The effects of coagulant types on the quality and added value of raw rubber materials

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Abstract. Many processing problems still occur, causing the low quality of raw rubber materials and farmers low-income. This can be seen from the use of coagulants, storage methods and the level of cleanliness. This study was aimed at analyzing the quality and added value of raw rubber materials based on the use of coagulant types. This study was conducted in October - November 2021. Fresh latex was obtained from the rubber plantation in Mulyaguna Village, OKI Regency. Completely randomized design was used with 5 treatments and 4 replications. The coagulants used were the recommended ones (liquid smoke, formic acid), and the commonly used by the farmers (sulfuric acid, aluminum sulfate, and TSP fertilizer). The results of the study showed that liquid smoke and formic acid were better than the coagulants commonly used by farmers, which could be seen from the ash content, initial plasticity, and plasticity retention index. The dry rubber contents (DRCs) using liquid smoke, formic acid, sulfuric acid, aluminum sulfate, and TSP fertilizer were 66.081; 62.978; 59.067; 56.202 and 60.796 respectively. Liquid smoke and formic acid provided the added value for raw rubber materials of 1,203/kg IDR and 792/kg IDR compared to sulfuric acid commonly used by farmers.

1 Introduction

Indonesia is the second largest rubber producing country after Thailand. Together with Vietnam, India and China, they are the five largest natural rubber producing countries. These five countries produce almost 70 percent of the world's rubber. Indonesia's rubber production share to the world's total rubber ranges from 22.3 percent to 24.1 percent while Thailand's share ranges from 26.5 percent to 32.4 percent [1]. This rubber plantation business by smallholder farmers contributes more to the expansion of rubber plantations than plantation companies in both Thailand and Indonesia [2,3].

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In 2019, rubber plantations in Indonesia covered an area of 3,683,482 ha (the second largest after oil palm). South Sumatra is the province with the largest planted area of 861,640 ha, dominated by smallholder rubber plantations covering an area of 812,421 ha with a productivity of 1.08 t/ha [4]. This commodity has an important economic value because it is the third largest contributor after wood pulp and mineral fuels, with a value of US$ 890 853 833.78 [5].

The development of natural rubber faces two competitors, namely new competitor countries and synthetic rubber whose price is highly dependent on fuel oil prices [6]. More countries will hopefully buy natural rubber from Indonesia, so that farmers will be able to compete in the international market, and entrepreneurs will be more eager to produce rubber with better quality [7]. The use of natural rubber is very diverse, especially as the main material for making tires for transportation vehicles and various equipment/products that require flexibility [8].

Rubber prices at the farm level are shaped by world market mechanisms. If world rubber prices fall, domestic rubber prices will follow suit [9]. The fact also shows that rubber prices in the international market not only fluctuate every year but also vary widely [10]. Although rubber prices fluctuate, its exploitation is much more profitable for farmers. It is not surprising that this plant dominates and has taken over the rural economy in the Xishuangbanna rubber growing area of Yunnan, Southwest China [11].

Processing problems that cause the low quality of raw rubber materials still occur in South Sumatra [12]. This can be seen from the level of cleanliness, types of coagulants used and the storage methods of raw rubber materials, most of which do not meet the applicable standards. Improving the quality of raw rubber materials must start from the handling of latex in the farm until the final processing stage. Good quality latex, the use of recommended coagulants and proper processes will result in clean raw rubber materials.

The government has tried to overcome various existing problems by issuing the Regulation of Minister of Agriculture No. 38/PERMENTAN/OT.140/8/2008 concerning Guidelines for Processing and Marketing Raw Rubber Materials. This regulation is intended as guidelines for processing latex into raw rubber materials in accordance with quality standards and for marketing activities at the farm level with the aim of obtaining proportional prices for farmers (Article 2 paragraph 1). In the areas having organized marketing systems through the Raw Rubber Material Processing and Marketing Unit, it is necessary to provide supervision and development. The Unit is established to assist rubber farmers in the latex processing in order to produce good-quality lump in accordance with predetermined standards and help to market their raw rubber materials.

At the farm level, many still use non-recommended coagulants such as para vinegar, alum, and TSP fertilizer [12]. Through the Unit, the recommended use of coagulants such as formic acid and liquid smoke is continuously being pursued. This study was aimed at analyzing the quality and added value of raw rubber materials based on the use of coagulant types.

2 Research method

This study was conducted in October and November 2021. Fresh latex was obtained from the smallholder rubber plantations in Mulyaguna Village, Teluk Gelam District, Ogan Komering Ilir Regency. The materials used were fresh latex, water, coagulants as coagulation, namely coagulants according to the Indonesian National Standard 06-2047-2002 in the form of liquid smoke (Deorub K) and formic acid (Spekta), also coagulants commonly used by farmers in the form of sulfuric acid (para vinegar), aluminum sulfate (alum), and Triple Super Phosphate (TSP) fertilizer. The tools used were measuring cups, scales, Wallace plastimeters and ovens.

Deorub-K was made into a 5% solution (1 part of Deorub-K mixed with 19 liters of water) and 1.2 liters of the solution to coagulate 12 liters of latex. Spekta was made into a 2% solution (1 part of Spekta mixed with 49 parts of water) and 0.72 liters of the solution was used to coagulate 12 liters of latex. The concentration and volume of para vinegar were made the same as Spekta, while aluminum sulfate and TSP each was used as much as 50 g/l of water and 25 g/l of water, and each was used to coagulate 12 liters of latex.

Completely randomized design was used with 5 treatments and 4 replications. The parameters observed were the ash content, Initial Plasticity (Po), Plasticity Retention Index (PRI) and Dry Rubber Content (DRC). The study began with coagulation of latex into raw rubber materials, with a thickness of ± 5 cm. The slabs were stored for 2 weeks, and the parameters were observed. This study also analyzed the cost of coagulation and the net income obtained from 2-week raw rubber materials.

3 Results and discussion

3.1 Quality improvement of raw rubber materials

Rubber farmers in Mulyaguna Village, especially those who market raw rubber materials together through auctions at the Raw Rubber Material Processing and Marketing Unit, currently no longer insert contaminants such as rubber bark chips, stones, used sandals, sand to make raw rubber materials heavier. This is to avoid any discounts from buyers due to dirty raw rubber materials. In this case, supervision is carried out by the Unit personnel on the collected raw rubber materials. However, variations in the use of the freezers still occur by using vinegar. Even several years ago, farmers who were not members of the Unit also used TSP and aluminum sulfate.

The absence of price differences based on the quality has resulted in the farmers still using non-recommended coagulants which can be obtained at relatively cheaper prices. At Sumber Rejeki Raw Rubber Material Processing and Marketing Unit, the auctions of raw rubber materials are held in a period of one week, namely Thursday. In the auction, the winner is determined by the highest price; the DRC is only based on predictions. This also causes many farmers not to use recommended coagulants. All rubber farmers in Mulyaguna Village make raw rubber materials by using brittle-resistant plastic molds which do not crack easily, and they no longer mold on soil holes. However, its thickness can reach 30-45 cm. The lumps from the bowls are collected and put into the molds, then latex and coagulants are poured into the molds which coagulate form blocks. The results of the study on smallholder rubber plantations in Kapuas, Central Kalimantan [10] showed that the raw rubber materials produced by farmers were in the form of latex and lumps. Fresh latex is the raw material for Ribbed Smoked Sheets (RSS) and concentrated latex. Lumps are used to produce rubber in the form of blocks [13]. Smoked sheets and wind sheets are advanced products produced by factories.

Dry rubber content is rubber solids content per unit weight, which is calculated in percent. It is important to know the dry rubber content (DRC) as a guide for determining rubber prices. The analysis results of DRC stored for 2 weeks showed that the DRCs of slabs coagulated with liquid smoke (Deorub-K) and formic acid (Spekta) were 66.081 and 62.978 respectively. As for the DRCsof raw rubber materials coagulated by farmers using TSP, para vinegar and alum were 60.796; 59.067 and 56.202 respectively (Table 1). Based on the types of coagulants used, the treatment with Deorub-K produced the highest DRC; this is related to the most percentage of solution /dose of Deorub-K used compared to the other coagulants. The more concentration of rubber coagulant added, the faster the coagulation time and the greater the decrease in rubber wet weight [14]. The higher the concentration, the lower the

pH of the coagulant or the more acidic; it causes the coagulant to be more concentrated so that the amount of liquid fraction in the latex and coagulant mixture is smaller because the distance between rubber particles is closer [15]. Liquid smoke is able to completely coagulate rubber so that the water is pushed out which has an impact on the high weight loss and an increase in slab DRC [16].

The results also showed that alum coagulation produced the lowest DRC. This is because alum solution absorbs or stores water so that the amount of coagulation serum produced is the least compared to Deorub-K, Spekta and para vinegar [17]. This water-absorbing property causes the DRCof slabs coagulated with alum to produce the lowest percentage of DRC.

Table 1. DRC, Ash Content, Po and PRI Values of Raw Rubber Materials Based on The Coagulant Types

Coagulant Types	DRC (%)	Ash Content (%)	Po	PRI
Deorub – K	66.081 c	0.260 a	62.000 c	59.175 b
Spekta	62.978 bc	0.375 b	51.000 ab	78.500 c
Para vinegar	59.067 ab	0.395 b	44.750 a	51.350 b
Alum	56.202 a	0.485 c	52.000 b	44.950 b
TSP	60.796 b	0.380 b	46.500 ab	18.875 a

Note: Numbers followed by the same letter in the same column are not significantly different in DNMRT5%.

Ash content in rubber gives an idea of the amount of mineral material in rubber. Rubber with high ash content can reduce the superior dynamic properties, such as heat built-up and flex cracking resistance of vulcanized rubber. The ash content values of raw rubber materials from various coagulants are still acceptable because they meet the requirements of Standard Indonesian Rubber (SIR) 20 (maximum 1), where most of Indonesia's natural rubber products are exported in the form of SIR 20.

Habits of using freezers such as TSP, alum, vinegar acid and soaking will spur the development of natural antioxidant destroying bacteria in raw rubber materials. Bad smell is caused by the growth of spoilage bacteria that biodegrade the protein in raw rubber materials to ammonia and sulfide [12]. Both things happen because the latex freezers currently used cannot prevent the growth of bacteria so that the values of initial plasticity (Po) and plasticity after being heated for 30 minutes at a temperature of 140^{o}C (PRI) become low.

Initial plasticity is the plasticity of raw rubber directly tested without any special treatments, while plasticity retention index is a measure of rubber resistance to degradation by oxidation at high temperature [18] (heated for 30 minutes at 140^{0}C). A lower value indicates a lower molecular weight contained in the rubber clot. Rubber with low molecular weight will have poor physical properties. The PRI value is an indicator to determine whether or not rubber becomes soft and sticky if it is stored or heated for a long time; this is important in relation to the vulcanization process of rubber in the manufacture of finished goods, in order to obtain stronger rubber properties. The results of the study [18] showed that there was resistance to oxidation and damage to rubber molecules at higher temperatures with the use of liquid or solid hydroxylamine sulfate as an additive compared to rubber that did not use it. Similar to the Po results, the PRI values of rubber using hydroxylamine sulfate were also relatively stable compared to rubber that did not use it after 12 weeks of storage.

Po value for SIR 20 is at least 30. Based on the results of the study, all the coagulants used, both recommended and commonly used by farmers, still meet the standard. The PRI value for SIR 20 is at least 40, while TSP as a coagulant does not meet the standard because it produces raw rubber materials with a PRI value of 18.875. Rubber with a low PRI value will be easily oxidized to soft rubber.

Based on Table 1, the highest PRI value was produced from Spekta coagulant, then Deorub-K, para vinegar, alum, and TSP. This means that the latex coagulated with Spekta has better resistance to aging or oxidation at high temperatures than the latex coagulated with

Deorub-K, para vinegar, alum, and TSP. Spekta is the strongest acid of the carboxylic acid group and is an antioxidant that can protect rubber particles from degradation due to oxidation. The antioxidant property of formic acid is the strongest compared to other coagulants, so it is not easily degraded due to oxidation [19].

The results of the study [20] showed that about 80-90% of rubber farmers used alum or sulfate, which resulted in a low 15-35% DRC and thus a lower price. Meanwhile, farmers who sold through the Raw Rubber Material Processing and Marketing Unit used formic acid, the recommended coagulant, according to the needs of the Unit, to achieve 45-50% DRC. The results of previous studies in the form of a coagulation between formic acid and liquid smoke with a ratio of 20:80 produced 41% DRC, Po 43, PRI 47 and 0.3% ash content. Liquid smoke as a substituent in latex coagulation affected the quality of crumb rubber products that met SIR 20 [19].

3.2 Added value of raw rubber material quality improvement

The analysis of raw rubber material processing income used a price at 100% DRC, which is 20,434/kg IDR (10 November 2021). DRC calculations were conducted on slabs stored for two weeks. For every 12 liters of latex frozen using Deorub-K, Spekta, para vinegar, alum and TSP, farmers received gross incomes of 74,858 IDR; 68,736 IDR; 64,467 IDR; 62,930 IDR and 67,953 IDR respectively, while the net incomes obtained for each kg of raw rubber materials with a shelf life of 2 weeks were 13,226/kg IDR; 12,817/kg IDR; 12,022/kg IDR; 11,328/kg IDR and 12,386/kg IDR respectively (Table 2).

Table 2. Income analysis based on the use of coagulant types

No.	Description	Deorub-K	Spekta	Para vinegar	Alum	TSP
1.	2-week slab weight (kg)	5.544	5.342	5.342	5.480	5.470
2.	DRC (%)	66.080	62.978	59.066	56.201	60.796
3.	Dry rubber weight (kg) = a x b	3.663	3.363	3.155	3.079	3.325
4.	Price of 100% DRC(IDR/kg)	20,434	20,434	20,434	20,434	20,434
5.	Farmer Income = c x d	74,850	68,720	64,469	62,916	67,943
6.	Cost of latex coagulants (IDR/liter latex)	127.5	22.2	20.4	70.83	16.66
7.	Cost of 12 liters of latex coagulants (IDR) = f x 12	1,530	266,4	244,8	850	200
8.	Net Income from 12 liters of latex = e - g	73,320	68,454	64,224	62,066	67,743
9.	Net income from 2-weekraw rubber materials (IDR/kg) = h: a	13,225	12,814	12,022	11,326	12,384
10.	Added value of using recommended coagulants (compared to para vinegar) (IDR/kg)	1,203	792			

Note: Price of 100% DRC on 10 November 2021 = 20,434/kg IDR,
Price of Deorub-K = 25,500/kg IDR; Price of Specta = 18,500/kg IDR.
Price of para vinegar = 17,000/liter IDR; Price of Alum =17,000/kg IDR
Price of TSP = 8,000/kg IDR.

This analysis was conducted without taking into account processing fees and latex prices (farmers' latex). By using Deorub-K and Spekta, the added values of production were 1,433/kg IDR and 796/kg IDR respectively, compared to the coagulant commonly used by farmers, namely para vinegar. The added value is obtained if the determination of DRC is accurate.

Rubber prices cannot be interrupted because they are shaped by world market mechanisms. However, the portion of price received by the farmers can be increased through organized marketing in the Raw Rubber Material Processing and Marketing Unit. Marketing through the Unit has the rules to improve the quality, such as the use of formic acid, free of contaminants, no soaking, and selling raw rubber materials with the same shelf life [9]. Raw rubber material marketing in the Unit is done through auctions after raw rubber materials are stored for one to two weeks. At the study location of Sumber Rejeki Raw Rubber Material Processing and Marketing Unit, Mulyaguna Village, raw rubber materials were stored for one week. The findings on small-scale rubber farmers in Edo and Delta, Nigeria showed that the majority (73.33%) of respondents sold their rubber coagulants once a month to middlemen and they did not pay much attention to the quality of coagulants they produced. The study also revealed that most of the farmers had not been trained in the handling and quality of coagulants [21].

Low prices in recent years have discouraged farmers from managing their rubber plantations properly. Many regional-level factories have ceased operations while large-scale ones are still able to withstand price pressures (Five to ten years ago, farm-level prices were stable at USD 1.20-1.30/kg (12,000-13,000/kg IDR) and peaked at USD 2.00-2.40/kg (20,000-24,000/kg IDR) [20].

3.3 Raw rubber material quality improvement efforts

3.3.1 Guidance for farmers

The improvement of raw rubber material quality at the research site was carried out through technical guidance and demonstration on how to make clean raw rubber materials. The technical guidance explained how to make clean raw rubber materials. In the demonstration, farmers directly involved in making clean raw rubber materials by using the recommended coagulants and comparing the results with the coagulants they usually used.

The technical guidance was interesting for the farmers to learn. Demonstration was also supported by learning aids, which would certainly deepen farmers' understanding of making quality raw rubber materials. The limited number of participants in both events required that the information received by the participants be disseminated to other farmers.

The use of learning aids by extension workers in Kuantan Singingi District, Riau Province, had been quite effective and made it easier for farmers to understand the information provided on raw rubber material quality improvement. Although there were some farmers who had received similar information, there were still many farmers who had not got the information [22].

3.3.2 Coagulant assistance distribution

The government in 2021 through rubber processing assistance activities distributed assistance in the form of tools (tapping knives, tapping gutters, bowl rings, bowls, freezer tanks, freezing liquid, scales, hooks, wheelbarrows) and rubber product processing unit buildings. The coagulating liquid was formic acid (Sintas 90). In the research area (Teluk Gelam District, Ogan Komering Ilir) and other areas, the rubber distribution centers had been established and used by the farmers to improve the quality of raw rubber materials.

4 Conclusion

The recommended coagulants, namely liquid smoke (Deorub-K) and formic acid (Spekta), are better than those commonly used by the farmers, such as sulfuric acid (para vinegar), aluminum sulfate (alum) and TSP fertilizer, in terms of the ash content, initial plasticity and plasticity retention index. The dry rubber contents using liquid smoke, formic acid, sulfuric acid, aluminum sulfate, and TSP fertilizer were 66.081; 62.978; 59.067; 56.202 and 60.796 respectively. The recommended coagulants of liquid smoke and formic acid provided the added value for raw rubber material processing of 1,203/kg IDR and 792/kg IDR compared to sulfuric acid commonly used by the farmers.

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