The effect of chitosan on the characteristics of the ramie rope as fishing gear material

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Abstract. The creation of environmentally friendly fishing gear is one of the focuses of the fisheries today. The use of natural materials as an alternative material for fishing equipment is one solution that can be taken. One natural material that has been widely used is ramie fiber, but information on the physical and mechanical properties of ramie rope is still very limited. In this study, chitosan was used to coat the ramie rope, in order to improve its mechanical properties. This study aims to determine the physical and mechanical properties of ramie rope and determine the opportunity for its use as fishing gear. This research was conducted in September-December 2017, located at the Laboratory of Fishing Gear Technology, of Fisheries Resource Utilization Department, Faculty of Fisheries and Marine Science Technology, Bogor Agricultural University and Laboratory of Wood Building Engineering and Design, Department of Forest Products Technology, Faculty of Forestry, Bogor Agricultural University. The research method used is an experimental laboratory. Ramie rope used was ±3 mm in diameter, and length of sample of 35 cm. The physical properties observed were color, stiffness, and impression of touch. The mechanical properties observed were breaking strength and elongation. The results showed that the ramie rope uncoated with chitosan in yellowish white, the texture was rough and stiff. Meanwhile, ramie rope has a creamy color, smooth surface texture and not too stiff. The breaking strength of ramie ropes with chitosan and without chitosan was significantly different (P value (1.6×10^{-5}) <0.05). Ramie rope coated by chitosan has an average breaking strength of 37.03 kgf or 0.011 kgf/tex, while ramie rope without chitosan has a breaking strength average of 30.08 kgf or 0.013 kgf/tex. The elongation of ramie rope coated and uncoated by chitosan is not significantly different (P value: 0.66>0.05). The elongated ramie rope coated by chitosan has an average of 17.93 mm, while the ramie rope without chitosan 17.72 mm. The breaking strength of ramie rope after being immersed for 42 days experienced a decrease in strength of 42.23%.

Key Words: breaking strength and elongation, environmental friendly, ghost fishing, physical and mechanical properties.

Introduction. The use of fishing gear materials undergoes dynamic changes. Humans initially caught fish using simple materials around them, such as rocks, wood, twigs, and so on. Furthermore, making plant fibers become rigging and used to catch fish (Vond Brandt 2005). Later in the early 19th century, fishermen began to switch to using synthetic materials as material for fishing. The rise of the use of synthetic materials is inseparable from the incessant research conducted at that time and the discovery of the advantages of synthetic materials for fishing equipment (Klust 1982, 1983).

The use of synthetic materials that are so massive, has a negative impact on the environment. One of them is the occurrence of the ghost fishing phenomenon for missing a fishing gear. Ghost fishing is a phenomenon that continues to capture a missing fishing gear, without the control of fishermen (Smolowitz 1978; Perrin et al 1994; Laist 1995). The missing fishing gear will continue to make arrests until the fishing power (capture ability) of the fishing gear is lost, or in other words, until the fishing gear is damaged (Erzini et al 1997). One characteristic of synthetic materials is that it is not easily damaged, so fishing equipment made from synthetic materials will have the chance of long-term ghost fishing when lost. Some fishing gear made from synthetic materials may cause ghost fishing including gillnet, trammel net, traps, etc. (Sancho et al 2003; Al-Masroori et al 2004; Takagi et al 2007; Marco et al 2015).

The use of fisheries resources must be carried out according to environmentally friendly principles. The fishing gear used must have good selectivity, to do not damage habitat, to have a low biodiversity impact, and to do not endanger the protected fauna (FAO 1995). Therefore, the selection of the right fishing gear is also important, in order to minimize the adverse effects of fishing gear when operated.

The use of natural materials as a substitute for synthetic materials in fishing equipment certainly requires a comprehensive study. Factors that can be taken into consideration are physical properties (color, the impression of touch, stiffness, size), and mechanical properties including breaking strength, elongation, resistance to friction, and so forth. In addition, the availability of raw materials and low production costs must also be considered.

Ramie rope (*Boehmeria nivea*) is a natural material that has been widely used today. This rope is widely used, especially large rope for the purposes of rigging in the shipping sector. Ramie rope is a natural rope that has a high breaking strength so that it has the potential to be able to use it as a material for fishing equipment. According to Soeprijono et al (1973), the extensibility of ramie rope is also low, so it is quite stable when used. In this study, chitosan was used to coat the ramie rope, in order to improve its mechanical properties. The aims of this study was to determine the physical and mechanical properties of the ramie rope coated and uncoated by chitosan and also to determine the rate of degradation of the rope soaked in freshwater and seawater.

Material and Method. The study was conducted in September-December 2017, held at the Laboratory of Fishing Gear Technology, of Fisheries Resource Utilization Department, Faculty of Fisheries and Marine Science Technology, Bogor Agricultural University, and Laboratory of Wood Building Engineering and Design, Department of Forest Products Technology, Faculty of Forestry, Bogor Agricultural University. The research method used was an experimental laboratory.

Materials and tools used were:

1. Samples of ramie rope with a diameter of ±3 mm as 200 samples. Each sample was cut to 35 cm long pieces.
2. 1% chitosan solution as much as 3 liters.
3. Seawater and freshwater each of 25 liters.
4. Plastic jars to soak 5 groups of sample.
5. Scissors and cutter blades.
6. Ruler.
7. Universal testing machine (UTM) INSTRON

The study began with measuring the weight and diameter of ramie rope. Then immerse the ramie rope in 1% chitosan solution for 24 hours (Figure 1). Then the physical and mechanical properties of the ramie rope coated and uncoated by chitosan were observed.

Figure 1. Immersion of ramie rope in 1% chitosan solution.

The physical properties observed included color, the impression of touch, stiffness, diameter, and weight. Meanwhile, the mechanical properties observed were breaking strength and elongation.

The next step was soaking the ramie rope coated and uncoated by chitosan in freshwater and seawater, to determine the degradation rate. Soaking was done for 42 days, and testing of breaking strength and elongation was carried out every week.

***Statistical analysis**.* Determination of physical properties was analyzed descriptively. Furthermore, the effect of the use of chitosan on the mechanical properties of ramie rope was analyzed using ANOVA (Analysis of variance), and the experimental design used was Completely Randomized Design.

Results and Discussion

Physical properties of ramie rope. Ramie rope that was uncoated with chitosan appeared yellowish white, the texture was rough and stiff. According to Subandi (2011), the natural color of ramie fiber is white. The color will undergo changes that are affected by the manufacturing and storage process. In the manufacturing process, if ramie fiber is contaminated by eating tannin, it will turn yellowish white. In addition, according to Ihsan (2018), ramie fiber has rigid characteristics and low elasticity. Meanwhile, ramie rope coated by chitosan has a creamy color, smooth surface texture and not too stiff. Ramie rope coated with chitosan has a darker color than ramie rope without chitosan. This is because chitosan is used to coat yellowish cords. Mima et al (1983) stated that the color of chitosan is yellowish white. According to Kusumawati & Tania (2012), chitosan membranes have very small pores, so the surface is smooth and shiny. Ramie rope coated and uncoated by chitosan can be seen in Figure 2.

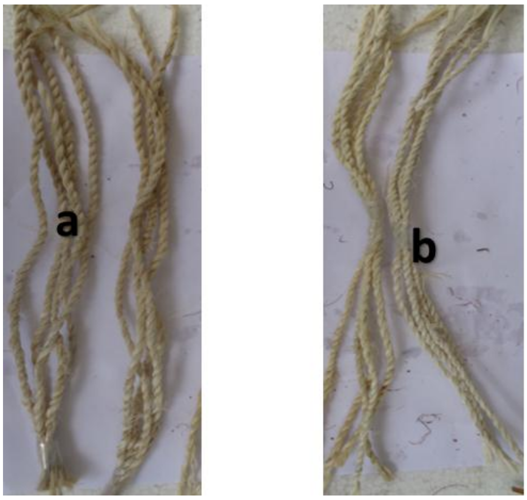

Figure 2. a) Ramie rope coated by chitosan, b) ramie rope uncoated by chitosan.

The weight and diameter of chitosan-coated ramie rope is higher than that which is not chitosan coated. The average weight of ramie coated chitosan is 1 g, with an average diameter of 3.1 mm. Meanwhile, the average weight of ramie rope which is uncoated by chitosan is 0.8 g, with an average diameter of 3 mm. Addition of the weight and diameter of the ramie rope is caused by seeping and sticking chitosan to the rope fiber, then drying.

The direction of twisting the ramie rope used is Z. The direction of the twist of a rope depends of course on the habits of the rope maker and the purpose of using the rope itself. This ramie rope making machine has a clockwise direction of rotation. This, results in the direction of the twist that is produced are Z-stretch (Figure 3).

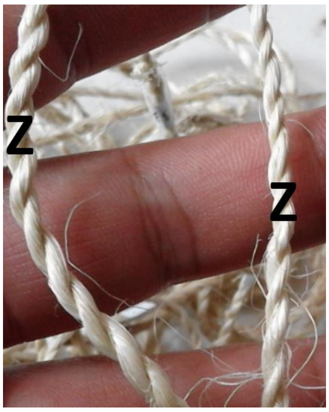

Figure 3. The direction of Z-twisted on ramie rope.

Mechanical properties of ramie rope. The breaking strength of ramie ropes with chitosan and without chitosan was statistically significantly different (P value (1.6 x 10-5) <0.05). Ramie rope has an average breaking strength higher than ramie rope without chitosan. Ramie rope with chitosan has an average breaking strength of 37.03 kgf or 0.011 kgf/tex, while ramie rope without chitosan has an average breaking strength of 30.08 kgf or 0.013 kgf/tex (Figures 4 & 5). Chitosan coating on ramie rope can increase the breaking strength of the rope by 23.09%. This increase in breaking strength is due to the chitosan layer on the ramie rope providing additional breaking strength. According to Wuriyudani et al (2017), the addition of chitosan to the banana midrib fiber rope can increase its breaking strength and can reduce the rope's water absorption.

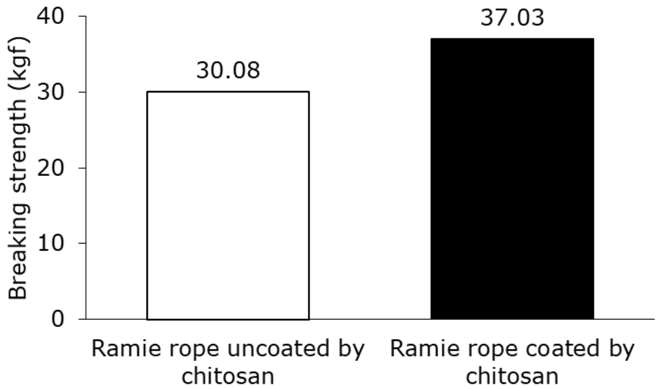

Figure 4. Breaking strength of ramie rope coated and uncoated by chitosan.

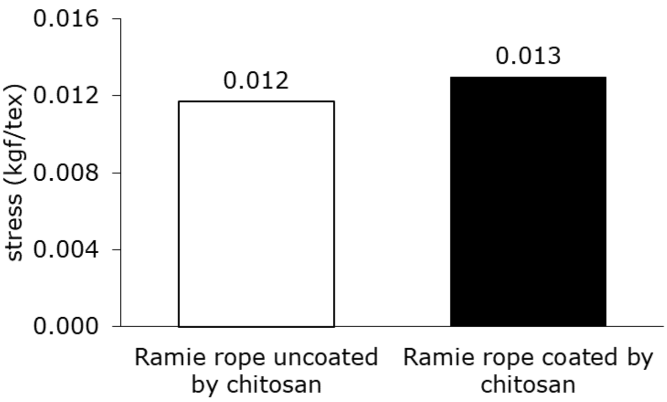

Figure 5. Stress of ramie rope coated and uncoated by chitosan.

The elongation of ramie rope coated and uncoated by chitosan is not significantly different (P value (0.66) >0.05). This means coating chitosan on ramie rope does not have a significant effect on its elongation. The elongated ramie rope coated by chitosan has an average of 17.93 mm, while the uncoated rope 17.72 mm (Figure 6). This is due to the characteristics of rigid ramie rope due to its very tight constituent cells so that the hemp rope has a small stretch strength. According to Soeprijono et al (1973), ramie fiber has a rigid nature so that the level of elasticity and elongation is low. The elongation of ramie rope without chitosan was 5.06%, while the hemp rope with chitosan was 5.12%. According to Noerati et al (2013), the spread of hemp fiber ranges from 2 to 10%.

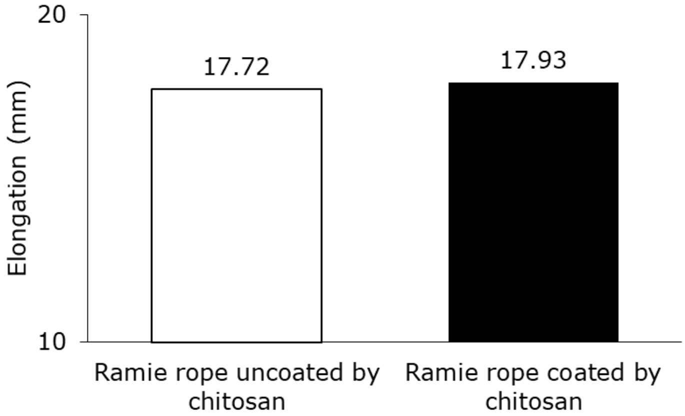

Figure 6. Elongation of ramie rope coated by chitosan and uncoated by chitosan.

The chitosan polymer chain structure is composed of monomers which form very long straight chains (Yanming et al 2001). When ramie is soaked in chitosan solution, chitosan polymers that form a straight chain will wrap around and coat the ramie rope, so that the chitosan will stick well to the rope. In addition, it will also be possible to form branched polymers which are combined through cross-linking between chitosan and cellulose making up ramie rope. Assisted bonds will increase the breaking strength and elongation of chitosan-coated ramie rope.

Effect of immersion on breaking strength of ramie rope. Chitosan coated and uncoated ramie rope was soaked in freshwater and seawater for 42 days. The initial breaking strength of the ramie rope coated by chitosan before being immersed in seawater and freshwater was 48.35 kgf or 0.016 kgf/tex. Furthermore, the breaking strength of ramie rope coated by chitosan, soaked in both freshwater and seawater has fluctuated, with a downward trend. In the 42nd day immersion, the breaking strength of ramie rope soaked in freshwater was 27.93 kgf or 0.0098 kgf/tex and soaked in seawater was 27.13 or 0.0095 kgf/tex (Figure 7).

The initial breaking strength of ramie rope uncoated by chitosan was 36.55 kgf or 0.016 kgf/tex. The breaking strength subsequently fluctuated with a downward trend until the 42nd-day immersion. At the 42 days, day immersion the breaking strength was 22.048 kgf or 0.0098 kgf/tex for seawater, while for immersion in freshwater the breaking strength was 22.02 kgf or 0.0095 kgf/tex. More clearly, the stress of ramie rope uncoated by chitosan and soaked in freshwater and seawater can be seen in Figure 8.

The breaking strength of ramie rope without chitosan in a certain immersion period is generally higher than that of ramie rope without chitosan. Based on the statistical test, the breaking strength of the ramie rope coated and uncoated by chitosan was statistically significantly different, P value (7.2 x 10-4) <0.05 for seawater and P value (1.2 x 10-3) <0.05 for freshwater. This proves that chitosan coating on hemp rope will inhibit the decay process on the rope so that when the rope is immersed in freshwater and seawater, the breaking strength can be maintained for a longer period than that of ramie rope without chitosan. According to Soeprijono et al (1973) naturally, ramie fiber has properties that are resistant to bacteria and fungi, so this rope tends to be more durable than other types of rope. Chitosan coating can increase the durability of the hemp rope against the growth of decomposing bacteria because chitosan has anti-bacterial properties (Pelczar & Chan 2005; Herliana 2010; Kumar et al 2011). Coating of chitosan on the rope can also reduce the absorption of the water. Based on research conducted by Wuriyudani et al (2017), coating chitosan on a banana rope can reduce the water absorption by 50%. As a result, the chitosan coated ramie rope will absorb less water than the ramie rope without chitosan. This will reduce the decay rate too because the decomposing bacteria contained in the ramie rope will be less.

The value of breaking strength of ramie rope on seawater immersion media is on average higher than in freshwater (Figures 7 & 8), this condition occurs both on ramie ropes with and without chitosan. This is presumably because the salt content in seawater media can inhibit several types of decomposing bacteria. Except for halophilic bacteria, namely bacteria that can withstand high levels of salt up to a concentration of 26.6%. According to Ilyas & Arifudin (1972), salt has bacteriostatic properties (inhibiting power) and bacteriocide (killing power) against bacteria. According to Rahayu et al (1992), the salt will increase osmotic pressure so that bacterial cells will lose water content, salt ionization will produce chlorine ions which are toxic to microorganisms, and salt can interfere with the work of proteolytic enzymes because it can lead to denaturation of bacterial proteins.

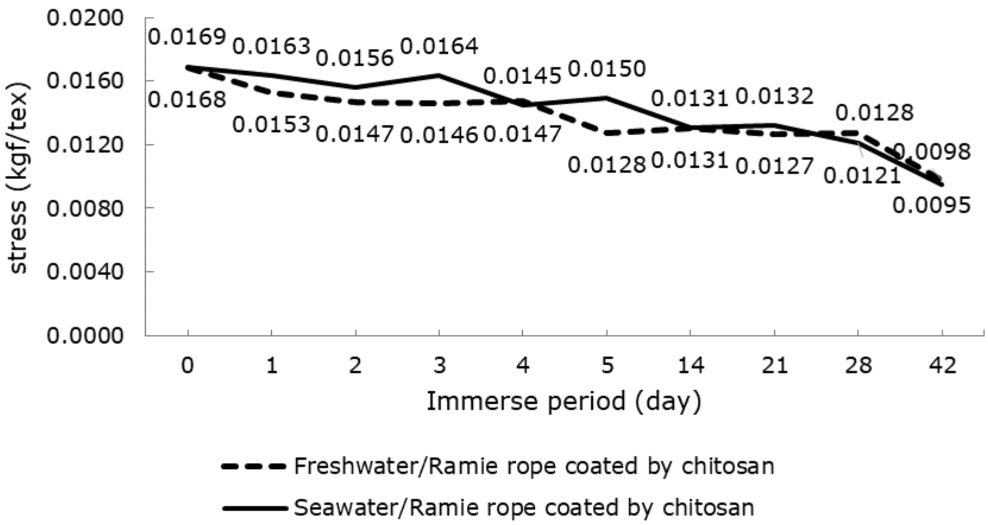

Figure 7. The stress of ramie rope coated by chitosan has an effect on the immersion period.

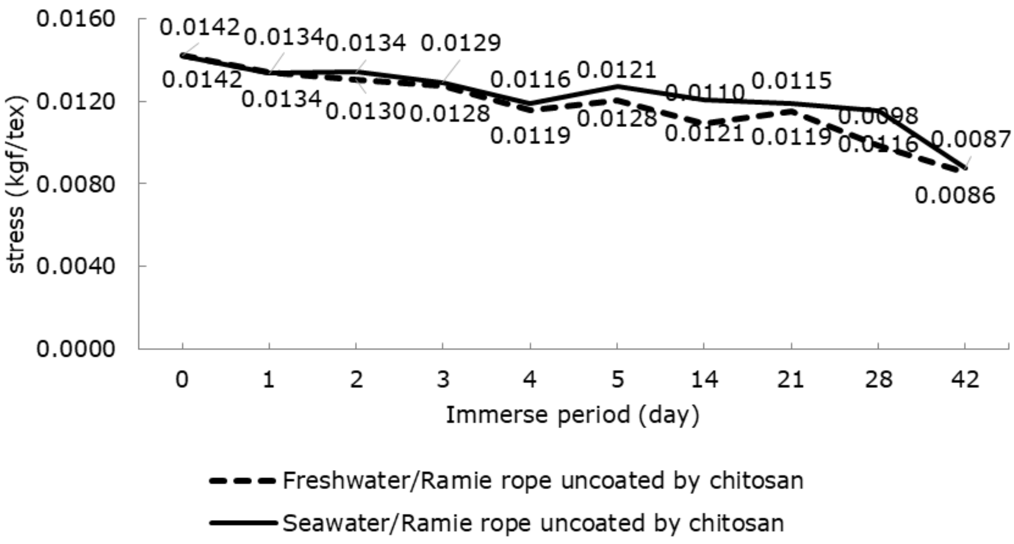

Figure 8. The stress of ramie rope uncoated by chitosan has an effect on the immersion period.

Effect of immersion on elongation of ramie rope. The elongation of ramie rope, whether it is with or without chitosan soaked at a certain time period is not statistically different. Based on the ANOVA test, the elongation of ramie rope with no chitosan on fresh and sea water immersion media produced P values in a sequence of 0.17 and 0.12. When compared with the degree of trust (ie 0.05), the value of P-value is higher. This means that the immersion media of seawater and freshwater does not have a significant influence on the elongation of ramie rope. The value of elongation of ramie rope soaked in fresh and sea water media can be seen in Figures 9 & 10.

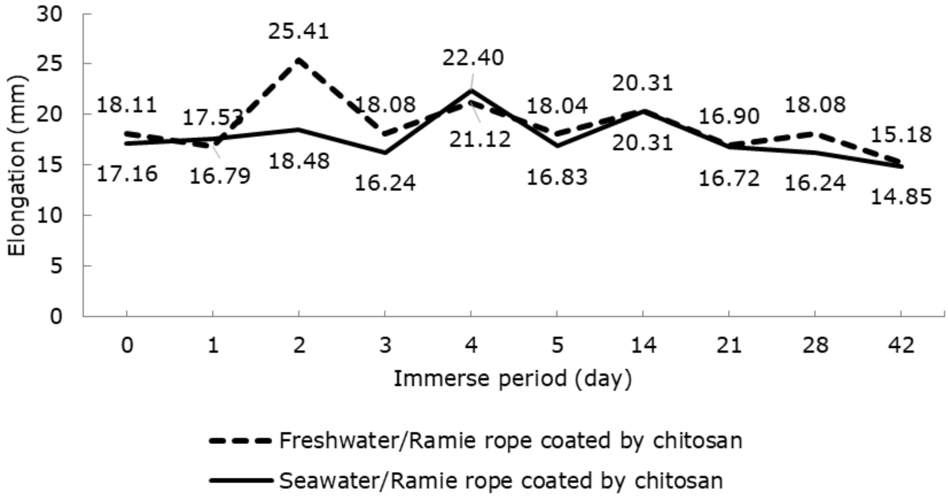

Figure 9. Elongation of ramie rope coated by chitosan in freshwater and sea water immersion.

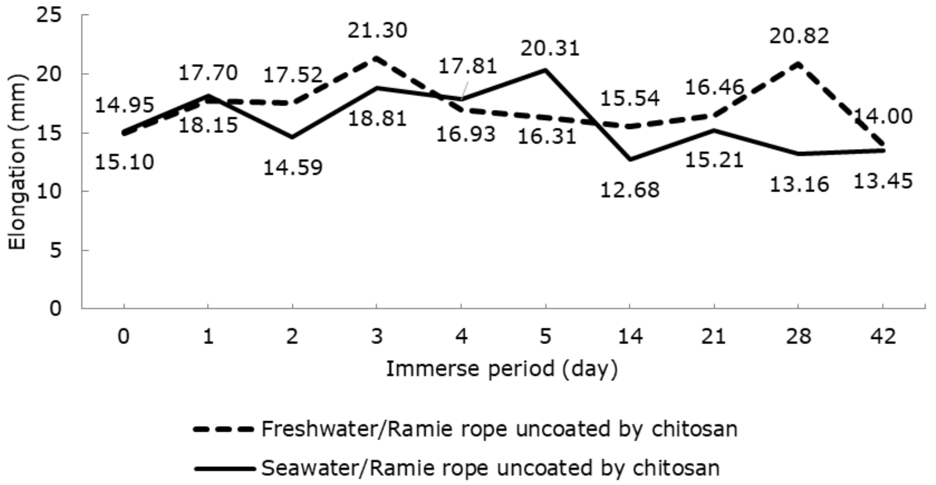

Figure 10. Elongation of ramie rope uncoated by chitosan in freshwater and sea water immersion.

The elongation of ramie rope coated or uncoated by chitosan, fluctuates in soaking until day 42. These fluctuations produce a trend that tends to be constant, the decrease in elongation that occurs is very small. This happens because the nature of flax tends to be rigid and has a low elasticity (Soeprijono et al 1973). Fluctuations occur allegedly due to the diameter of the rope which was not exactly the same in each sample, because the rope used was handmade. However, the relationship between diameter and weight of the hemp rope used was in a strong category (R2 = 0.71), meaning that the size of the rope used as the sample in the study was relatively uniform. This fluctuation in elongation is thought to be caused also by the type of hemp rope which is classified as a short fiber (staple fiber). This type of rope is composed of short fibers that are spun and twisted to become a rope. The strength of each bond between fibers will of course vary, resulting in a fluctuating elongation value.

Application of ramie rope on fishing gear. Ramie rope has physical properties that are quite supportive to be used as a material for fishing gear, smooth and rigid surfaces, very similar to the characteristics of synthetic ropes that are currently widely used by fishermen. The type of fiber in the form of short fibers also makes the surface of the rope not slippery when used. In addition, the elasticity of the ramie rope is also low so that the rope is not easily loosened when used as an attachment to the fishing gear.

The breaking strength of ramie rope is quite high compared to other natural fiber strings. According to Subandi (2011), the strength of ramie fiber is stronger than the breaking strength of cotton (natural fiber), and even synthetic fibers such as polyester fiber. According to the results of the study, the breaking strength of ramie rope was stronger than the breaking strength of agel rope. Agel rope without chitosan has a breaking strength average of 15.06 kgf (on an average diameter of 3.07 mm), while a ramie rope without chitosan 30.08 kgf (on an average diameter of 3.14 mm).

Ramie rope can be applied to gillnet. Ramie ropes can be used as headrope, footrope, and hanging twine (Figure 11). Ramie ropes can also be applied as a binder between the footropes and hanging twine. Ramie rope can be used on gillnet types which have a short technical life, such as crab gillnet. According to interviews with Rajungan net fishermen in Karangantu, the technical age of the crab gillnet they use ranges from 2 to 4 weeks. The crab nets will be damaged as a whole, due to the crunching of the crab and the process of removing the crab from the net. This 2-4 week is still enough for the ramie rope to survive before it is finally broken.

However, ramie rope is not suitable as headrope, footrope, and hanging twine on gillnet which has a high technical life, such as the gillnet used to catch pelagic fish. Usually, this type of gillnet requires a long time to break. Based on the results of interviews with fishermen in Palabuhanratu, Sukabumi, gillnet used to catch pelagic fish can last more than 1-2 years. The damage that occurs is only a mild type of damage, which can be repaired easily. Even according to Gerba et al (2015), surface gillnet nets operated in the drift in Toboali District, Bangka Belitung, have a service life of more than 5 years. When using a ramie rope on a headrope, footrope on the surface gillnet, the ramie rope will be damaged faster than the body of the net. Based on Figure 7, the breaking strength of hemp rope will decrease more than 50% after 42 days of immersion.

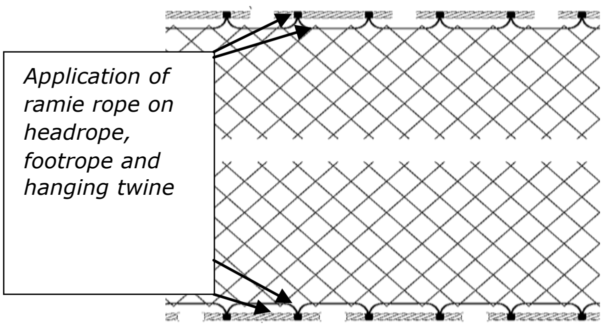

Figure 11. Application of ramie rope to gillnet.

Conclusions. Ramie rope uncoated by chitosan is ivory white, the surface texture is rough and stiff. Meanwhile, ramie rope coated by chitosan has a creamy color, smooth surface texture, and not stiff. The breaking strength of ramie rope coated and uncoated by chitosan is statistically significantly different, in which the breaking strength was 37.03 kgf or 0.011 kgf/tex, and 30.08 kgf or 0.013 kgf/tex respectively. The elongation of ramie rope coated and uncoated by chitosan was not significantly different; respectively the elongation was 17.93 mm and 17.72 mm. The breaking strength of ramie rope has decreased by more than 40% after immersion for 42 days.

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References

Al-Masroori H., Al-Qufi H., McIlwain J. L., McLean E., 2004 Catches of lost fish traps (ghost fishing) from fishing grounds near Muscat, Sultanate of Oman. Fisheries Research Journal 69:407-414.
Erzini K., Monteiro C. C., Ribeiro J., Santos M. N., Gaspar M., Monteiro P., Borges T. C., 1997 An experimental study of gillnet and trammel net 'ghost fishing' off the Algarve (Southern Portugal). Marine Ecology Progress Series 158:257–265.
Gerba S. V., Agustriani F., Isnaini, 2015 Financial analysis of fishing with drift gillnet in Toboali District, South Bangka Regency, Bangka Belitung. Maspari Journal 7(2):19-24.
Herliana P., 2010 Potential of chitosan as anti-bacterial cause of periodontitis. Jurnal UI Untuk Bangsa Seri Kesehatan, Sains, dan Teknologi 1:20-28.
Ilyas S., Arifudin E., 1972 Preliminary experiments for processing elements. Rural Technology Development Institute. Surakarta, Indonesia.
Klust G., 1982 Netting materials for fishing gear. Fishing News Books Ltd. In collaboration with Food and Agriculture Organization of the United Nation (FAO), London.
Klust G., 1983 Fiber ropes for fishing gear. Fishing News Books Ltd. By Arrangement with Food and Agriculture Organization of the United Nation (FAO), England.
Kumar A., Ashwin K. K., Arumugam K. P., 2011 Biodegradable polymers and its applications. International Journal of Bioscience, Biochemistry, and Bioinformatics 1(3):173-176.
Kusumawati N., Tania S., 2012 Manufacture and test of chitosan membrane ability as ultrafiltration membrane for separation of rhodamin B dyes. Molekul Jurnal 7(1):43-52.
Laist D. W., 1995 Marine debris entanglement and ghost fishing: a cryptic and significant type of bycatch? In: Solving bycatch: considerations for today and tomorrow. Baxter B., Keller S. (eds), pp. 33–39, Proceedings of the Solving Bycatch Workshop, The University of Alaska Sea Grant College Program Report 96.
Marco A., da Graca J., Garcia-Cerda R., Abella E., Freitas R., 2015 Patterns and intensity of ghost crab predation on the nests of an important endangered loggerhead turtle population. Journal of Experimental Marine Biology and Ecology 468:74-82.
Mima M., Mima S., Miya M., Iwamoto R., Yoshikawa S., 1983 Highly deacetylated chitosan and its properties. Journal of Applied Polymer Science 28(6):1909-1917.
Noerati, Gunawan, Ichwan M., Sumihartati A., 2013 Textile technology - teaching materials for teacher professional education and training. Sekolah Tinggi Teknologi Tekstil, Bandung, Indonesia.
Pelczar M. J., Chan E. C. S., 2005 Basics of microbiology 1. Translated by Hadioetomo R. S., Imas T., Tjitrosomo S. S., Angka S. L. Universitas Indonesia Press, Jakarta, Indonesia.
Perrin W. F., Donovan G. P., Barlow J., 1994 Gillnets and cetaceans. Report of the International Whaling Commission. Special Issue 15, Cambridge.
Rahayu W. P., Maamoen, Suliantri, Fardiaz S., 1992 Fisheries product fermentation technology. PAU Food and Nutrition, Bogor Agricultural University, Bogor, Indonesia.
Sancho G., Puente E., Bilbao A., Gomez E., Arregi L., 2003. Catch rates of monkfish (*Lophius* spp.) by lost tangle nets in the Cantabrian Sea (Northern Spain). Fisheries Research Journal 64:129-139.
Smolowitz R. J., 1978 Trap design and ghost fishing: discussion. Marine Fisheries Review 40:59-67.
Soeprijono P., Poerwanti, Widayat, Jumaeri, 1973 Textile fibers. Institut Teknologi Tekstil, Bandung, Indonesia.
Subandi M., 2011 Plantation plant cultivation (part of ramie plants). Gunung Djati Press, Bandung, Indonesia.

Takagi T., Shimizu T., Korte H., 2007 Evaluating the impact of gillnet ghost fishing using a computational analysis of the geometry of fishing gear. ICES Journal of Marine Science 64(8):1517-1524.
Von Brandt A., 2005 Fish catching methods of the world. 4th edition, Blackwell Publishing Ltd., United Kingdom.
Wuriyudani H. A., Sulhadi, Darsono T., 2017 Utilization of banana fronds fiber as a waterproof rope material. Proceedings of the National Seminar on Physics (E-Journal) SNF 2017. 6:93-98.
Yanming D., Congyi X. U., Jiawei W., Mian W., Yusong W. U., Yonghong R., 2001 Determination of degree of substitution for N-acylated chitosan using IR spectra. Science in China Series B: Chemistry 44(2):216-224.
*** FAO (Food and Agriculture Organization), 1995 Code of conduct for responsible fisheries. Food and Agriculture Organization, Rome, Italy.
*** Ihsan, 2018 Ramie (*Boehmeria nivea*). Available at: https://www.petanihebat.com/tanaman-rami-boehmeria-nivea/. [Accessed 20 July 2018].

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