Application of Ca-Stearate Palm Oil Derivative Rubber Processing Aid in Testing Rubber Industry

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Abstract. In its application, *Ca-stearate* served as a *processing aid* to smooth the flow of rubber in the mold and reduce the viscosity value during the printing process of rubber goods. This study aims to observe the application of ca-stearate synthesis of palm oil derivatives compared to commercial ca-stearate manufacturing rubber goods between rubber *processing aid* (RPA) formulas. The testing was adjusted to the industry's evaluation parameters for the rubber goods production process. The results of the Spiral Flow Test showed that the length of rubber flow with RPA was 53.14%, and the commercial RPA was 38.16% longer than without RPA. The weight of rubber samples with RPA was 54.86%, while the commercial RPA was 42.58% heavier than without RPA. As for the *hardness* value, the change in the value of the *Compression set* was 25%, 100^{o} C, 72hrs, *Tensile Strength* (tensile strength), and *Elongation at Break*. The *rubber processing aid* formulation of *Ca-based* palm oil derivatives excels in the 3 PHR rubber formula; 68kgf, 2.72kg/ cm^{2}, 966.713kg/cm^{2}, and 145.75%.

Keywords: Ca-Stearate formula, rubber processing aid, import substitution, rubber industries

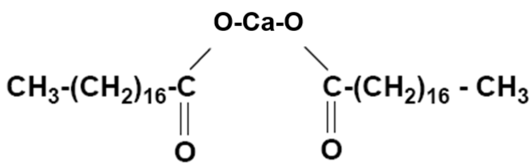
1 Introduction

Ca-Stearate is a carboxylate salt of alkaline earth of stearic acid and calcium with chemical formula $C_{36}H_{70}CaO_4$ or $Ca(C_{18}H_{35}O_2)_2$, molecular weight 607,03gr/mol and density 1,08gr/cm^3. This metallic soap is insoluble in water or in polar solvents but soluble in hot aromatic hydrocarbons such as Benzene, which is important in the application [1]. This metallic salt has widespread usage in industries for *processing aid*, *filler*, or color dispersions in paint, *varnishes*, and *lacquer* [1]. In rubber industries, these compounds are used as processing additives or aids, such as for releasing agents [2]. The salt function is to lose the stickiness of uncured rubber on mill surfaces, internal rotor mixers, and other process

ICoSHIP 2023, November 18-19, Surabaya, Indonesia

DOI 10.4108/eai.18-11-2023.2342561

machinery and to prevent lump formation [2]. This compound, as an additive material for rubber processing, also reduces viscosities; thus, it would smoothen molding processes. Ca stearate is also used as a mold release agent for cured rubber [3].



Rubber processing requires a certain temperature and duration in the extruder, transfer molding, and molding; thus, a Ca-Stearate melting point of 160^0C is suitable for the processes [3]. At this temperature, the melted salt incorporated in the rubber compound without leaving traces and defacing of rubber surface products.

2 Research Method

The materials used in this research involved polymer (rubber), activator, reinforcer, plasticizer, Calcium Stearate LAPTIAB Syntheses, Calcium Stearate Commercial [4], anti-oxidant, and accelerator. Meanwhile, the equipment used were Spiral Flow Tester, *MC Press*, digital scale, scissors, and ruler.

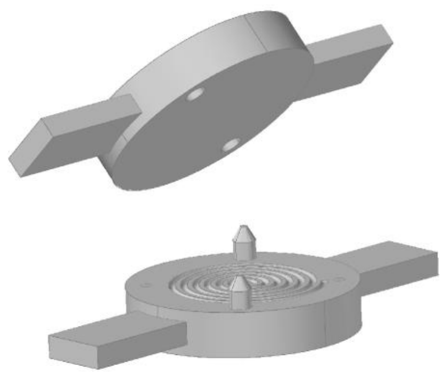


Fig 1. Spiral Flow Tester

The research process was conducted by formulating rubber compounds, making rubber products, and testing them. Rubber sheets were formed using rubber, activator, reinforcer, plasticizer, anti-oxidant accelerator, and Calcium Stearate LAPTIAB Syntheses or Calcium Stearate Commercial as a comparison or without the salt/blank as a control. The rubber formulas were kneaded to homogenize the components and then flattened to form a rubber sheet. The sheet was cut and scaled to 10 gr. These cutting sheets were molded by applying heat at 150^0C, pressure of 30kg/cm^2, injection/ pressure duration of 25 seconds, and flow for 5 minutes, in which melted rubber flowed through the mold channel. After this process, the mold was opened, and the tested material was measured [5]. The tested parameter was rubber form in the channel, and its length and weight were measured. The remaining rubber did not enter the channel, and its weight was also measured.

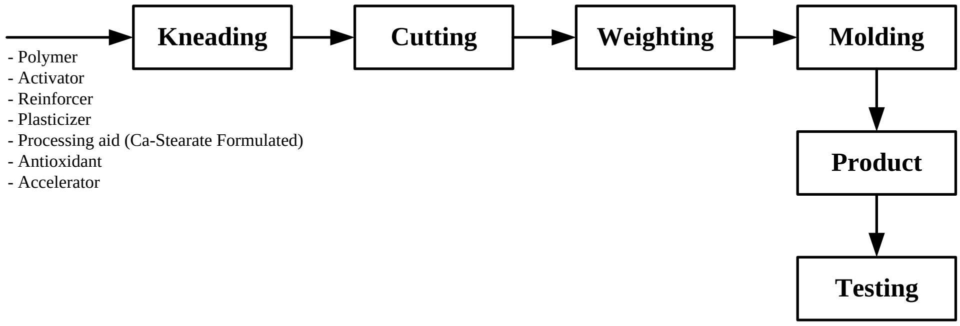


Fig 2. Flow Diagram of Rubber Processing Aid (RPA) Addition in Rubber Compound Testing

The material for the rubber composition formula used in the testing *Rubber Processing Aid* (RPA) is shown in Table 1.

Table 1. Rubber Compound Formula for Rubber Processing Aid Test

No	Material	Compound (phr)		
		LAPTIAB	**Commercial**	**Control**
1	NBR N3345	100	100	100
2	ZnO	5	5	5
3	Stearic acid	1	1	1
4	TMQ	1	1	1
5	IPPD	1	1	1
6	DOP	10	10	10
7	Processing aid	30	30	0
8	Sulfur	1,5	1,5	1,5
9	CBS	1,5	1,5	1,5
10	TMTD	0,5	0,5	0,5
11	N 550	30	30	30
	Total	181,5	181,5	151,5

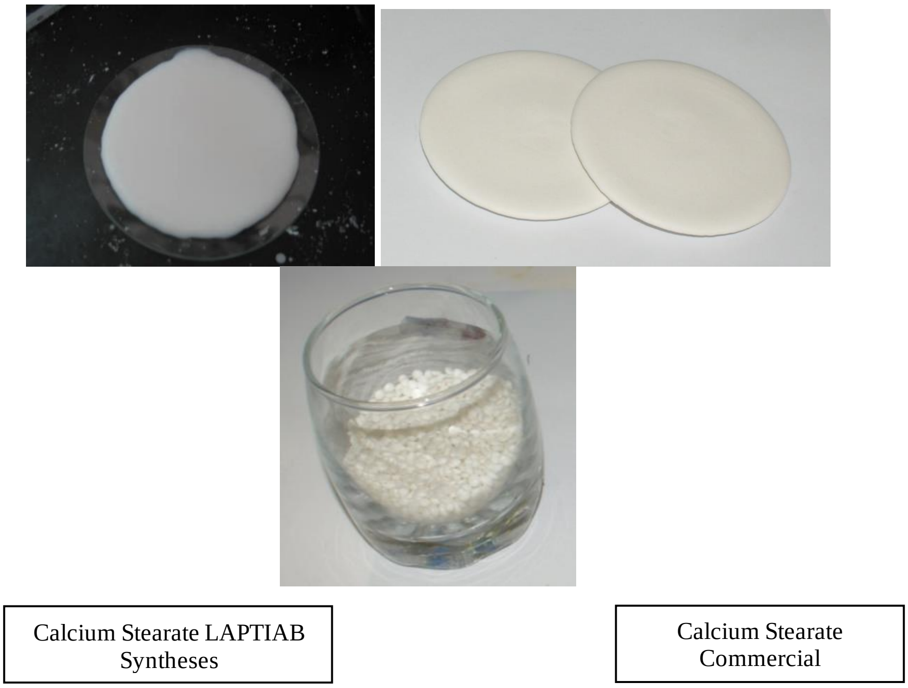


Fig 3. Rubber Processing Aid (RPA) of Palm Base Calcium Salt for Rubber Industries

Fig 4. Rubber Molding Product Using *Rubber Processing Aid* (RPA) of Palm Based Calcium Salt

3 Results and Discussions

The tests were subjected to the rubber compounds using a formula applied in automotive component rubber industries. The formula used rubber, activator, reinforcer, plasticizer, anti-oxidant accelerator, and Rubber Processing Aid of Calcium Stearate LAPTIAB Syntheses or

Rubber Processing Aid of Calcium Stearate Commercial as a comparison or without Rubber Processing Aid or blank as a control. The distance passage and its weight in The Spiral Flow Apparatus Tester of Rubber Compound used Ca-Based Palm Oil Derivative Rubber Processing Aid

The Spiral Flow Tester Apparatus was used to evaluate the flowability of rubber compound in a mold when exposed to mold temperature and pressure by measuring the distance of a compound in the spiral passage of the apparatus. The apparatus was a mold of an Archimedean spiral in which the distance from the center increased proportionately to the rotation angle and was used to determine spiral flow.

Table 2. Distance Passage in The Spiral Flow Apparatus Tester of Rubber Compound Using Ca-Stearate Palm Oil Derivative Rubber Processing Aid

RPA Type	Running 1	Running 2	Running 3	Total	Mean	Distance Passage Increase (%)
Without RPA (Control)	35	34		69	34.50	
Ca-Stearate RPA - LAPTIAB	50.5	54.5	53.5	158.5	52.83	53.14
Commercial RPA	46	48	49	143	47.67	38.16

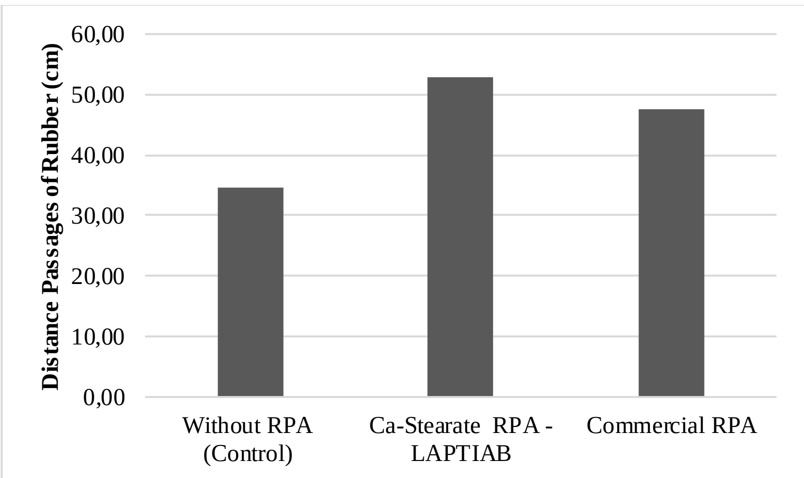


Fig 5. Distance Passage in The Spiral Flow Apparatus Tester of Rubber Compound Using Rubber Processing Aid Vs Control

The measurement of distance passages of rubber compounds exhibited the significant differences among the rubber formula compounds. The control or compound without RPA had a distance passage of 34.5 cm and a weight of 2.85 gr. In comparison, the Rubber Processing Aid of Calcium Stearate LAPTIAB Syntheses had a Distance Passage of 52,83 cm and a Weight of 4,41 gr, and the Rubber Processing Aid of Commercial had a Distance Passage of 47,67 cm and Weight of 4,06 gr. It can be concluded that RPA improved the fluidity of the compounds, thus it increased the possibility of filling all mold cavities and avoided air trapped in rubber products.

Table 3. Rubber Weight in The Spiral Flow Apparatus Tester of Rubber Compound Using Ca-Stearate Palm Oil Derivative Rubber Processing Aid

RPA Type	Running 1	Running 2	Running 3	Total	Mean	% Weight Increase
Without RPA (Control)	2.9257	2.7648		5.6905	2.85	
Ca-Stearate RPA – LAPTIAB	4.2113	4.4956	4.5117	13.2186	4.41	54.86
Commercial	3.9644	4.0431	4.1626	12.1701	4.06	42.58

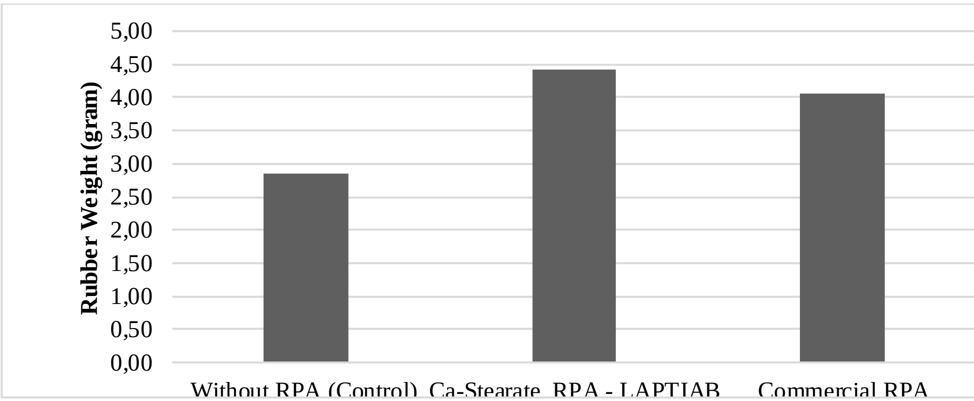


Fig 6. Rubber Weight in the Spiral Flow Apparatus Tester of Rubber Compound Using Ca-Stearate Palm Oil Derivative Rubber Processing Aid

3.1 Effect of RPA Addition to Rubber Hardness Value

Rubber hardness values are compared between the rubber compound without RPA addition, the rubber compound content RPA of calcium stearate LAPTIAB Syntheses, and the rubber compound content RPA of commercial**.** The tests show a slight increase of 0.5kgf with RPA addition of either one of 1 PHR (Per Hundred Rubbers) compared to the control. However, adding RPA up to 3 PHR has a different response. The Calcium Stearate LAPTIAB Syntheses RPA addition increases rubber Hardness from 3 kgf to 68 kgf. In comparison, the Commercial RPA addition does not affect rubber Hardness and remains the same at 65 kgf.

Table 4. Hardness Value of Rubber Compound with Different PHR RPA Addition

No.	Sample	Hardness (kgf)
1	Without RPA (O)	65
2	*Ca-Stearate* RPA - LAPTIAB (1 PHR)	65.5
	Commercial RPA (1 PHR)	65.5
3	*Ca-Stearate* RPA - LAPTIAB (3 PHR)	68
	Commercial RPA (3 PHR)	65

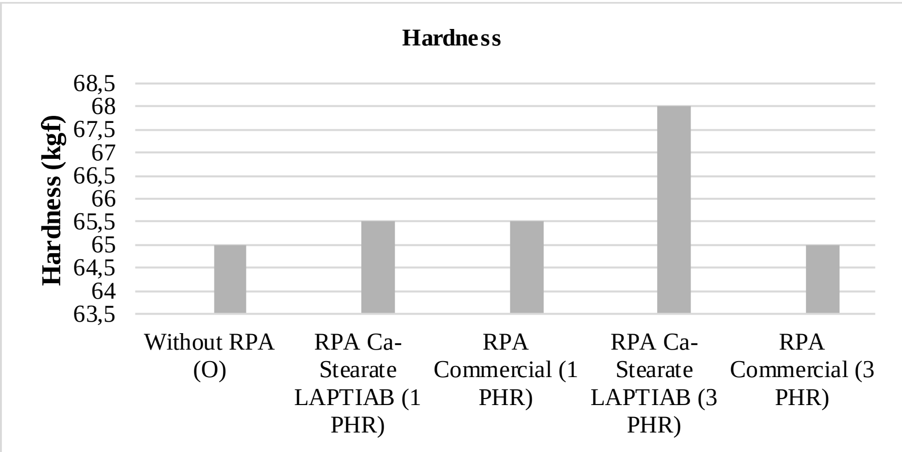


Fig 7. Hardness Value of Rubber Compound with Different PHR RPA Addition

3.2 Effect of RPA Addition in Rubber Compound on Compression Value

The rubber compound flow test subjected to *compression was at* 25%, 100^{o}C, 72hrs. The compression values of the rubber compound without RPA addition, the rubber compound content RPA of Calcium Stearate LAPTIAB Syntheses, and the rubber compound content RPA of Commercial were compared**.** The amount of RPA added was 1 PHR and 3 PHR. The tests showed that before heating, the samples' compression values were almost the same regardless of the addition of RPA, with the value of 13.1 -13.18 kg/cm^2. After the test load was conducted, the Compress Value of the sample without RPA addition and RPA addition at a low concentration of 1 PHR were the same at 10.68 – 13.7 kg/cm^2. Adding more RPA at 3 PHR slightly decreased the Compress Value of the Calcium Stearate LAPTIAB Syntheses at 10.38 kg/cm^2, while for the Commercial RPA also a bit decreased at 10.57 kg/cm^2.

Table 5. Compression Value of RPA Effect on Rubber Compound

No.	Sample	Start (kg/cm^2)	Compression (kg/cm^2)	Change (kg/cm^2)
1	Without RPA	13.1	10.68	2.42
2	Ca-Stearate RPA- LAPTIAB (1 PHR)	13.15	10.7	2.45
	Commercial RPA (1 PHR)	13.18	10.68	2.5
3	*Ca-Stearate* RPA - LAPTIAB (3 PHR)	13.1	10.38	2.72
	Commercial RPA (3 PHR)	13.1	10.57	2.53

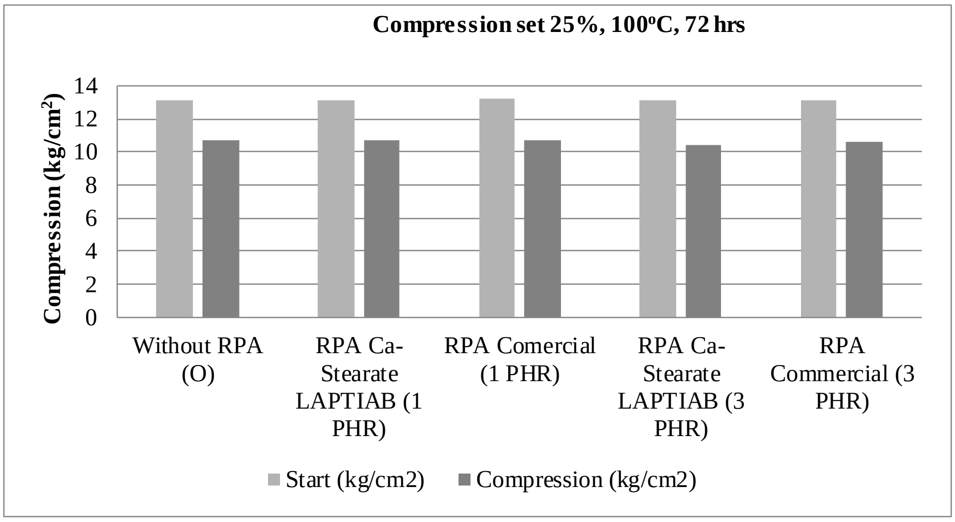


Fig 8. Compression Value of RPA Effect on Rubber Compound

3.3 Effect of RPA Addition in Rubber Compound on Tensile Strength

The tensile strengths of the rubber compound without RPA addition, the rubber compound content RPA of calcium stearate LAPTIAB Syntheses, and the rubber compound content RPA of commercial were also compared**.** The amount of RPA added was 1 PHR and 3 PHR. It showed that all the samples with the addition of RPA increased their Tensile Strength, compared to rubber compounds without RPA addition. Rising RPA concentration in the compound formulas also increased their tensile strength. In addition, The commercial RPA had a bigger effect than calcium-stearate LAPTIAB Syntheses on the tensile strength. The sample without RPA had a tensile strength of 921.508 kg/cm^2, while Calcium Stearate LAPTIAB Syntheses RPA addition at 1 PHR had a Tensile Strength of 938.125 kg/cm^2. Moreover, the tensile strength of 3 PHR was 966.713 kg/cm^2, the commercial RPA addition at 1 PHR was 946.045 kg/cm^2, and the tensile strength of 3 PHR was 976.157 kg/cm^2.

Table 6. Effect of RPA Addition in Rubber Compound on Tensile Strength

No.	Sample	Tensile Strength (kg/cm^2)
1	Without RPA	921.508
2	Ca-Stearate RPA-LAPTIAB (1 PHR)	938.125
	Commercial RPA (1 PHR)	946.045
3	Ca-Stearate RPA-LAPTIAB (3 PHR)	966.713
	Commercial RPA (3 PHR)	976.157

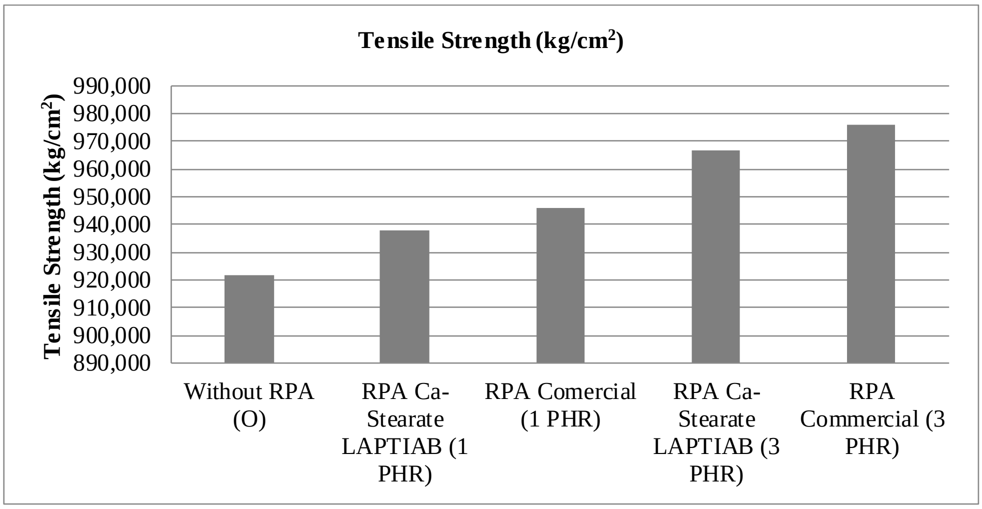


Fig 9. Effect of RPA Addition in Rubber Compound on Tensile Strength

3.4 Effect of RPA Addition in Rubber Compound on Elongation at Break

The elongations at break of the rubber compound without RPA addition as a control, the rubber compound content RPA of Calcium Stearate LAPTIAB Syntheses, and the rubber compound content RPA of commercial were compared**.** The amount of RPA added was also 1 PHR and 3 PHR. The tests showed that the samples with the addition of RPA had mixed effects. The three samples had a slight effect, with the one having shorter elongation at break and the other two having longer ones. One exceptional occurrence had a big effect. The rubber compounds without RPA addition had elongation Break of 112.5 %, while Calcium Stearate LAPTIAB Syntheses RPA and the commercial RPA addition at 1 PHR had elongation of break at 115.5 % and 117.5 % respectively.

Nevertheless, the commercial RPA addition at 3 PHR had elongation at break of 107 %, which was less than the control. Meanwhile, the Calcium Stearate LAPTIAB Syntheses RPA addition of 3 PHR surged elongation at break of 145.75 %, 33.25% longer than the control.

Thus, a higher concentration of Calcium Stearate LAPTIAB Syntheses RPA addition improved the elasticity of the rubber compound.

Table 7. Effect of RPA Addition in Rubber Compound on Elongation at Break

No.	Sample	Elongation at Break (%)
1	Without RPA	112.5
2	Ca-Stearate RPA-LAPTIAB (1 PHR)	115.5
	Commercial RPA (1 PHR)	117.5
3	Ca-Stearate RPA-LAPTIAB (3 PHR)	145.75
	Commercial RPA (3 PHR)	107

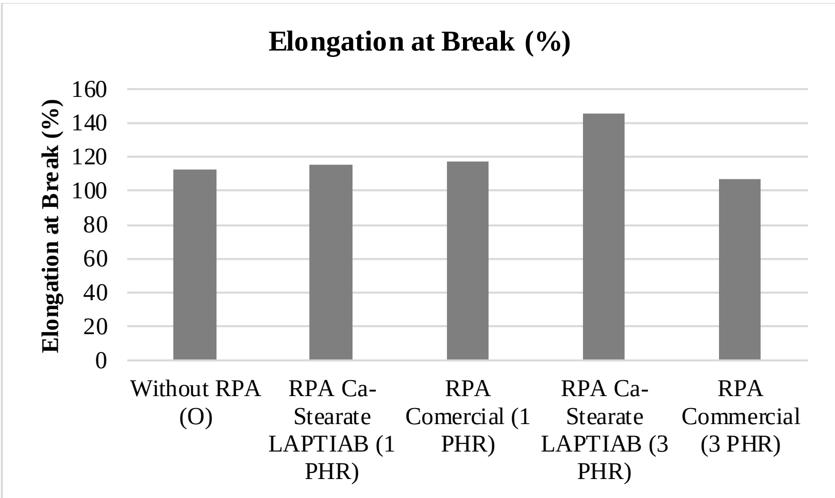


Fig 10. Effect of RPA Addition in Rubber Compound on Elongation at Break

Table 8. RPA Specification of *Ca-Stearate*

Properties	Commercial RPA	Ca-Based RPA-LAPTIAB
Form	White pastilles, homogen, and solid	White pastilles, homogen, and solid
Specific Gravity (g/cm^3)	1.15	1,26
Dropping Point (°C)	60	80
Ash Content (%)	27	27,92
FFA (%)	< 1	41
Melt Product Feature	Instantly melt homogeneously White	Instantly melt homogeneously White

4 Conclusions

The tests showed a mixed result of two RPA additions. Adding Ca-Stearate RPA - LAPTIAB in rubber compound improved its flowability more than the commercial in the Spiral Flow Apparatus Tester discerned to control the Distance Passage of 53.14 % and its Weight 54.86 %. Adding RPA at 3 PHR gave the highest increasing hardness value using Ca-Stearate RPA - LAPTIAB at 68 kgf. RPA did not affect the Compression Value at a low concentration of 1 PHR and Commercial RPA of 3 PHR, but it reduced more using Ca-Stearate RPA - LAPTIAB of 3 PHR at 10.57 kg/cm^2, while the control one was 10.68 kg/cm^2. The addition of RPA improved its Tensile Strength. Moreover, Commercial RPA of 3 PHR had the highest effect at 976.157 kg/cm^2, compared to the control one, which was at 921.508 kg/cm^2. The Elongation at Break improved slightly by adding RPA at a low concentration of 1 PHR, and it decreased using Commercial RPA of 3 PHR at 107 %, compared to the control at 112,5 %. However, using Ca-Stearate RPA - LAPTIAB of 3 PHR surged elongation at break of 145.75 %, 33.25% longer than the control one.

Acknowledgment

This research was conducted at the Research Center for Agroindustry, Research Organization for Agriculture and Food - BRIN. The authors would like to thank all the team members involved in the Ca-Stearate Palm Oil Derivative Rubber Processing Aid Application in Rubber Industry Testing and also PT Trisigma Indonusa for providing the testing site.

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