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Characteristics of PB 260 clone rubber coagulated with natural coagulants: Type of averrhoa

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ABSTRACT

The purpose of this study was to use coagulants of the Averrhoa type to ascertain the characteristics of the rubber clone, PB 260. In this investigation, Averrhoa bilimbi and Averrhoa carambola were employed as natural coagulants. Po, PRI, DRC, ash content, dirt content, volatile matter, and Mooney viscosity were among the rubber attributes that were examined. The plasticity of rubber that has been evaluated immediately without any prior special treatment is known as initial plasticity or Po. The degree to which raw rubber can withstand oxidation at elevated temperatures is indicated by the Plasticity Retention Index (PRI). The percentage of rubber particles included in rubber latex is indicated by the term "dry rubber content," or DRC. Additionally, this study used a unique method known as centrifugation speed. The natural coagulant's pH value rises and its H^+ ion value decreases with increasing centrifuge speed, hastening the latex's coagulation time. The Averrhoa bilimbi extract had the highest values of 40%, 94.17%, 32.83%, 0.32%, 0.038%, and 77 MU for Po, PRI, DRC, ash content, dirt content, and Mooney viscosity in the natural coagulant extract at 0 rpm. Averrhoa carambola at 5000 rpm had the highest value in the volatile matter content test, with a value of 0.23%.

1. Introduction

Natural rubber, or *Havea Brasiliense* in Latin, is derived from rubber trees and is a fundamental component of many goods that are useful to people [1]. Global natural rubber production will decline by around 4.6% in 2020. Global rubber demand is also estimated to decline by 5.7% in 2020. In 2019, global rubber consumption was 52.65% synthetic rubber and 47.35% natural rubber [2]. The Central Statistics Agency (BPS) provided data indicating that Indonesia produced 3.14 million tons of natural rubber on 3,690,000 hectares in 2022. This statistic indicates an increase of 0.64% compared to the preceding year's production of 3.12 million tons [3]. With this large amount, it can be a source for the community in fulfilling their needs. At present, rubber is not only used in making toys and household products, rubber can also be applied to construction materials, packaging materials, and health products.

Standard Indonesian Rubber (SIR) is a set of trade specifications commonly known and used for rubber. To meet SIR, it is necessary to select a good type of rubber that meets the standards. The product of a rubber cross between PB 5/51 and PB 49 is the PB 260 clones that produce latex. This clone has a high metabolism and efficient regeneration system, fast growth, and good latex production [4].

The rubber processing process has several problems, namely, farmers still rely on chemical coagulants to coagulate latex. The most commonly used chemical coagulant is formic acid. However, Formic acid has been used as a latex coagulant, which has negatively impacted rubber growers, processing, machinery, and the environment [5]. Therefore, in this study, researchers sought to find an alternative natural coagulant that could replace the use of chemical coagulants.

The natural coagulants used in this study are *Averrhoa bilimbi* (AB) and *Averrhoa carambola* (AC). These natural coagulants are employed in a coagulation method designed to ascertain how changes in centrifugation speed affect pH during the natural coagulant fruit extract separation process. Additionally, based on SNI 06-1903-2017, which satisfies the standard criteria for SIR 20 rubber, this research investigated the impact of natural coagulants on various rubber properties, including ash content, Mooney viscosity, dirt content, Dry Rubber Content (DRC), Plasticity Retention Index (PRI), and Initial Plasticity of Rubber (Po).

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2. Materials and Methods

The natural coagulant centrifugation method used in this study was produced at the Microbiology Laboratory, Institut Teknologi Sumatera. Testing for rubber properties was done at PT Perkebunan Nusantara VII's diagnostic laboratory, Way Berulu Unit, Pesawaran, Lampung. The Way Berulu Unit's Sub-Div. 1 garden provided the latex samples, which were collected every three days using natural coagulants AB and AC and a D3 rubber tapping device. The PB 260 rubber clone, which is sixteen years old, was planted in 2007, and tapping began in 2012.

2.1. Coagulant preparation

AB and AC were the natural coagulants that were employed, while 2% formic acid was the chemical coagulant that was used as the control variable. Organic coagulants were cleaned by running water, and then a blender was used to purée each fruit. The mashed fruit is then filtered to separate the extract from the pulp. Then the fruit extract was centrifuged at speeds of 3000 and 5000 rpm. Next, the fruit extract's pH was tested both before (at 0 rpm) and after (3000 and 5000 rpm) centrifugation. To coagulate the latex, the extracted fruit is placed in a measuring cup that holds 75 mL.

2.2. Latex sampling process

On PB 260 clone rubber trees, latex sampling was done every three days or at regular intervals using a tapping method of three Tap (tapping) D3. The sample has been tapped with a latex bottle, before being filtered to prevent contamination. For each of the eight samples to be utilized, take 150 mL of latex.

2.3. Latex coagulation process

150 mL of latex that has been measured is put into a coagulation container. In a 75 mL mixture of natural coagulant and latex, the ingredients were agitated until the mixture was uniformly dispersed. A stopwatch is used to measure the amount of time that latex coagulates until clots develop. Using a measuring cup, the rubber was extracted from the coagulated water once it had clothed. In addition, the water's pH was determined and the coagulated water's color was examined.

2.4. Rubber characteristic test

Tests on rubber properties such as Mooney viscosity, DRC, PRI, and Po as well as impurity content such as dirt content, ash content, and volatile materials. Rubber durability analysis is based on the SNI ISO 2013 standard and uses the Plasticity Retention Index (PRI) and Initial Plasticity (Po). The SNI 8384: 2017 standard is used for the Mooney viscosity analysis, whereas the SNI ISO 247: 2012 standard is used for dirt content characteristics such as ash content, and the SNI 8383: 2017 standard is used for rubber dirt content. Under the SNI 8356:2017 standard, the content of vaporized substances is tested.

3. Results and Discussion

3.1. The effect of coagulant type on Latex coagulation pH

Coagulants are utilized to speed up the coagulation process in latex, which is instigated by the latex's pH level dropping. The purpose of measuring pH is to determine the kind of acid and the concentration of hydrogen ions present in each extract of a natural coagulant. The outcomes of how the coagulant type influences the latex coagulation pH are displayed in Figure 1.

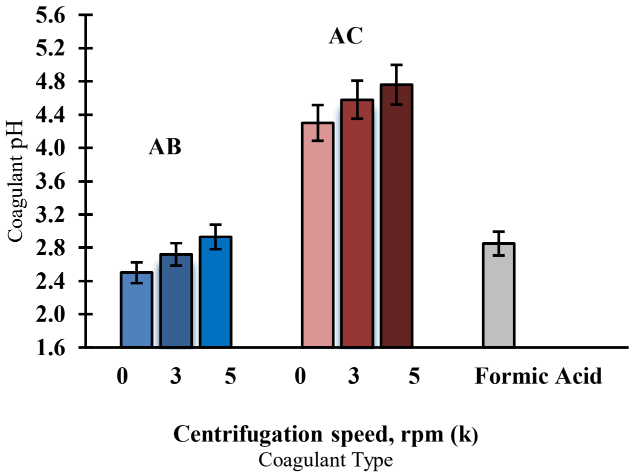

Fig. 1. The effect of coagulant type on latex coagulation pH

The pH level was impacted by the centrifugation rates of 0 rpm, 3000 rpm, and 5000 rpm used on the AB and AC natural coagulant extracts. The study's maximum pH value was the lowest pH value of 2.5 was discovered for AB natural coagulant without centrifugal treatment (0 rpm), while 4.76 was obtained for the natural coagulant subjected to centrifugation at 5000 rpm. In the meantime, the 2% formic acid chemical coagulant's pH rose to 2.85. These findings demonstrated that the pH values of the natural coagulants that were centrifuged at 3000 and 5000 rpm were greater than those of the coagulants that were not. Elevated centrifugation speed levels cause the natural coagulant's pH value to rise and the H^+ ion value to fall. The cause is the precipitation of organic acids such as ascorbic acid, citric acid, malic acid, and oxalic acid contained in the natural coagulant during the centrifugation process so that the amount of these organic acids in the coagulant decreases [6].

3.2. The effect of coagulant type on Latex coagulation time

The duration of the coagulant's addition to the latex until the latex coagulates is known as the coagulation period. Latex can coagulate with any kind of natural coagulant because the number of organic acids in the natural coagulants that are used varies [7]. The effect of coagulant type on coagulation time is shown in Figure 2.

Figure 2 The maximum coagulation time in AB without centrifugation (0 rpm) is 2.57 minutes, while in AC centrifugation treatment, the longest coagulation time is 5.44 minutes equals 5000 rpm. When used as a chemical coagulant, 2% formic acid had a coagulation time of 3.36 minutes. These findings suggest that the coagulant without centrifugation treatment (0 rpm) had a faster coagulation time than the coagulants with centrifuge treatment (3000 and 5000 rpm). The precipitation of organic acids in natural coagulants during the centrifugation process is the reason for the extended coagulation time. Because there is more organic acid present, the latex coagulation time needed is greater than for natural coagulants without centrifugation treatment. The coagulant's chemical composition and pH have an impact on the latex's coagulation time [8]. State that the latex will coagulate more quickly if the coagulant's pH is lower because H^+ ions have a stronger ability to bind OH ions in the latex.

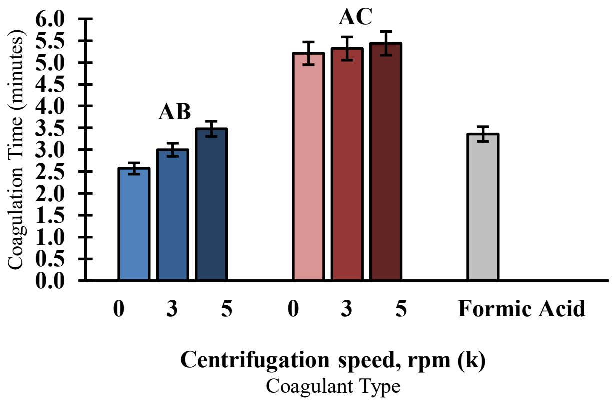

Fig. 2. The effect of coagulant type on latex coagulation time

3.3. The effect of coagulant type on DRC

The term "dry rubber content," or DRC, indicates the percentage of rubber particles in rubber latex. The quality of the product is better the higher the DRC value sample since there is also a higher amount of dry rubber in it, improving the sample's quality [9]. Figure 3 displays the findings about how coagulant type affects DRC.

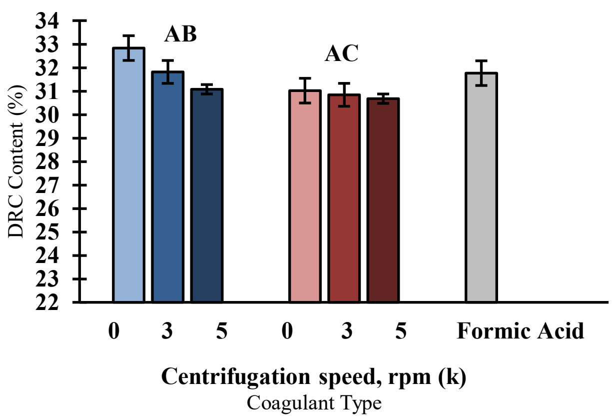

Fig. 3. The effect of coagulant type on DRC

The DRC value is influenced by centrifugation speed; a high speed will provide a low DRC value. This is because organic acids will precipitate at high centrifugation speeds to lessen the coagulant's coagulation strength and coagulate the rubber particles less. The DRC value will drop with decreased rubber particle content. The color of the ensuing coagulum serum, generated by AB and formic acid to produce a clearer serum and AC to produce a whiter serum, indicates the presence of fewer coagulated rubber particles. The presence of imperfectly coagulated latex is indicated by white serum, which lowers the DRC value by allowing the latex content to be transported by the coagulum serum [10]. Based on the coagulant comparison, AB without centrifugation (0 rpm) has a higher DRC value.

3.4. The effect of coagulant type on Po

The term "initial plasticity" (Po) refers to the plasticity of rubber that has been directly measured without any prior special treatment. Wallace Plastimeters are typically used to measure this [10]. To get an initial plasticity value that represents the initial resistance to degradation, Po analysis is employed this value is then used in the PRI test [11]. Figure 4 displays the findings about how the coagulant type affects Po.

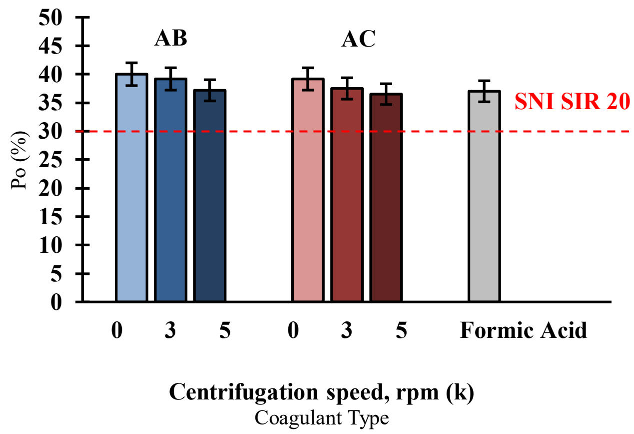

Fig. 4. The effect of coagulant type on Po

Figure 4 compares BB with the formic acid coagulants with lower pH values, AB, which has the lowest pH of 2.5, has a higher Po value of 40%. Formic acid's Po value as a chemical coagulant is 37%. Formic acid, AB, and AC as well as coagulants have complied with the SNI 06-1903-2017 standard's 30% SIR 20 requirement. The Po value is influenced by centrifugation speed; a greater centrifugation speed will result in a lower Po value. This is because the acids in natural coagulants precipitate, separating these organic acids' antioxidant content more and more [8]. The greater the rubber properties, the higher the Po value. Rubber characterized by a high Po value is characterized by an elongated molecular chain, providing resistance to oxidation, while rubber with a low Po value is distinguished by a shorter molecular chain. This is due to the soft texture and ease of oxidation of rubber with a short molecular chain. Using too much acid during the latex coagulation process and improperly handling rubber raw materials are two of the causes that affect the Po value [12].

3.5. The effect of coagulant type on PRI

According to Suwardin [13], the Plasticity Retention Index (PRI) measures the ability of raw rubber to withstand oxidation at high temperatures, both before and after curing at 130ºC for 30 minutes. Figure 5 displays the findings of the coagulant type's impact on PRI.

According to Figure 5, AB without centrifugation (94.17%) had the highest PRI value and AC centrifuged at 5000 rpm had the lowest PRI value (79%). Formic acid, on the other hand, had the highest PRI value (85.59%). Coagulants AB, AC, and formic acid have satisfied the minimum required value of 40% stipulated in the SNI 06-1903-2017 standard for SIR 20. Antioxidants, metal ions, latex's organic acid content, and the length of time it takes to test PRI all affect its value. The oxidation process at high temperatures that breaks down rubber molecules can be slowed down by the antioxidant content found in organic acids in natural coagulant extracts [14]. The PRI value is influenced by centrifugation speed; the lower the PRI value, the higher the centrifugation speed. This is because the organic acids contained within are precipitated more readily and their antioxidant contents are lost more readily at higher centrifugation speeds. After that, the rubber will deteriorate more quickly and the PRI value will drop [15].

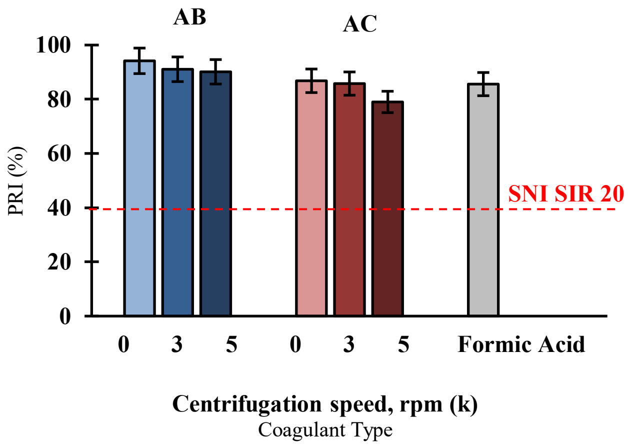

Fig. 5. The effect of coagulant type on PRI

3.6. The effect of coagulant type on mooney viscosity

Rubber plasticity testing uses a property called Mooney Viscosity. The length of the natural rubber molecular chain is described by Mooney viscosity. This investigation's Mooney viscosity is a parameter that is used to identify the properties of natural rubber [16]. Figure 6 displays the findings of the investigation on how coagulant type affects Mooney viscosity.

Based on Figure 6, the highest Mooney viscosity value is obtained for AB without centrifugation (0 rpm) which is 77 MU and the lowest PRI value is at 5000 rpm centrifugation BW which is 61 MU while for formic acid the Mooney viscosity value is 75 MU. The number of natural rubber molecular chains that branch so that the rubber's length is represented by the high Mooney viscosity value chain of molecules gets longer [5]. Natural coagulants' organic acid content affects the Mooney viscosity value. The organic acids that precipitate more and more throughout the centrifugation process are the reason for the low Mooney viscosity value, whereas the high Mooney viscosity value is brought on by the abundance of organic acids in natural coagulants. The Mooney viscosity value and the organic acid content decrease with increasing centrifuge speed. Next, it shows that the rubber molecule chain is getting shorter.

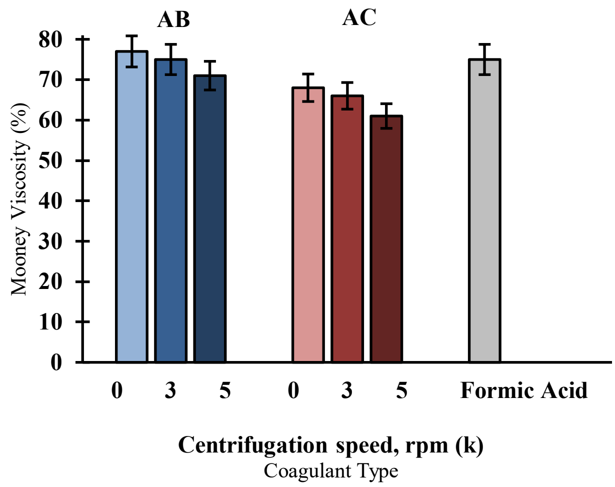

Fig. 6. The effect of coagulant type on Mooney viscosity

3.7. The effect of coagulant type on ash content

Rubber's ash content is caused by metals such as calcium, magnesium, potassium, sodium, and other mineral components. Minerals in the ash also contribute to its content of crystalline silicates [11]. Figure 7 displays the findings about how coagulant type affects ash content.

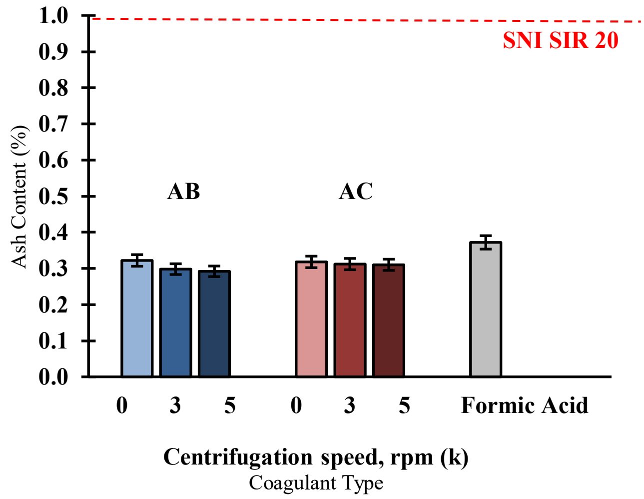

Fig. 7. The effect of coagulant type on ash content

Figure 7 shows that the highest ash content value is in AB without centrifugation (0 rpm) which is 0.322% and the lowest ash content value is in AB centrifuged at 5000 rpm which is 0.292% while for formic acid the ash content value is 0.372%. Coagulants A, B, and C as well as formic acid have satisfied SNI 06-1903-2017 standards for SIR 20, where 1% is the minimum value of the ash content test standard. Compared to the natural coagulant extract after centrifugation (3000 and

5000 rpm), the high ash concentration before centrifugation is caused by the fact that numerous mineral components have not yet been removed. Because formic acid is diluted with water that still includes a lot of minerals, formic acid has a high ash content. The presence of minerals in rubber can affect the dynamic characteristics of rubber products, including the elasticity and resistance to flex cracking of natural rubber [16].

3.8. The effects of coagulant type on dirt content

According to Handayani [17], dirt content is the quantity of material other than rubber that cannot be passed through a 325-mesh sieve. Several factors include the coagulants and equipment utilized, the purity of the latex, and assembling and disassembling machine components. Figure 8 displays the findings about the impact of coagulant type on dirt content.

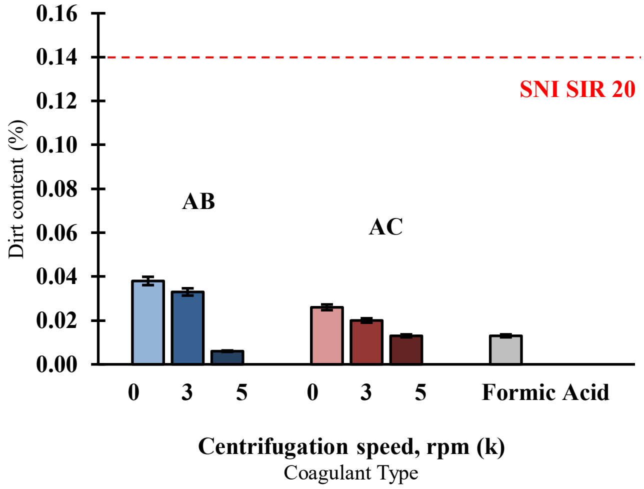

Fig. 8. The effect of coagulant type on dirt content

Based on Figure 8, the highest dirt content value was obtained for AB without centrifugation (0 rpm), namely, 0.038%, and the lowest dirt content was observed with AB centrifuged at 5000 rpm, at 0.006%. Meanwhile, the ash content for formic acid was recorded at 0.013%. Coagulants AB, AC, and formic acid have fulfilled the standards outlined in SNI 06-1903-2017 for SIR 20, which specifies a minimum dirt content test value of 0.16%. According to this investigation, the centrifugation treatment had a lower dirt content than the 0 rpm coagulant. The number of impurities present in natural coagulants is influenced by centrifugation speed; as centrifugation speed increases, more fiber or sand contaminants will precipitate out of the coagulant, lowering the dirt levels. The dynamic characteristics of rubber products, such as elasticity and resistance to flex breaking of natural rubber, can be diminished by high dirt content in rubber [18].

3.9. The effect of coagulant type on vaporized substance content

The volatile matter content indicates the amount of water, serum, and other substances retained in the rubber post-oven drying [16]. A lower volatile content in the rubber suggests higher quality, as it implies a reduced water content. The results regarding the effect of the type of coagulant on the volatile matter content are shown in Figure 9.

Figure 9 shows that the highest vapor content, at 0.236%, was observed in AC centrifugation (5000 rpm), while the lowest vapor content, at 0.153%, was recorded in AB without centrifugation (0 rpm). Additionally, the vapor content value for formic acid stood at 0.013%. Coagulants AB, AC, and formic acid have fulfilled the standards outlined in SNI 06-1903-2017 for SIR 20, which specifies a minimum value of 0.80% for the dirt content test standard. Rubber's volatile component concentration is influenced by centrifuge speed; the higher the speed, the faster organic acids in natural coagulants precipitate, preventing the coagulation process from being fully completed. Additionally, there will be less coagulated latex and more water binding. Accordingly, it results in a higher level of volatile chemicals [6]. Natural coagulants don't utilize any water at all, but the diluting procedure in 2% formic acid results in a larger concentration of volatile chemicals. Volatile substances in rubber can cause mold growth and unpleasant odors [12]. High levels of volatile substances will reduce the quality of rubber.

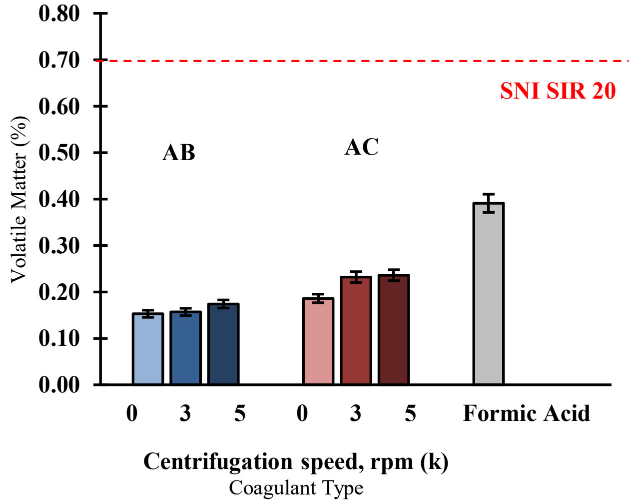

Fig. 9. The effect of coagulant type on volatile matter content

3.10. Advantages and disadvantages of natural and chemical coagulants

This study also compared the advantages and disadvantages of natural and chemical coagulants. Comparative data on the advantages and disadvantages of natural and chemical coagulants are shown in Table 1. All coagulants used in this study, both natural coagulants and chemical coagulants, meet SNI for SIR 20. However, the natural coagulants of AB and AC are fruits whose availability is not always available every time they are needed or are seasonal. But the price is cheap and environmentally friendly and safe for rubber plantation workers is the advantage of this natural coagulant. The color of the resulting coagulum is yellow and brownish for all coagulants used in this study.

Table 1. Advantages and disadvantages of natural coagulants and chemical coagulants

	Coagulant Type		
	AB	AC	Formic Acid
Adv	Meets SNI SIR 20 standard	Meets SNI SIR 20 standard	Meets SNI SIR 20 standard
	Color of Coagulum Brownish yellow	Coagulum color brown	Color of Coagulum Brownish yellow
	Environmentally Friendly	Environmentally Friendly	Not Environmentally Friendly
Disadv	Seasonal	Seasonal	Not seasonal

4. Conclusion

In the process of separating fruit extract, the speed of centrifugation impacts pH levels; as centrifuge speed increases, so does the pH of the natural coagulant. This is because the centrifugation process precipitates the organic acids in the natural coagulants, lowering their organic acid content. Superior properties of natural coagulants, such as low ash and volatile matter content, as well as high Po, PRI, DRC, and Mooney viscosity tests, are exhibited by Averrhoa in particular. Based on all test results related to the characteristics of this study, SNI 06-1903-2017 for SIR 20 is satisfied by the coagulants of star fruit, star fruit, and formic acid.

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