can be determined that the amount for 18 watt obtained at 6,3 watts/m2, is still within the limits specified by the Indonesian National Standard (SNI).The area required by SME Randang Kacang is with length 10 meters dan width 8 meters ,so :

Area = length x width
Area = 10 meters x 8 meters
Area = 80 m^2.

To determine the bulbs mounting point can be determined by the formula :

$$N = \frac{E \times L \times W}{O \times LLF \times CU \times n} \quad (2)$$

Given :

E = 200
L = 10 meters
W = 8 meters
O = 1098 (for 18 watt)
Luminous Efficacy Lamp = 61,
LLF = 0,8
CU = 65 % and
n = 1

$$N = \frac{200 \times 10 \times 8}{1098 \times 0{,}8 \times 65\ \% \times 1} = 28 \text{ point light bulb}$$

So far the space of 10 meters x 8 meters required installation of lamps as much as 28 points with and power 18 watt by using fluorescent lamps in the form of vertical with the Phillips brand.

4. Conclusion

According to the result of the study of the installation of turbine ventilators and lighting systems to improve occupational health and safety in the SME *Randang Kacang*, West Pasaman can be concluded that :

1. Installation of turbine ventilator at SME *Randang Kacang* by installing 2 turbine ventilator on roof top, turbine ventilator made from aluminum material with diameter 60 cm and able to suck 200 % more hot air.
2. The design of lighting system at SME *Randang Kacang* is done by the installation of fluorescent light bulb with Phillips brand. Power 18 watt and mounted on 28 spots scattered indoors. With a maximum distance of 3 meters and installed in parallel. In order to achieve maximum illumination in accordance with SNI

From these conclusion, some things into suggestions or recommendation towards improvement on SME *Randang Kacang*. It's good SME *Randang Kacang* to propose a proposal, which makes a turbine ventilator with a diameter of 60 centimeters mounted on the roof position in order to reduce work accidents when the room temperature is high.

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Production Quality Analysis by using System Modelling (Case Study of Tea Production Process at PTPN VI Solok)

Zulhamidi[a*], Mila Meliana Putri[b]

[ab] *Agro Industrial Engineering Department, Polytechnic ATI Padang, Indonesia*

Abstract

Quality control is a key process in production activity that determines the outcome of it's product. One of the most important quality control activities is identifying the factors that cause rejected product. The system modeling states that production activities can be divided are input, processes and outputs that are interconnected with one another. This research was conducted at PTPN VI, a company that produces orthodox black tea. Production process starts from tea harvest, withered, leaves rolling, fermentation, drying, sorting, tester and packing. This research was conducted in the sorting process to analyze the cause of the low quality of tea leaves as measured by using water content parameters. The results show that the input of raw materials entering the sorting section is not in accordance to the company standards. Analysis of process quality using X and R control charts show that the process is uncontrolled. Thus causes the output of this stage is uncontrolled too

Keywords: tea, quality control, statistical process control, hypothesis testing;

1. Introduction

Quality or quality can be defined as a measure of how closely a good or service is conforming to specified standards. The specified standards can vary, depending on which party establishes them. So to get a good quality need to apply quality control starting from raw materials, production process, storage, material handling and distribution to consumers.

Quality control activities are technical and management activities to measure the characteristics of the quality of a good or service, then compare the measurement results with product specifications desired by the customer and take appropriate improvement measures if there is a discrepancy between actual and standard performance. Gasperz (2005) Quality control is a technique and operational activities used to meet the standard of quality expected. Based on the description above the quality control is a methodology of collecting and analyzing quality data, and determine and interpret measurement measurements that explain the process in an industrial system to improve product quality in order to meet customer needs and expectations.

PTPN VI is a company that produces black tea by orthodox that is processing of tea through all process start from receipt of wet leaf, down leaf, rolling, fermentation, drying, sorting and packing. Phase focusing on this research is the process of sorting is the process of separating / cleaning the powder of fiber (leather), stolok (leaf bone), and to get the size and color of tea particles are uniform in accordance with the standard of each type of quality desired consumer (Nazaruddin, 1993). The quality parameters to be analyzed in the production process are the moisture content, due to the mismatch of the moisture content in this process to the standards set by the firm

Problem solving by using a system approach is to look at the problem based on the components that make up it as well as the interactions between the components. In general the system is composed of 3 main components namely input, process and output. In this research, the sorting process is viewed as a smaller system that has input from the previous process and the output will be forwarded in the next stage

2. Method

Sorting process is the process of separating powder from fiber (leather), stolok (leaf bone), and to get the size and color of uniform tea particles. Process sorting with the system approach can be described as the Figure 1.

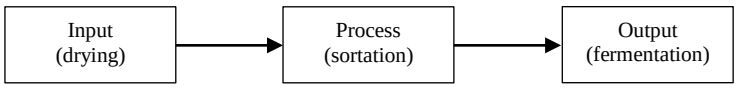

Fig 1. The System of Sortation Process

The process of quality control with system approach is to define work station sorting into 3 parts of the system namely:

* Corresponding author. Tel.: +6285263047084
*E-mail address:*zulhamidi@gmail.com

1. Input

The input of the sorting process is the output of the previous process, ie the drying process. The drying process is the process of reducing the moisture content from the initial conditions to the standard set by the company. The process of quality control at this stage is to prove whether the water content that has been completed from the drying process is in accordance with company standards.

Testing is done by using hypothesis test to prove that water content is in accordance with company standard. Statistically can be written as follows:

Ho : $\mu = \mu_0$

Hı : $\mu > \mu_0$ and Hı : $\mu < \mu_0$

Ho is null hypotheses while Hı is the alternative hypotheses .

$$z_{\text{observe}} = \frac{\bar{x}-\mu}{\sigma/\sqrt{n}} \quad (1)$$

Where : z = z observe
$\bar{x}$ = mean
μ_0 = parameter
σ = standard deviation
n = total amount of sample

2. Process

To determine that the sorting process is controlled X control chart and R control chart used to ensure the process are controlled statistically .

a. $\bar{x}$ chart

1. Determine $\bar{\bar{X}}$.

$$\bar{\bar{x}} = \frac{\sum_{i=1}^{g} \bar{x}i}{g} \quad (2)$$

Where: $\bar{\bar{X}}$ = average of sub-group averages
X_i = average of sub-group i
g = number of subgroups

2. Determine the control limit for x chart

Upper Control Limit (UCL) = $\bar{\bar{X}} + A_2\bar{R}$

Lower Control Limit (LCL) = $\bar{\bar{X}} - A_2\bar{R}$

Where: A_2 = coofecient value
R = gap of Xmaks dan Xmin

3. Plotting the x chart.

b. *R-chart*

1. Determine the average of range

$$\bar{R} = \frac{\sum_{i=1}^{g} Ri}{g} \quad (3)$$

Where: $\bar{R}$ = average of subgroup's range
R_i = subgroup' range i
g = number of subgroup

2.Determine the control limit for R chart

Upper Control Limit (UCL) = $D_4.\bar{R}$

Lower Control Limit (LCL) = $D_3.\bar{R}$

Wherw D_4 and D_3 is the coofecient value

3.Plotting the R chart

3. Output

Similar to input, the quality control process at the output is to ensure that the water content of the sorting process is in accordance with the standards set by the company. The method that will be used is to use hypothesis test of water content. More fully developed model can be seen in figure 2.

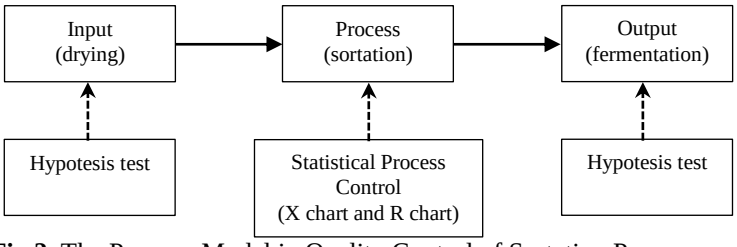

Fig 2. The Propose Model in Quality Control of Sortation Process

3. Results and Discussion

The data needed is data of water content conducted by observation directly at orthodox black tea production for 23 days starting from 8th February until 5th March 2017. From the data collected the standard deviation value obtained as follows;

Standard deviation $\sigma = \sqrt{\frac{\sum(xi-x)^2}{N-1}}$

$= \sqrt{\frac{11.55}{115-1}}$

= 0.32

a. Hypothesis test for input
   For α = 0.05
   H_0 : μ = 2.5%
   H_1 : μ > 2.5% and H_1 : μ < 3.0%
   so, $z_{(\propto/2)} = z_{(0.05/2)}$
   = 0.025
   From the table, z_{table} = 1.96

   To find the value of z observe, calculate the z observe for company standard in 2.5% - 3.0%
   1. z observe for the water content standard in 2.5%
      $z_{observe} = \frac{\bar{x}-\mu}{\sigma/\sqrt{n}}$
      $= \frac{2.52-2.5}{0.32/\sqrt{115}}$
      $= 0.69$
      Because of $z_{observe} < z_{table}$ (0,69 < 1,96) so, H_0 accepted

   2. z observe for the water content standard in 3.0%
      $z_{observe} = \frac{\bar{x}-\mu}{\sigma/\sqrt{n}}$
      $= \frac{2.52-3.0}{0.32/\sqrt{115}}$
      $= -16.55$
      Because of $z_{observe} < z_{table}$ (−16.55 < - 1.96) so, H_0 rejected

Based on the calculation obtained above can be concluded that the average of water content of the sample compared to the company standard in 2.5% - 3.0% the average water content of black tea from the drying stations not in accordance.

b. Quality control at the process using Statistical Process Control (SPC)
   1. X control chart
   To create x control chart, the steps are
   - Calculate the $\bar{\bar{X}}$
     $\bar{\bar{x}} = \frac{\sum_{i=1}^{g} \bar{x}i}{g}$
     $= \frac{80.8}{23}$
     = 3.5
   - Calculate the control limit for X chart

     Upper Control Limit (UCL) = $\bar{\bar{X}} + A_2\bar{R}$
     = 3.5 + 0.419 x 1.2
     = 4.00
     Lower Control Limit (LCL) = $\bar{\bar{X}}$ - $A_2\bar{R}$
     = 3.5 – 0.419 x 1.2
     = 3.03
   - Plotting the X chart graph (as seen in Figure 3)

   2. R control chart
   To create R control chart, the steps are
   - Calculate the average of range

$$\bar{R} = \frac{\sum_{i=1}^{g} \text{Ri}}{\text{g}}$$
$$= \frac{26.5}{23}$$
$$= 1.2$$

- Calculate the control limit for R chart
  Upper Control Limit (UCL) $= D_4 . \bar{R}$
  $= 1.924 \times 1.2$
  $= 2.22$
  Lower Control Limit (LCL) $= D_3 . \bar{R}$
  $= 0.076 \times 1.2$
  $= 0.09$
- Plotting the R chart graph (as seen in Figure 3)

From the calculation of X and R chart can be illustrated control chart of X and R as seen at Figure 3:

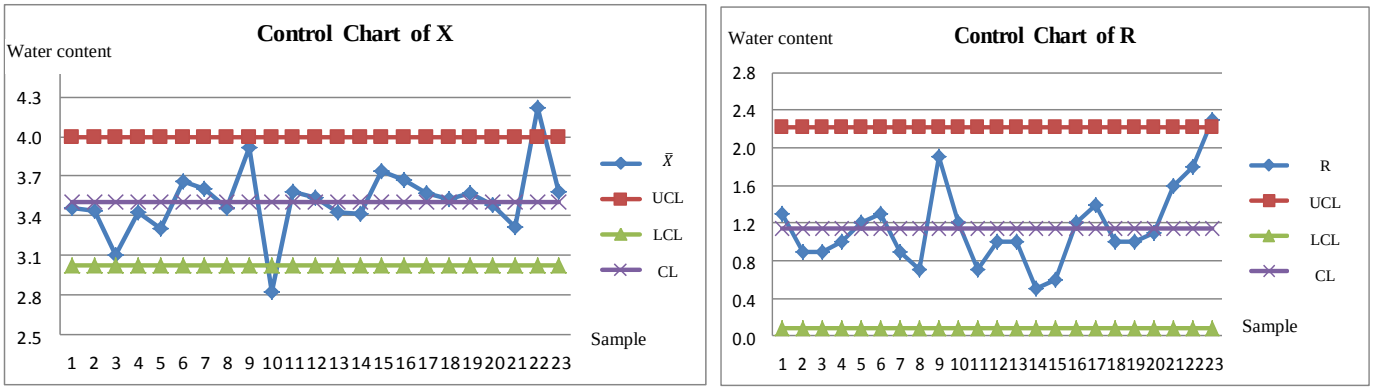

Fig 3. Control Chart of X and R

Note : The value of A_2 = 0.419, D_3= 0.076 dan D_4 = 1.924 for sub group sizes are 7 obtained from A and D table that indicate the factor of control charts.

As shown at Figure 3, the control chart of X shows 2 points of X (the average of water content sample) pass the control limit (out of control) at point 10 and 22 that indicated the sorting process is not statistically controlled. While, the control chart of R shows that there is 1 range that passes the control limit (out of control) point 23, this indicates that the control chart R also not controlled statistically. Thus, it can be concluded that from X and R control charts on the sorting process are not controlled statistically.

c. Hypothesis test for output
For $\alpha = 0.05$
$H_0 : \mu = 3.0\%$
$H_1 : \mu > 3.0\%$ and $H_1 : \mu < 4.0\%$
so, $z_{(\propto/2)} = z_{(0.05/2)}$
$= 0.025$
From the table, $z_{table} = 1.96$

To find the value of z observe, calculate the z observe for company standard in 3.0% - 4.0%

1. z observe for the water content standard in 3.0%
$$z_{observe} = \frac{\bar{x} - \mu}{\sigma / \sqrt{n}}$$
$$= \frac{3.51 - 3.0}{0.32/\sqrt{161}}$$
$$= 15.45$$
Because of $z_{observe} > z_{teble}$ $(15.45 < 1.96)$ so, H_0 rejected

2. z observe for the water content standard in 4.0%
$$z_{observe} = \frac{\bar{x} - \mu}{\sigma / \sqrt{n}}$$
$$= \frac{3.51 - 4}{0{,}42/\sqrt{161}}$$
$$= -14.48$$
Because of $z_{observe} < z_{table}$ $(-14.48 <$ - 1,96) so, H_0 rejected

Based on the calculation obtained above can be concluded that the average of water content of the sample compared to the company standard in 3.0% - 4.0% the average water content of black tea from the sorting stations not in accordance.

4. Conclusion

Based on calculation of input at drying process using test of hypothesis of average of water content finding the H_0 denied meanwhile of water content of black tea at drying station not in accordance with standard specified by company. While the process on the sorting station using the control chart found that the X and R chart are not controlled because there are measurement data that are out of control and the resulting output using the calculation of the test hypothesis z finding the H_0 rejected means the average rate black tea water content at a sorting station does not conform to the standards set by the company.

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Efficiency Analysis of Sterilizer Machine Using Overall Equipment Effectiveness (OEE) Method at PT. Gersindo Minang Plantation, Pasaman Barat

Maryam[a*], Selvi Novia Wahyuni[a], Yunizurwan[a]

[a]*Politeknik ATI Padang, Jl Bungo Pasang Tabing, Padang, 25171, Indonesia*

Abstract

PT. Gersindo Minang Plantation is a company in the field of processing of palm oil to Crude Palm Oil (CPO). The boiling section uses three sterilizer machines. Machine number three has many disruptions during operation so that causing decreased level of productivity. Therefore, special attention should be paid to the maintenance of the sterilizer machine so that the production process is effective and efficient. Total Productive Maintenance (TPM) is a management principle to improve productivity and production efficiency by using machinery effectively. The first step in improving production efficiency is by measuring the effectiveness of the sterilizer machine. The purpose of this study is knowing the value of Overall Equipment Effectiveness (OEE) on sterilizer machine number 3 and knowing the factors causing it. The value of OEE in the period of January - December 2016 was 57.08%. The value is low and has not reached the standards required by Japan Institute of Plant Maintenance (JIPM) is more than 85%. Factors that affect the low value of OEE are speed loss factors which include idling, minor stoppages and reduced speed. Companies need to conduct training to operators and technicians in order to improve the ability to overcome the problems on the sterilizer machine so that companies can apply autonomous maintenance.

Keywords: OEE, Sterilizer, Efficiency

1. Introduction

The company requires a system that can prevent the machine from damage and if the machine has been damaged can be immediately known cause of damage. Total Productive Maintenance (TPM) can be a solution for companies to optimize machine work and maximize machine maintenance in order to minimize maintenance cost. Total Productive Maintenance (TPM) is a machine maintenance system that involves all factory operators. The operator is not only in charge of running the machine, but also in charge of maintaining the machine before and after its use.

Maintenance is an activity to maintain or maintain plant facilities and equipment by making necessary repairs or adjustments and replacements in order to have a satisfactory operational condition of production in accordance with what is planned. Maintenance plays an important role in the production activities of a company concerning the smoothness or congestion of production, so that the product can be produced and received by consumers in time without delay and keep no work resources idle due to damage to the machine during the production process so that can minimize the cost of losing production or if it is possible the cost can be eliminated [1].

Engine efficiency is a measure of the engine's ability to perform an operation or inspection process. The greater the value of efficiency, meaning more processes can be done by the machine in question. And Efficiency is a measure that shows how resources should be used in the production process to produce output and is also a characteristic process of measuring the actual performance of a resource relative to a defined standard [2].

The principle of efficiency is to avoid all forms of waste. Engine efficiency is the ratio between actual exit and effective capacity. Effective capacity is the maximum output that a machine can produce in real conditions which, among other things, are affected by production scheduling, engine maintenance, defects, and lack of raw materials [3].

The low productivity of machines / equipment that cause losses to the company is often caused by the use of ineffective and efficient machinery / equipment there are six factors called six big losses. In today's era of free competition, the measurement of a production system that only refers to the quantity of output alone can be misleading as it does not take into account the main characteristics of the process: capacity, efficiency and effectiveness. Using the machine / equipment efficiently means to maximize the function of the performance of machine / equipment of production with appropriate and efficient. To increase the productivity of the machine / equipment used it is necessary to analyze the productivity and efficiency of machinery / equipment in six big losses. The six big losses are as follows [4] :

a. Loss due to equipment damage (Equipment / Breakdown).
b. Disadvantages due to installation and adjustment (Set-up and adjustment)
c. Losses due to operate without expense or stop for a moment (Idling and Minor stoppages)
d. Loss due to reduced speed (Reduced speed).
e. Loss due to defective products or due to the work of processed products (Process defect).
f. Losses at the beginning of production time to reach a stable production time (Reduced yieled losses).

* Corresponding author phone : +62751 7055053; fax: +62751 41152
Email : Maryam.atip@gmail.com

Overall equipment effectiveness (OEE) is a product of six big losses in machinery and equipment. The six factors in the six big losses can be grouped into three main components in OEE to be used in machine / equipment performance measurement: donwtime losses, speed losses and defect losses. For more details OEE calculations can be seen in Figure 1 [5].

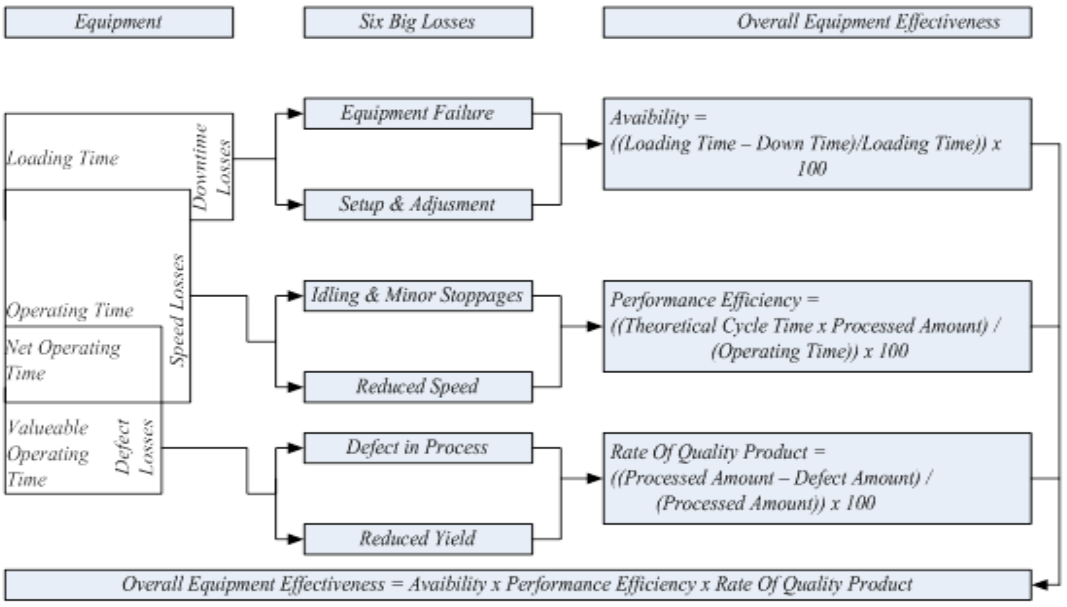

Fig. 1 Chart of OEE Calculation

The standards set in the JIPM (Japan Institute of Plant Maintenance for Performance Ratio) OEE ideal conditions are as follows [5] :

a. Availibity > 90 %
b. Performance Efficiency > 95 %
c. Quality Product > 99 %

So the ideal OEE is: 0.90 x 0.95 x 0.99 = 85%. For the benchmark standard world class recommended JIPM is OEE = 85%. The Japan Institute of Plant Maintenance (JIPM) has set the standard benchmarks that have been widely practiced worldwide:

a. OEE = 100%, production is considered perfect: only produce products without defects, work in fast performance, and no downtime.
b. OEE = 85%, production is considered world class. For many companies, this score is a suitable score to be a long-term goal.
c. OEE = 60%, production is considered fair, but shows there is great room for improvement.
d. OEE = 40%, production is considered to have a low score, but in most cases can be easily improved through direct measurement (e.g by tracking downtime reasons and handling the sources of downtime one by one).

PT. Gersindo Minang Plantation (GMP) is a branch of one of the largest group of CPO companies in Asia, namely Wilmar Group. In order to maintain the quality and superiority of its products PT. Gersindo Minang Plantation must perform maintenance and more monitoring on the smoothness of its production process. One more care that must be done in PT. GMP is the treatment of sterilizer machine number 3. PT. Gersindo Minang Plantation has three sterilizer machines that operate in sterilizer but the number three machine is often damaged because of older age when compared with other Sterilizer engines. This sterilizer machine is one machine that has a major influence in the CPO production process, in case of problems in this machine then the processing at the next station will be disrupted and even can stop operating.

Machine maintenance can be done through job loss analysis by Overall Equipment Effectiveness (OEE) method. The OEE method is performed on the sterilizer machine to determine the efficiency level of the machine. Method Overall Equipment Effectiveness is an open way in terms of providing information to deal with problems of a work system. Overall Equipment Effectiveness (OEE) helps maximize the company's assets on availability in generating performance with the best quality product.The objectives of the research are:

1. Obtain an OEE value from the number three Sterilizer machine at PT. GMP in order to know the level of machine efficiency.
2. Knowing the cause factors that affect the value of Overall Equipment Effectiveness (OEE) on Sterilizer machine number 3.

2. Method

This research was conducted at boiling station at PT. Gersindo Minang Plantation located in Tanjung Pangkal, Kenagarian Simpang Empat Pasaman Barat, West Sumatera. Data was collected :

a. Downtime
b. Planned downtime for the sterilizer machine
c. Data for setup
d. Time sterilizer production data
e. Number of Output
f. Rejected Products

Data processing is done by using the Overall Equipment Effectiveness method steps are carried out as follows [4]:

a. Availability

$$\text{Availability} = \frac{\text{OperasionTime}}{\text{LoadingTime}} \times 100\% \quad (1)$$

Operation Time = Loading Time – Downtime (2)
Loading Time = Total Available Time – Planed Downtime (3)

b. Peformance efficiency

$$\text{Performance effieciency} = \frac{\text{Processed amount} \times \text{Actual cycle time}}{\text{Operating time}} \quad (4)$$

c. Rate of Quality Product

$$\text{Rate of Quality Product} = \frac{\text{Processed Amount} \times \text{Defect Amount}}{\text{Processed Amount}} \times 100\% \quad (5)$$

d. *Overall Equipment Effectiveness* (OEE)
OEE (%) = Availability (%) x Performance (%)x Quality Rate (%) x 100% (6)

e. Analysis of Factors Affecting the Value of OEE

3. Results and Discussion

Downtime is the time that should be used to make the production process but due to the damage or disturbance in the machine cause the machine can not carry out the production process as it should. Downtime is an activity that can be seen clearly, because the damage / engine stopped suddenly and resulted in the absence of output produced by the machine does not produce. Data of downtime, planned downtime and setup can be seen in Table 1.

Table 1. Data of downtime, planned downtime and setup

Month	*Downtime (hours)*	*Planned Downtime* (hours)	*Setup* (hours)
January	7,34	20	5,25
February	6,24	16	5,55
March	7,15	16	6,04
April	6,23	16	5,45
May	12,54	20	6,35
June	7,21	16	5,25
July	8,27	20	6,05
Augustus	2,25	16	5,02
September	6,00	16	6,05
October	3,34	20	5,03
November	3,37	16	6,45
December	5,50	16	7,05

Source : PT. Gersindo Minang Plantation, 2016

Data downtime is not stable, because the amount of breakdown time and steam instability in sterilizer machine number 3 is not the same in every month, but depends on the type of damage that is in the sterilizer machine itself. The highest downtime was in May, due to the unavailability of the spare parts required in the event of damage, requiring the workshop to purchase the required spare parts to the place that provides them outside the factory environment causing the cessation of sufficient production process activities long.

Planned downtime is the time already scheduled in the production plan. Scheduled maintenance is done by the company to keep the machine is not damaged during the production process last. Maintenance is done regularly and on schedule

made by maintenace department. Setup time is the production time to produce the first good product until the last well finished product is executed. The time required to carry out engine setup starts from the engine stop time until the process for subsequent production activities.

Production data of Sterilizer machine at boiling fresh fruit bunch at PT. Gersindo Minang Plantation (GMP) in the period January - December 2016 can be seen in Table 2.

Table 2. Production data of Sterilizer machine (January – December 2016)

Month	Total Available Time (hours)	Total Product Procesed (Ton)	Total Reject Product (Ton)	Total Good Product (Ton)
January	744	7.128,23	0,00	7.128,23
February	696	7.282,44	0,00	7.282,44
March	744	7.654,14	0,00	7.654,14
April	720	8.416,20	0,00	8.416,20
May	744	8.437,30	0,00	8.437,30
June	720	6.910,34	0,00	6.910,34
July	744	9.388,53	0,00	9.388,53
Augustus	744	8.691,20	0,00	8.691,20
September	720	7.376,43	0,00	7.376,43
October	744	7.815,33	0,00	7.815,33
November	720	9.487,77	0,00	9.487,77
December	744	9.349,65	0,00	9.349,65

Source : PT. Gersindo Minang Plantation, 2016

A. Avaibility

Loading time is the time available per day or per month minus the planned engine downtime. Data downtime can be seen in Table 3.

Table 3. Loading Time of Sterilizier (January-December 2016)

Month	Total Available Time (hours)	Planned Down Time (hours)	Loading Time (hours)
January	744	20	724
February	696	16	680
March	744	16	728
April	720	16	704
May	744	20	724
June	720	16	704
July	744	20	724
Augustus	744	16	728
September	720	16	704
October	744	20	724
November	720	16	704
December	744	16	728

Downtime is the time that should be used to perform the production process, but because of a disturbance in the machine (equipment failures) then resulted in the machine can not carry out the production process as appropriate. Data downtime can be seen in Table 4. Operation Time is the total effective processing time. In this case the operation time is the result of the reduction of Loading time with Downtime machine. The value of Operation Time can be seen in Table 5. The availability value can be seen in Table 6.

Table 4. Downtime of Sterilizier (January-December 2016)

Month	Break Down time (hours)	Setup (hous)	Downtime (hours)
January	7,34	5,25	12,59
February	6,24	5,55	11,79
March	7,15	6,04	13,19
April	6,23	5,45	11,68
May	12,54	6,35	18,89
June	7,21	5,25	12,46
July	8,27	6,05	14,32
Augustus	2,25	5,02	7,27
September	6,00	6,05	12,05
October	3,34	5,03	8,37
November	3,37	6,45	9,82
December	5,50	7,05	12,55

Table 5. Operation time of Sterilizier (January-December 2016)

Month	*Loading time* (hours)	*Downtime* (hours)	*Operation time* (hours)
January	724	12,59	711,41
February	680	11,79	668,21
March	728	13,19	714,81
April	704	11,68	692,32
May	724	18,89	705,11
June	704	12,46	691,54
July	724	14,32	709,68
Augustus	728	7,27	720,73
September	704	12,05	691,95
October	724	8,37	715,63
November	704	9,82	694,18
December	728	12,55	715,45

Table 6. Availability of Sterilizier (January-December 2016)

Month	*Operation time (hours)*	*Loading Time* (hours)	*Availability* (%)
January	711,41	724	98,26 %
February	668,21	680	98,27 %
March	714,81	728	98,19 %
April	692,32	704	98,34 %
May	705,11	724	97,39 %
June	691,54	704	98,23 %
July	709,68	724	98,02 %
Augustus	720,73	728	99,00 %
September	691,95	704	98,29 %
October	715,63	724	98,84 %
November	694,18	704	98,61 %
December	715,45	728	98,28 %

Value Availability indicates the extent to which the sterilizer machine can function properly [6]. It can be concluded that the Availability level for the Sterilizier machine from January to December 2016 is ideal, since the Availability value on the Sterilizer machine is over 90% (Japan Institute of Maintenance for Performance Ratio). This proves that the sterilizer machine can still function properly.

B. Performance Efficiency

Performance efficiency is the number of products generated multiplied by the ideal cycle time to the time available to perform the production process. The performance efficiency value can be seen in Table 7. Ideal cycle time is the cycle of process time that is expected to be achieved in the optimal state or not experiencing barriers. Ideal cycle time on a Sterilizier machine is a processing time cycle that a machine can achieve in a production process in its optimal state or this machine has no barriers in production. The optimal time sterilizier machine in producing the product is 8 hours. With the provision in a single process for 1.5 hours sterilizier engine can produce semi-finished CPO products. Ideal cycle time machine sterilizier = 1.5 hours/30 ton = 0.05 hours/ton.

Table 7. Performance Efficiency of Sterilizer machine (January – December 2016)

Month	*Total Product Procesed* (Ton)	*Ideal Cycle Time* (Ton/hours)	*Operation time* (hours)	*Performance Effiecicency* (%)
January	7.128,23	0,05	711,41	50,10 %
February	7.282,44	0,05	668,21	54,49 %
March	7.654,14	0,05	714,81	53,54 %
April	8.416,20	0,05	692,32	60,78 %
May	8.437,30	0,05	705,11	59,83 %
June	6.910,34	0,05	691,54	49,96 %
July	9.388,53	0,05	709,68	66,15 %
Augustus	8.691,20	0,05	720,73	60,29 %
September	7.376,43	0,05	691,95	53,30 %
October	7.815,33	0,05	715,63	54,60 %
November	9.487,77	0,05	694,18	68,34 %
December	9.349,65	0,05	715,45	65,34 %

Performance Efficiency is the ratio of actual production to expected levels [6]. Based on the table above Performance efficiency calculation results can be concluded that the level of Performance efficiency for Sterilizier machine number three

in the period January 2016 - December 2016 is not ideal, because the value of Performance Efficiency on Sterilizier machines are all below 95% (Japan Institute of Plant Maintanance For Performance Ratio) Performance Efficiency value of sterilizer machine obtained is between 50.10% to 68.34%, this means the actual production rate of sterilizer machine is not as expected.

The low value of Performance Efficiency on Sterilizier engine is caused by two main causal factors based on six big losses analysis ie idling and minor stoppage losses and reduced speed loss, downtime on the machine Sterilizer number three high that affect the value of the operation time and consequently the final value of the low Performance Efficiency is below 95% (Japan Institute of Plant Maintenance for Performance Ratio). This is what affects the low value of OEE on sterilizer machine number 3.

C. Rate of Quality Product

Rate of Quality Product is a good product ratio with product quality specifications that have been determined against the number of products processed. Value of quality product can be seen in Table 8.

Table 8. Rate of Quality Product (January-December 2016)

Month	Total *Product Procesed* (Ton)	Total *Reject Product* (Ton)	*Rate Of Quality Product* (%)
January	7.128,23	0,00	100,00
February	7.282,44	0,00	100,00
March	7.654,14	0,00	100,00
April	8.416,20	0,00	100,00
May	8.437,30	0,00	100,00
June	6.910,34	0,00	100,00
July	9.388,53	0,00	100,00
Augustus	8.691,20	0,00	100,00
September	7.376,43	0,00	100,00
October	7.815,33	0,00	100,00
November	9.487,77	0,00	100,00
December	9.349,65	0,00	100,00

Based on the Rate of Quality Product table can be concluded that the Rate of Quality Product for Sterilizier machine in the period January 2016 - December of 2016 is very ideal. This is because the value of the Rate of Quality Product on Sterilizier machines are all above the 99% average (Japan Institute of Plant Maintenance for Performance Ratio). Percentage Rate of Quality Product is perfect that is 100%, this is because the number of defects for CPO products in PT. GMP can not be detected due to lack of quality checking tools.

D. Overall Equipment Effectiveness (OEE)

The Overall Equipment Effectiveness (OEE) values can be seen in Table 9. During the period of January to December 2016, the value of Overall Equipment Effectiveness (OEE) ranged from 49.08% to 67.38% with an average of 57.08%, so it can be said that the effectiveness and efficiency of the machine has not met the global standard where the value of OEE ≥85% (Japan Institute of Plant Maintenance for Performance Ratio). Therefore it is necessary to make some improvements for the effectiveness of the Sterilizer machine is getting better.

Table 9. Overal Equipment Effectiveness (OEE) values (January – December 2016)

Month	*Availability* (%)	*Performance Effieciency* (%)	*Rate of Quality Product* (%)	OEE (%)
January	98,26	50,10	100,00	49,23
February	98,27	54,49	100,00	53,55
March	98,19	53,54	100,00	52,57
April	98,34	60,78	100,00	59,77
May	97,39	59,83	100,00	58,27
June	98,23	49,96	100,00	49,08
July	98,02	66,15	100,00	64,84
Augustus	99,00	60,29	100,00	59,69
September	98,29	53,30	100,00	52,39
October	98,84	54,60	100,00	53,97
November	98,61	68,34	100,00	67,38
December	98,28	65,34	100,00	64,21

The low value of OEE on Sterilizer number three engine is caused by low performance eficiency value. This is influenced by the loss of production speed. That is the loss caused by idling and minor stoppages and loss due to reduced

speed. This is because the machine often occurs sudden damage at the time of production process resulting in high downtime value resulting in low operation time value so that affect the low value Performace Effieciency.

Another factor that affects idling and minor stoppages is that the lorries can not run into the Sterilizer engine without the loader help that will push it, while the loader is still in the sorting station to push the fresh fruit bunches into the loading ramp. PT. Gersindo Minang Plantation has only one unit loader so it requires that the Sterilizer machine pause for a moment. Therefore the sterilizer machine will wait until the loader arrives and push the lorry into the sterilizer machine.

In addition to the two factors above the steam that goes into the Sterilizer also greatly affects the speed losses because the steam pressure is not sufficient to boil, requiring the operator to close the inlet valve. This causes the engine to stop operating until the steam state is restored. This problem often occurs when the boiling process takes place, requiring the operator to close the steam entrance valve and wait until the steam is recovered to continue the boiling process. Furthermore, the factors that affect the speed losses are losses due to decreased speed (Reduced Speed), this is a loss that occurs due to decreased engine speed, so that the machine can not operate with the maximum. One of the factors that cause the engine to experience a decrease in speed is the age and wear and tear of a machine

4. Conclusion

The average value of OEE Sterilizer machine number 3 is 57.08%. It is at a low level and has not reached the standard set by JIPM (> 85%) so the machine can not yet be said to work effectively and efficiently.A brief summary should be given for the principal conclusions of the work. The factors that affect the value of OEE on the number three sterilizer machine are the speed loss factors (Idle and minor stoppages) and Reduced Speed.

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Models of Centralized Inventory for Single-Vendor and Single-Buyer System with Controllable Leadtime and Batch of Production

Yevita Nursanti*

[a]*Politeknik APP Jakarta, Jl Timbul No 34 Jakarta Selatan 12630, Indonesia*

Abstract

This research will be developed a model of centralization between vendor-buyer with probabilistic demand ,lot quantities, leadtime, frequency of delivery and batch of production as one of the decision variables. The objectives of this research were total cost minimization on vendor and buyer. The mathematical model was developed by attempting various inputs on the model and comparing the results for each variation of the model inputs to obtain mutually beneficial policies on vendors and buyer. Lead time can be reduced by adding crashing costs (extra costs incurred to shorten lead time), so lead time can be controlled. Benefits from reduced lead times are low safety stocks, reduced stock outs, improved service levels to consumers, and provide competitive advantage, as evidenced by Just-In-Time (JIT) production. At the end, the authors evaluate the advantages of the coordination strategy offered by numerical examples.This paper describes one types of models with controlled lead times, a model with centralized decision model. The solution to be given is the optimal solution.

Keywords:centralized inventory, controllable leadtime, backorder,batch of production

1. Introduction

This paper describes the centralized model with controlled lead times and batch production. The solution to be given is the optimal solution. In most literature on the amount of economical ordering (EOQ), lead time is seen as a constant or stochastic variable that uses a deterministic or probabilistic model. But in a model that becomes very unrealistic is often lead time assumed as an uncontrolled variable. According to Tersine, lead time consists of components:

- Order preparation time
- Ordering time
- Leadtime from vendor
- Delivery time
- Set up time

Lead time can be reduced by adding crashing costs (extra costs incurred to shorten lead time), so lead time can be controlled. Benefits from reduced lead times are low safety stocks, reduced stock outs, improved service levels to consumers, and provide competitive advantage. As evidenced by Just-In-Time (JIT) production. Reduction of lead time is seen as an effective way to realize the rapid response of the entire supply chain and one of the most important sources in competitive advantage.

Research Position

Goyal (1976) is the first researcher to model buyer and supplier coordination called Joint Economic Lot Size model. The solutions generated from this model can provide significant savings on total combined inventory costs. Pujawan and Kingsman (2002) develop a supplier-buyer supply model for an unlimited time horizon. In this model the buyer wants the shipment to be done n times, while the production made by the supplier is m times. If the delivery is done in q quantity, then the buyer's ordering lot is formulated as nq and the production lot as mq. The researchers compared the lot stream model with no lot streaming for 2 different cases, ie: (i) if the decision was made by each party, and (ii) if the decision was made jointly. The solutions obtained show that good synchronization between supplier and buyer in determining delivery frequency and production time will result in significant savings on total inventory cost. Some of the above models also still assume a deterministic demand, whereas in real conditions the demand will vary over time. For that reason Jauhari (2009) makes inventory models in real conditions that try to relax the assumptions of deterministic demand into probabilistic demand, but do not consider leadtime and backorder. Therefore, in this research will be developed a model of coordination between buyer and supplier which with controllable leadtime and backorder policy. Expected from this model can minimize the total cost of buyers and vendors, and also balances the total cost between the two.

* Corresponding author

System Analysis

In this study,the issues discussed are one vendor and one buyer. In the supply chain usually consist of suppliers, manufacturers, retailers, and consmers.There is a flow of physical, information, and finance, process starts with the raw materials produced by the supplier and ends with the finished product consumed by the consumer. The supply chain network can consist of one vendor model and one buyer in known conditions.

The objective of the research is to optimize the supply system in the supply chain by controlling the lead time of the decentralized mode. With the centralized mode (centralized mode) is the expected total inventory cost on buyers and vendors can be balanced. Which with the decentralized mode in the previous paper there is an imbalance of total cost inventory between buyer and vendor. Illustration can be seen in figure 1 below.

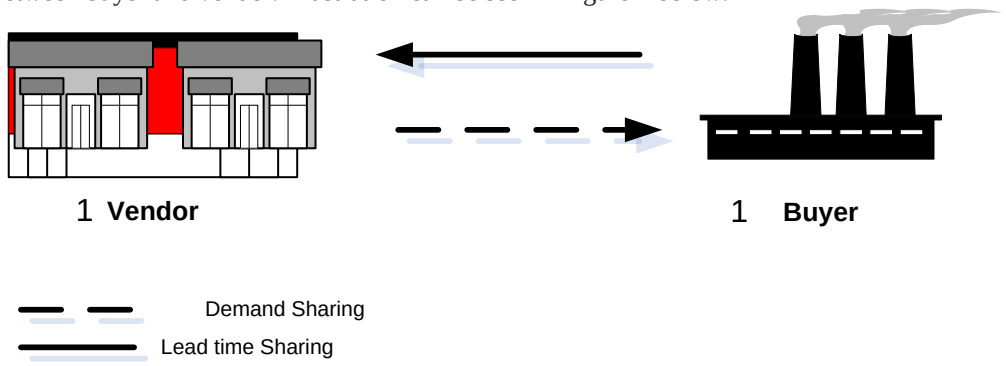

Fig. 1. Two Echelon Inventory Problem

Structural Aspects : 1 vendor – 1 buyer
Functional Aspects :Relationship between vendor and buyer
Evironment : Ignored
Objective :Minimize total cost of vendor and buyer

2. Method

Table 1. Component Model

Component Model	Fei Ye danYi Na Li (2008)	This research
Problem	Determining optimal inventory policy	How to determine the optimal inventory policy?
Criteria Performance	Expectation of total minimum cost (buyer and vendor)	Expectation of total inventory cost for vendor and total inventory cost for buyer
Decision Variable	Order lot size*(Q)*	Order lot size (q)
	Lead Time *(L)*	Lead time (L)
		Frequency of delivery (n)
		Batch of production (m)
Parameter	Ordering cost *(A)*	Ordering cost (A) atau set up cost *(S)*
	Holding cost of buyer (hr)	Holding cost of buyer *(hr)*
	Holding cost of vendor (hs)	Holding cost of vendor *(hs)*
	Crashing cost (ci)	Crashing cost (ci)
	Price/unit (P)	Shortage cost (γ)
	Shortage cost (γ)	Delivery cost (f)
		Price/unit (P)
Constraint	-	-

Model Formulation

Notation mathematical

D = Average demand/year
p =vendor production level (P > D)
A =Ordering cost for buyer
h_r = Holding cost for buyer
h_s = Holding cost for vendor
S = Set up cost
q = Optimal lot size (decision variable)
L = Lead time (decision variable)

γ =Shortage cost
f =Delivery cost
k = Safety factor
δ= Deviation standard

The following assumptions that used for this research :

a. Supply chain of two echelons consists of a single vendor and a single buyer
b. Production rate of the supplier is assumed to be P, where the production rate is greater than demand rate (P>D)
c. Inventory is continuously replenished where refilling is determined by its point reorder (r).
d. The demand during lead time L is assumed to be normal distribution with mean = uL and standard deviation = $\delta\sqrt{L}$ and k is safety factor, shortages inventory is fullfiled with back order
e. Lead time has n independent components. The*i*thcomponent has a minimum duration$a_i$and normal durationb_i, buyer's crashing costc_i, and vendor's crashing cost d_i. To simplify we can arrange $c_i$dan$d_i$like $c_1 \leq c_2 \leq \ldots c_n$. and $d_1 \leq d_2 \leq \ldots . d_n$. So it can bee seen clearly that to reduction of lead time, it should be first on component 1 (cause it has minimum crashing cost) and then component 2, and so on.
f. If $L_0 = \sum_{j=1}^{n} b_j$and $L_i$is the length of leadtme at component 1, 2,...,icrashed to the minimum duration then $L_i$is expressed as

$$L_i = \sum_{j=1}^{i} a_j + \sum_{j=1+1}^{i} b_j = \sum_{j=1}^{i} b_j - \sum_{j=1}^{i}(b_j - a_j) = L_0 - \sum_{j=1}^{i}(b_j - a_j) \quad \textbf{(1)}$$

i= 1,2,...n

g. buyer orders a number of products *nq* to vendor withthe delivery frequency of*n* time (based on buyer's need) with lot of delivery*q*, so to fullfilbuyer's demand, vendor produce the productwith batch production*mq*. Delivery of product from vendor to buyer is done every period(*nq/D*) and can be done if vendor has minimum inventory*q*, so no need to wait for all batches to be produced

Mathematical model

a. Buyer's inventory cost model

Based on assumption above, so year cost expectation for buyer :
TEC_r = Ordering cost + Holding cost + Leadtime crashing cost + Shortage cost

- **Ordering cost (Op)**
  In this model buyer orders the product a number of *nq* to vendor with delivery frequency of *n* time (base on buyer's need) and delivery lot*q*, so expectation of the ordering cost becomes :
  $$Op = \frac{D}{nq}(A + fn) \quad \textbf{(2)}$$

- **Holding cost (O_{hr})**
  Because the model development is done by using backorder policy, so holding cost for buyer becomes:
  $$Ohr = h_r\left(\frac{q}{2} + r - D(L_0 - \sum_{j=1}^{i}(b_j - a_j)\right) \quad \textbf{(3)}$$
  with*r* = reorder point

- **Leadtime crashing cost (Oc)**
  Crashing cost is a cost that must be issued by buyer because it can reduced leadtime. For that reason leadtime crashing cost of buyer can be searched with :
  $$R(L) = c_i(L_{i-1} - L) + \sum_{j=1}^{i} c_j(b_j - a_j) \quad (4)$$
  Notation :
  c : buyer's crashing cost
  b : normal duration
  a : leadtime minimum duration

- **Shortage cost (Ok)**
  Ok = Shortage cost/unit X N
  $$Ok = \gamma \frac{D}{q}\int_r^{\sim}(x - r)f(x)dx \quad \textbf{(5)}$$
  $$\int_r^{\sim}(x - r)f(x)dx = SL(L_0 - \sum_{j=1}^{i}(b_j - a_j))[f(z_\alpha) - z_\alpha \varphi(z_\alpha)] \quad \textbf{(6)}$$

Total cost inventory for buyer becomes :

$$\boldsymbol{TEC_r = \frac{D}{nq}(A + fn) + h_r\left(\frac{q}{2} + r - D(L_0 - \sum_{j=1}^{i}(b_j - a_j)\right) + \frac{D}{q}R(L) + \gamma\frac{D}{q}\int_r^{\sim}(x - r)dx} \quad \textbf{(7)}$$

b. Vendor's inventory cost model

Base on notation and assumption, so year cost expectation for vendor becomes :

TEC_s = Set up cost + holdin cost + leadtime crashing cost

- **Set up cost (Os)**

  Suppliers produce products with batch productionmq, so set up cost for vendor becomes:

  $$Os = \frac{D}{mq}S \quad \textbf{(8)}$$

- **Holding cost (O_{hs})**

  To fullfil buyer's demand, vendor produc with batch production *mq*. The inventory level of vendor is obtained by reducing the accumulated production by the accumulation of buyer consumption. For more details can be seen in the figure below:

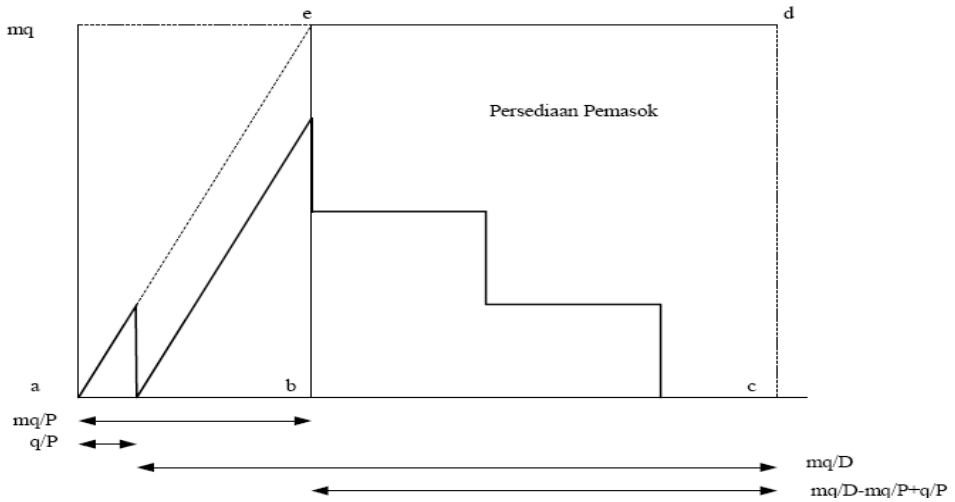

Fig.2. Holding cost

According to jauhari (2009) dan Ben-Daya (2004) holding cost for vendor becomes :

Total vendor's inventory = vendor production accumulation – buyer consumtion cumulation

Total vendor's inventory = $\left(\frac{mq}{2} - \frac{q}{2}\right) - \left(\frac{mq}{2} - q\right)\frac{D}{P}$

So holding cost for vendor becomes :

$$Ohs = h_s\frac{q}{2}\left[(m-1) - (m-2)\frac{D}{P}\right] \quad \textbf{(9)}$$

- **Leadtime crashing cost (Oc)**

  Crashing cost is a cost that must be issued by the vendor because it reduce leadtime.For that value of vendor's leadtime crashing cost can be searched with :

  $$M(L) = d_i(L_{i-1} - L) + \sum_{j=1}^{i} d_j(b_j - a_j)\,, \quad \textbf{(10)}$$

  Notation :

  d : vendor's crashing cost/unit/time

  b : normal duration

  a : leadtime minimum duration

  Expectation crashing cost/year for vendor :

$$Oc = \frac{D}{q} M(L) \quad \textbf{(11)}$$

notation :

m : the production undertaken by the vendor is as much as m times.

$$TEC_s = \frac{D}{mq} S + h_s \frac{q}{2} \left[(m-1) - (m-2) \frac{D}{P} \right] + \frac{D}{q} M(L) \quad \textbf{(12)}$$

c. Centralized Model

$$TEC_{Gab}(q, L) = TEC_r + TEC_s$$

$$TEC_{Gab} = \frac{D}{nq}(A + fn) + h_r \left(\frac{q}{2} + r - D(L_0 - \sum_{j=1}^{i}(b_j - a_j) \right) + \frac{D}{q} R(L) + \gamma \frac{D}{q} \int_r^{\sim} (x - r) dx + \frac{D}{mq} S + h_s \frac{q}{2} \left[(m - 1) - (m - 2) \frac{D}{P} \right] + \frac{D}{q} M(L) \quad \textbf{(13)}$$

Model Solution

a. Centralized Model

$$\frac{\partial TEC_{gab}(q, L)}{\partial Q} = 0$$

$$\frac{\partial TEC_r(Q,L)}{\partial Q} = -\frac{D}{nq^2}(A + fn) - \frac{D}{q^2} R(L) + \frac{1}{2} h_r - \frac{\gamma D}{q^2} \int_r^{\sim} (x - r) dx - \frac{D}{mq^2} S + \frac{1}{2} h_s \left[(m-1) - (m-2) \frac{D}{P} \right] - \frac{D}{q^2} M(L) = 0 \quad \textbf{(14)}$$

$$q^* = \sqrt{\frac{2D\left[\left(\frac{A}{n} + f\right) + R(L) + \gamma \int_x^r (x - r) f(x)\right] dx + \frac{S}{m} + M(L)}{h_r + h_s \left[(m-1) - (m-2)\frac{D}{P}\right]}} \quad \textbf{(15)}$$

$$\frac{\partial TEC_r(q,L)}{\partial r} = 0 \rightarrow \; h_r - \frac{\gamma D}{q} \int_r^{\sim} (x - r) f(x) dx = 0 \quad \textbf{(16)}$$

$$\int_r^{\sim} f(x) dx = \frac{h_r q}{\gamma D} \quad \textbf{(17)}$$

Thus the probability of shortage inventory can be expressed as:

$$\alpha = \frac{h_r q}{\gamma D} \quad \textbf{(18)}$$

Algorithm: set *m = 1*

Step 1 : Calculate initial $q_o$using formula:

$$q = \sqrt{\frac{2D\left[\left(\frac{A}{n} + f\right) + \frac{S}{m}\right]}{h_r + h_s \left[(m-1) - (m-2)\frac{D}{P}\right]}}$$

Step 2 :Based on the initial$q_o$above, we can find probability of shortage$\alpha$by using equation (17**)** and then we can calculate the values of*r1 ** and *N* (the number of shortage) using the following equation:

$$r1^* = D(L_0 - \sum_{j=1}^{i}(b_j - a_j) + z_\alpha \delta \sqrt{L}$$

$$\int_r^{65} (x - r) f(x) dx = SL(L_0 - \sum_{j=1}^{i}(b_j - a_j)) [f(z_\alpha) - z_\alpha \varphi(z_\alpha)]$$

Step 3 : Recalculateq_{o1}using the equation:

$$q^* = \sqrt{\frac{2D\left[\left(\frac{A}{n}+f\right)+R(L)+\gamma\int_x^r (x-r)f(x)\right]dx+\frac{S}{m}+M(L)}{h_r+h_s\left[(m-1)-(m-2)\frac{D}{P}\right]}}$$

Step 4 : Repeat above steps until *q* and *r* values do not change greatly.

Step 5 : If $TC\ (q_o) \leq TC\ (q_{o2})$, then repeat steps 1 to 4 with $m = m + 1$ but if on the contrary then proceed to step 6.

Step 6 : Calculate the value of $TC\ (q_o) = TC\ (q_{o2})$, so we get the value of *q* and *m* optimal.

3. Results

D = 600 unit/year

P = 2500unit/year

h_r = \$20/ unit/year

A = \$200/ order

δ = 7 unit/ week

γ =\$60/ unit

h_s = \$40/ unit/year

S = \$250/ setup

f = \$25

Table2. Numeric Data

i	*bi* (day)	*ai* (day)	*ci* (day)	*di* (day)
1	20	6	0,4	0
2	20	6	1,2	2
3	16	9	5	3

Leadtime calculation (Leadtime crashing cost)

For $i = 0$

Lo = 8 week

R(L) = 0

For $i = 1$

$$L_1 = L_0 - \sum_{j=1}^{1}(b_1 - a_1)$$

L_1 = 8 – 14 day (2 week) = 6 week

Tabel 3. Total Cost (before model development)

i	L_i	R(L)	M(L)	Q_i	TEC_{sc}	y	
						TEC_s	TEC_r
0	8	0	0	136,57	4834,56	1753,85	3078,06
1	6	5,6	0	137,20	4747,07	1751,84	2995,23
2	4	22,4	28	143,44	4805,91	1851,357	2954,56

Table 4. Total Costafter model development (this research)

N	m	K	R(L)	M(L)	q	TEC_r	TEC_s	Total Cost
1	1	1,45	0	0	140	2451	1744	4195
2	1	1,5	5,6	0	125	1954	1800	3754
3	1	1,45	2,4	28	127	850	1925	275

4. Conclusion

From the calculation result can be seen that total cost of buyer and total cost of vendor to be reduced, and the difference in total cost between buyer and vendor to be reduced. The occurance of balance with reduced total cost of buyer and vendor by using this centralization method, so buyer and vendor no one is too loss. Inventory model that has been developed in this research can still be developed according to the characteristics of different problems. Existing models can also be developed into more complex issues such as multi buyer, multi vendor, multi product.

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Last Mile Distribution in Relief Distribution Planning for Responding a Probable Tsunami

Reinny Patrisina[a]*, Alfadhlani[a], Rahmad Inca Liperda[a,b]

[a]*Department of Industrial Engineering, Universitas Andalas, Kampus Unand Limau Manis, Padang 25163, Indonesia*
[b]*Department of Industrial Engineering, Faculty of Engineering, Prince of Songkla University, Kho Hong, Hat Yai, Songkhla, 90112, Thailand*

Abstract

Due to time restrictions for conducting an emergency response, it will be not enough time for a disaster manager to provide an efficient and effective relief operation in case a preparedness plan regarding response operation has never set up. This study is aimed to develop a relief distribution plan for responding a probable tsunami by considering a limitation of supplies, resources, and response time. The Last mile distribution approach concerning the final stage of a relief chain structure that minimizes the transportation cost and penalty cost related to the victims' dissatisfactions cause of inequalities is applied in facing Sumatera Megathrust.

Keywords: Last mile distribution; Sumatra megathrust; disaster logistics; equitability; relief distribution

1. Introduction

Indonesia is located between three active tectonic plates; Indo-Australia, Eurasia, and Pacific plate. This geographical circumstances affect to the country's vulnerability of natural disaster such as earthquake, tsunami, and volcanic eruptions. Badan Nasional Penanggulangan Bencana (BNPB), Indonesian's national agency for disaster management, has mapped disaster risk index of cities in Indonesian to illustrate the risk level of each city to a disaster.

West Sumatra is one of provinces gaining the high index of vulnerability to disaster hazards. Today, West Sumatra is facing the tremendous hazard called Sumatra Megathrust. It has been predicted that an earthquake with magnitude 8.8RS would trigger an 8-10 m height of tsunami and reaching 2-5 km from the shoreline [1]. This hazard threaten almost one million people who live in seven coastal cities of West Sumatra including Padang, Pesisir Selatan, Pariaman, Padang Pariaman, Mentawai, Pasaman Barat, Agam. Moreover, the potential loss is forecasted equal to the 2004 Asian tsunami [2].

Soon in the aftermath, it is required to perform relief aid operation to fulfill the needs of the victims in order to save lives and to reduce human suffering. Though relief distribution is performed in response period but an operation plan could be set up prior to a disaster. There will be not sufficient time for the disaster authorities to organize activities related to the efficiency and effectiveness of the relief aid distribution in case of they never made the comprehensive preparedness to response the disaster in advance [3]. Actually, relief distribution is one of three aspects in humanitarian logistics (facility location, relief prepositioning stocks, and relief distribution) [4]. Humanitarian logistics is logistics that relates to humanitarian aspect. Though the government has included the logistics aspect in the West Sumatera's tsunami contingency plan, particularly the relief aid distribution plan is still not under the consideration of local government of West Sumatra province.

This research is aimed to develop a relief aid distribution plan in facing Sumatra megathrust by considering limitation of supplies, resources, and victims' vulnerabilities in order to minimize the transportation cost and the penalty cost related to the beneficiaries' dissatisfaction. Hence, delays and inequalities in the basic needs fulfillment can be minimized. This study is applied to two of the affected cites that is Pariaman and Padang Pariaman. Geographically, Pariaman is surrounded by Padang Pariaman.

2. Model Formulation

2.1. System Description

This study applies the last mile distribution model utilized for designing a relief distribution plan for Pariaman and Padang Pariaman. The model was developed by [5] considered a situation that usually occurs during a disaster such supplies, resources, and time restrictions. The objective function of the model is to minimize the transportation cost and the penalty cost related to the victims' dissatisfactions.

Demand characterization

Due to the tremendous effect of disaster, there are some factors leading to the great variation of required items such as the type and impact of the disaster, demographics, and social and economic conditions of the area. In order to cope with these conditions, it is possible to categorize emergency relief items into two main groups:

a. Type 1

Type 1 items are considered as critical items occurring once at the beginning of the emergency period such as tents, blankets, tarpaulins, jerry cans, and mosquito nets. Due to supply unavailability and vehicle capacity limitations, it may be impossible to meet all type 1 demands within a short period of time since the demand for type 1 items is typically very large. Hence, a penalty charge is applied and the costs accumulate over time for each unit unsatisfied (backordered). Therefore type 1 items will be immediately distributed to aid recipients once it arrived.

b. Type 2

Type 2 items occur periodically over the planning horizon which is considered as the items that are consumed regularly such as food and hygiene kits. The unsatisfied demand of type 2 items cannot be backordered, rather it is lost and penalty costs occur for each unit of lost demand.

Vehicles and routes

Particularly in the early days following a disaster, the most significant constraints in the last mile refers to the transportation capacity and supply availability. The vehicle fleet is unable to be optimized in the relief system, in terms of number, capacity, and compatibility. Hence, it is assumed that the vehicle fleet consists of limited number of vehicles with different characteristics. Each vehicle is differentiated based on capacity, speed, and compatibility with various arcs in the network and can load both type 1 and 2 items. Finally, the vehicle is assigned to complete multiple deliveries and to visit each demand location multiple times in a single planning period.

Planning horizon

The unpredictability related to resource levels over time becomes a unique characteristic of the last mile distribution system. It is difficult to obtain exact supply information (times and quantities). Hence, the estimation of inventory levels at an LDC for short-term period may be reliable. The great variation of vehicle availability involving its number and composition in the fleet leads to another uncertainty factor. These supply and demand related uncertainties affect to an assumption that the planning horizon will begin once the LDC is able to begin delivering relief supplies to demand locations and ends when the demand for type 1 and items are fulfilled.

2.2. Mathematical Formulation

The following notation used by Balcik et al. (2008), as follows:

T : set of days in the planning horizon; length of planning horizon
K : set of vehicles
R : set routes
N : set of all demand locations
N : set of demand locations visited on route r ∈ R
E : set of demand types : E = {1, 2}
c_{rk} : cost of route r for vehicle k ∈ K
q_k : capacity of vehicle k ∈ K (volume)
T_{rk} : duration (as a fraction of a day) of route r ∈ R for vehicle k ∈ K
d_i^1 : demand of type 1 at location i ∈ N (volume per planning horizon)
d_i^2 : demand of type 2 at location i ∈ N on day t ∈ N (volume per day)
P_{it}^1 : penalty cost factor for unsatisfied type 1 demand at location i ∈ N by day t ∈ T
P_{it}^2 : penalty cost factor for unsatisfied type 2 demand at location i ∈ N on day t ∈ T
a_t^e : amount of type e ∈ E relief supplies arriving to the LDC at the beginning of day t ∈ T
X_{rtk} : *Binary variable*, 1 if route r ∈ R is used by vehicle k ∈ K on day t ∈ T and 0 otherwise
Y_{irtk}^e: amount of demand of type e ∈ E delivered to location i ∈ N on day t ∈ T by vehicle k ∈ K via route r ∈ R
W_i^e : penalty cost associated with unsatisfied type e ∈ E demand on day t ∈ T
S_{it}^1 : fraction of unsatisfied type 1 demand at location i ∈ N by day t ∈ T
S_{it}^2 : fraction of unsatisfied type 2 demand at location on day i ∈ N on day t ∈ T
I_{it}^2 : inventory level of type 2 at location i ∈ N at the beginning of day t ∈ T

Objective function

$$Min \sum_{r \in R} \sum_{t \in T} \sum_{k \in K} crk\ Xrtk + \sum_{t \in T} \sum_{e \in E} W_t^e \quad (1)$$

Constraints

$$W_t^e \leq P_{it}^e S_{it}^e \qquad \forall i \in N, t \in T, e \in E \quad (2)$$

$$S_{it}^1 = \frac{(d_i^1 - \sum_{r:i\in N(r)} \sum_{\tau=1}^{t} \sum_{k\in K} Y_{ir\tau k}^1)}{(d_i^1)} \qquad \forall i \in N, \mathrm{t} \in \mathrm{T} \qquad (3)$$

$$S_{it}^2 = \frac{(d_i^2 + I_{i,t+1}^2 - \sum_{r:i\in N(r)} \sum_{k\in K}^{t} Y_{irtk}^2 - I_{it}^2)}{(d_i^2)} \qquad \forall i \in N, \mathrm{t} \in \mathrm{T} \qquad (4)$$

$$\sum_{r:i\in N(r)} \sum_{k\in K} \sum_{t\in T} Y_{irtk}^1 \geq d_i^1 \qquad \forall i \in N \qquad (5)$$

$$\sum_{\mathrm{r}\in\mathrm{R}} \sum_{\mathrm{i}\in\mathrm{N(r)}} \sum_{\tau=1}^{\mathrm{t}} \sum_{\mathrm{k}\in\mathrm{K}} \mathrm{Y}_{\mathrm{ir\tau k}}^{\mathrm{e}} \leq \sum_{\tau=1}^{\mathrm{t}} \mathrm{a}_{\tau}^{\mathrm{e}} \qquad \forall t \in T, e \in E \qquad (6)$$

$$\sum_{i\in N\,(r)} \sum_{e\in E} Y_{irtk}^e \leq q_k X_{rtk} \qquad \forall r \in R, t \in T, k \in K \qquad (7)$$

$$\sum_{\mathrm{r}\in\mathrm{R}} \mathrm{X_{rtk}} \,.\, \mathrm{T_{rk}} \leq 1 \qquad \forall \mathrm{t} \in \mathrm{T}, \mathrm{k} \in \mathrm{K} \qquad (8)$$

$$0 \leq S_{it}^e \leq 1 \qquad \forall i \in N, t \in T, e \in E \qquad (9)$$

$$I_{i1}^2 = 0 \qquad \forall i \in N \qquad (10)$$

$$I_{it}^2 \geq 0 \qquad \forall i \in N, t \in T \qquad (11)$$

$$Y_{irtk}^e \geq 0 \qquad \forall i \in N, r \in R, t \in T, k \in K, e \in E \qquad (12)$$

$$X_{rtk} \in \{0,1\} \qquad \forall\, r \in R, t \in T, k \in K \qquad (13)$$

2.2 Solving Methods

The relief distribution problem is solved in two phases as depicted in **Fig. 1**. Phase 1 is to generate all possible routes for delivering the relief aid, while phase 2 aims to determine delivery routes for each vehicle together with the amount of supplies to be sent to each demand point during the emergency period. Set of available vehicles, set of LDCs and demand locations, and travel time inclusive with its cost are utilized as input in phase 1 to construct the candidate of routes. In this study, the candidate of routes are obtained using the saving algorithm. The output of phase 1 together with demand needed, penalty cost, supply arrivals, and capacity of each vehicle are considered as inputs for phase 2. In the phase 2, the mathematical formulation of last mile distribution developed by [5] is implemented in order to optimize the route assignment of relief vehicles including number of relief aid to be delivered to every TEAs during the emergency period.

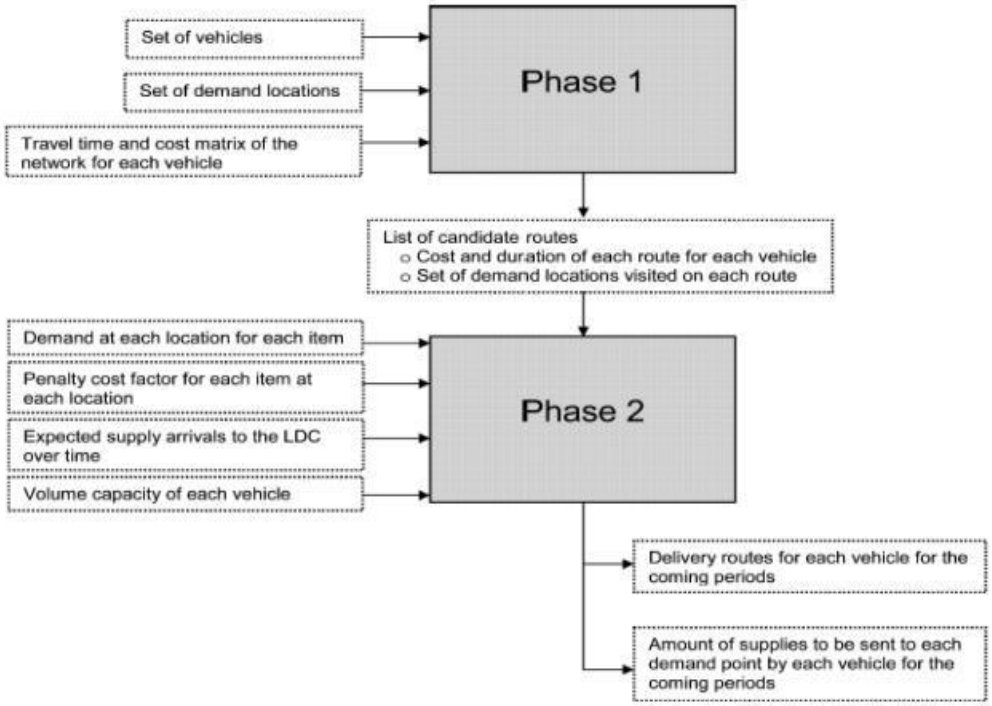

Fig. 1. Two-phase model [5]

3. Numerical Experience

The last mile distribution model is applied to Pariaman city and Padang Pariaman district which are considered as the vulnerable areas in term of dealing with Sumatra Megathrust. According to the contingency plan of West Sumatra Province to deal with Sumatra megathrust hazard, hence the planning horizon for fulfilling the needs in Pariaman city and Padang Pariaman district is set to be 14 days [1]. Padang Pariaman district have established one LDC for each area which has access to the affected area by considering such as safety and security, road reliability, and transportation modes [6] and [7] as well as Pariaman city [8]. The demand locations which are also called as TEA are set by considering evacuation routes developed by the local government. We assume that every evacuee will shelter themselves to the nearest TEA, hence there are 10 selected TEAs in Pariaman city (**Fig. 2.**) and 5 selected TEAs in Padang Pariaman district (**Fig. 3.**), respectively.

Fig. 2. Potential TEAs in Pariaman city

Fig. 3. Potential TEAs in Padang Pariaman district

The estimation of evacuees sheltering in every demand points is obtained by determining average number of household including its family members and vulnerable people in order to fit the demand needs into relief package to be delivered to every TEAs. The total number of evacuees in Pariaman city are estimated to be 17,322 people and 14,975 people in Padang Pariaman district, respectively. The dimension of relief package is set to be 1 m^3 for each type 1 and 2 items in order to simplify from determining vehicles' capacity. Type 1 items consist of clothes, blankets, petroleum, tents, mats, family kits, food ware, kid ware, and women's ware. Meanwhile, type 2 items consist of instant rice, side dishes, and mineral water (Table 1).

Due to number of evacuees in Pariaman city and padang pariaman district contribute to 3% of total victims, we assume that the allocation of relief vehicles will be 3% for each Pariaman city and padang pariaman district from total number of available vehicles. Those are pick up car (four wheels), medium truck (six wheels), big truck (10 wheels), and helicopter (Table 2).

The mathematical formulation of the problem is solved using LINGO 14.0 software. Solution gained by this calculation is optimal global. Based on the optimization result by using LINGO software, it is found that all of relief aids type 1 of Pariaman city and Padang Pariaman district are being fulfilled each in the 13^{th} and 12^{th} in the emergency period. Meanwhile, the relief aid type 2 belonging to basic needs will be satisfied in every period in the planning horizon. Due to the urgency of type 2 items to be immediately satisfied, hence the type 2 items fulfillment will be prioritized. From the optimization result, we found that the relief aid distribution cost of Pariaman city is 1,805,338,500 IDR which is more expensive than Padang Pariaman district gaining 1,100,661,721 IDR (Table 3). The relief aid distribution plan for Pariaman city in the day-1 is depicted on Table 4.

Table 1. Type of items

Type	Items	Unit	Requirement	Total requirements	Volume per package (m^3)
1	Clothes	Package/household	1	1	0.017
	Blanket	Sheet/head	1	1	0.003
	Petroleum	Gallon/household	1	1	0.014
	Tent	Package/household	1	1	0.14
	Mat	Package/household	1	1	0.009
	Family kit	Package/household	1	1	0.075
	food ware	Package/household	1	1	0.05
	kid ware	Package/infant	1	1	0.011
	women's ware	Package/woman	1	1	0.017
2	instant rice	Package/household/3 days	1	5	0.032
	side dishes	Package/household/3 days	1	5	0.032
	mineral water	bottle/day/head	3	42	0.001

Tabel 2. Available vehicles

No	Vehicle	Operational cost (IDR)	Vehicle allocation		Vehicle's capacity (package)		Total loading and unloading time/vehicle (hr)	Total loading and unloading cost/vehicle (IDR)
			Pariaman city	Padang Pariaman district	Pariaman city	Padang Pariaman district		
1	Pick up car	2,100/km	1	1	6	6	0.35	354,911
2	Medium truck	4,310/km	5	5	14	14	1	1,000,000
3	Big truck	6,731/km	1	1	32	32	1.5	1,500,000
4	Helicopter	2,000,000/hr	-	1	-	1	0.06	59,152

Table 3. Total relief distribution cost

Area	Vehicle	Routing cost (IDR)	Penalty cost (IDR)	Total cost (IDR)
Pariaman city	Big truck	1,170,074,000	635,264,500	1,805,338,500
	Medium truck (MT) 6a			
	Medium truck (MT) 6b			
	Medium truck (MT) 6c			
	Medium truck (MT) 6d			
	Medium truck (MT) 6e			
	Pick up car			

Padang Pariaman district	Helicopter	5,089,821	600,000,000	1,100,661,721
	Big truck	495,571,900		
	Medium truck (MT) 6a			
	Medium truck (MT) 6b			
	Medium truck (MT) 6c			
	Medium truck (MT) 6d			
	Medium truck (MT) 6e			
	Pick up car			

Table 4. Relief distribution plan in Pariaman city for the 1st day

Item Type – ½	Camp visited	1	2	3	4	5	6	7	8	9	10
Big Truck	5-1-2-3-8	0/4	3/0	15/0		7/0			3/0		
	6-7-9-10									9	1
M.T 6a	3-8			0/1		2	20				
	2-8		0/3								
M.T 6b	3			0/14							
	9									0/14	
M.T 6c	5-1-4	4/0			0/5	5/0					
	7						0/14				

4. Conclusions and Future Research

This research carried out the relief aid distribution plan for facing Sumatra megathrust by utilizing last mile distribution model in Pariaman city and Padang Pariaman district. The applied model has considered equity concept in the delivery process. It costs 1,805,338,500 IDR for 17,322 beneficiaries in Pariaman city and 1,100,661,721 IDR for 14,975 beneficiaries in Padang Pariaman district. The total penalty cost applied related to victims' dissatisfaction of relief aid shortage and inequality has also contributed to the total relief aid distribution cost.

The future research may be developed by utilizing decision support system of relief aid distribution to the beneficiaries in order to shorten decision-making process.

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