O USO DO EXTRATO DE *Cyperus kyllinga* NA SÍNTESE DE NANOPARTÍCULAS DE PRATA PARA MELHORAR A QUALIDADE DE COURO DE CABRA

THE USE OF *Cyperus kyllinga* EXTRACT IN SYNTHESIS OF SILVER NANOPARTICLE TO ENHANCE QUALITY OF GOAT LEATHER

PENGGUNAAN EKSTRAK *Cyperus kyllinga* DALAM SINTESIS NANOPARTIKEL PERAK UNTUK MENINGKATKAN KUALITAS KULIT KAMBING

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RESUMO

Melhorar a qualidade do couro com propriedades antifúngicas, antibacterianas e mecânicas superiores é um esforço contínuo. Os objetivos desta pesquisa foram sintetizar nanopartículas de prata utilizando o extrato de *Cyperus kyllinga* como bioagente e depositar as nanopartículas de prata sintetizadas no couro de cabra *ex situ* e *in situ*, além de caracterizar as propriedades antibacterianas, antifúngicas, mecânicas e ângulo de contato do couro de cabra antes e depois da modificação. As nanopartículas de prata foram preparadas pelo método de redução adicionando o extrato de folha de *Cyperus kyllinga*. As nanopartículas de prata foram caracterizada utilizando espectrofotômetro UV-Vis e classificação granulométrica. A adição do composto metiltrimetoxissilano (MTMS) na amostra de couro para conhecer as propriedades de hidrofobicidade do couro. O couro foi modificado pela adição de nanopartículas de prata e compostos de silano. Os testes antibacteriano e antifúngico foram realizados pelo método de difusão e testada a significância por meio de análise estatística. Foram realizados testes de propriedades mecânicas por meio de ensaios de resistência à tração, alongamento e também módulo de Young utilizando um testador de tração. A superfície do couro de cabra modificado foi testada quanto ao ângulo de contato pelo método da gota sêssil. Os resultados da caracterização indicaram que as nanopartículas de prata foram formadas no comprimento de onda de 406,60 nm, com tamanho de partícula de 200,1 nm. Os resultados do teste antimicrobiano mostraram que o couro de cabra modificado utilizando dois métodos de preparação teve significância diferente para inibir *S. epidermidis* e *E. coli*, e também fungos de *C. albicans*. O couro, após a modificação com nanopartículas pelo método *in situ*, apresentou as maiores atividades antibacterianas contra *S. epidermidis* e *E. coli*, no entanto, o couro após a modificação com adição de nanopartículas e MTMS pelo método *ex situ* tem a maior atividade antifúngica contra *C. albicans*. O couro após modificação da nanopartícula e do MTMS via método *in situ* possui a maior resistência à tração e a maior tenacidade. Todos os couros modificados apresentaram maior atividade antimicrobiana, ângulo de contato e também tenacidade em comparação ao couro não modificado.

Palavras-chave: anti-fungo contra *C. albicans*, extrato de *Cyperus kyllinga*, bactericida para *S. epidermidis* e *E. coli*, couro de cabra, couro autolimpante.

ABSTRACT

Improving leather quality with antifungal, antibacterial, and superior mechanical properties is an ongoing effort. The objectives of this research were to synthesize silver nanoparticle using *Cyperus kyllinga* extract as a bio-agent and to deposit synthesized silver nanoparticle into goat leather by *ex situ* and *in situ*, and also to characterize the properties of antibacterial, antifungal, mechanical, and contact angle of goat leather before and after modification. Preparation of silver nanoparticles by reduction method by adding *Cyperus kyllinga*'s leaf extract. The silver nanoparticle was characterized by using spectrophotometer UltraViolet-Visible and Particle

Size Analyzer. The addition of Methyltrimethoxysilane (MTMS) compound on the leather sample to know hydrophobicity properties of the leather. The leather was modified by adding silver nanoparticle and silane compounds. The antibacterial and antifungal test was conducted by the diffusion method and tested the significance by using statistical analysis. The mechanical properties were tested through tensile strength test, elongation, and also modulus Young by using a tensile tester. The modified goat leather surface was tested the contact angle by using the sessile drop method. The characterization results indicated that silver nanoparticles were formed at a wavelength of 406.60 nm, with their particle size were 200.1 nm. The results of the antimicrobial test showed that modified goat leather using two methods of preparation had a different significance to inhibit the *S. epidermidis* and *E. coli*, and also fungi of *C. albicans*. The leather, after modification with nanoparticle via *in situ* method, had the highest antibacterial activities against *S. epidermidis* and *E. coli*. However, leather after modification with adding nanoparticle and MTMS via *ex situ* method has the highest antifungal activity against *C. albicans*. The leather after modification nanoparticle and MTMS via *in situ* method has the highest tensile strength and the largest toughness. All modified leathers had larger antimicrobial activity, contact angle, and also toughness compared to unmodified leather.

Keywords: *anti-fungi against C. albicans, Cyperus kyllinga extract, antibacterial against S. epidermidis and E. coli, goat leather, self-cleaning leather.*

ABSTRAK

Peningkatan kualitas kulit dengan karakteristik antijamur, antibakteri, dan sifat mekanik unggul merupakan usaha yang harus dilakukan. Tujuan dari penelitian ini adalah untuk mensintesis nanopartikel perak menggunakan ekstrak *Cyperus kyllinga* sebagai bioreduktor dan untuk mendepositkan nanopartikel perak terhadap kulit kambing secara *ex situ* dan *in situ*, serta untuk mengkarakterisasi sifat-sifat antibakteri, antijamur, sifat mekanik, dan sudut kontak dari kulit kambing sebelum dan sesudah modifikasi. Preparasi nanopartikel perak dilakukan secara reduksi oleh ekstrak daun *Cyperus kyllinga*. Nanopartikel perak dikarakterisasi menggunakan spektrofotometer UltraViolet-Tampak dan alat Penganalisis Ukuran Partikel. Penambahan senyawa Metiltrimetoksisilan (MTMS) pada kulit untuk mengetahui sifat hidrofobisitas kulit. Kulit dimodifikasi melalui penambahan nanopartikel perak dan senyawa silan. Pengujian antibakteri dan antijamur dilakukan dengan metode difusi dan uji signifikansi dengan analisis statistik. Sifat mekanik yang diuji meliputi kuat putus, perpanjangan, dan modulus *Young*. Permukaan kulit kambing sesudah modifikasi diuji sudut kontakannya melalui metode tetes sessile. Hasil karakterisasi menunjukkan nanopartikel perak berhasil disintesis pada panjang gelombang 406,60 nm dengan ukuran partikel 200,1 nm. Hasil pengujian antimikroba menunjukkan bahwa kulit kambing hasil modifikasi dengan kedua metode memiliki perbedaan signifikan dalam menghambat *S. epidermidis* dan *E. coli*, serta jamur *C. albicans*. Kulit hasil modifikasi dengan nanopartikel secara *in situ* memiliki aktivitas antibakteri tertinggi terhadap *S. epidermidis* dan *E. coli*. Adapun kulit hasil modifikasi dengan penambahan nanopartikel dan MTMS secara *ex situ* memiliki aktivitas antijamur tertinggi terhadap *C. albicans*. Kulit hasil modifikasi dengan penambahan nanopartikel dan MTMS secara *in situ* memiliki kuat putus dan keuletan paling tinggi. Semua kulit hasil modifikasi memiliki aktivitas antimikroba, sudut kontak, dan keuletan lebih tinggi dibandingkan dengan kulit tanpa modifikasi.

Kata kunci: *antijamur terhadap C. albicans, ekstrak Cyperus kyllinga, antibakteri terhadap S. epidermidis dan E. coli, kulit kambing, kulit anti-kotor.*

1. INTRODUCTION:

The leather and textile industry has progressed in recent years and is one of the pioneering sectors in the application of the Indonesian industry 4.0. Based on statistical data obtained from the Directorate General of Livestock and Animal Health (2018), exports of leather products reach 76.750.012 USD per the year 2017. The results of leather exports are the most significant results among other non-food animal products. Also, leather and leather products are included in the order of 10 potential export commodities in 2012-2017. As reported by the Ministry of Industry, the leather and textile industry

is one of the country's biggest foreign exchange earners and ranks third of all export commodities in Indonesia. Achievement of export value in 2018 was obtained at USD 18.96 billion or a sum of 10.52% of the total national exports in that year. The high interest in leather in the community is necessary to have an effort to improve the quality of the leather.

To improve the quality of the leather industry it is necessary to develop antimicrobial leather. Silver nanoparticles have been known to have interesting physicochemical properties. Also, the strong toxicity shown by silver in various chemical forms for a variety of microorganisms is reported to be very good. Silver nanoparticles

have been proven to have good antimicrobial properties and are also environmentally friendly (Amin *et al.*, 2009; Muliawati and Yulianti, 2018). Silver nanoparticles are also one of the antibacterial agents which are non-toxic and safe for the human body. Also, silver nanoparticles are reported to have antifungal activity (Kalishwaralal *et al.*, 2010).

In general, metal nanoparticles can be prepared by physical (top-down) and chemical (bottom-up) methods (Sharma *et al.*, 2009; Rohaeti *et al.*, 2020). Silver nanoparticles can be obtained by various methods, including the microwave irradiation method (Hasany *et al.*, 2013), photochemical method (Selvam and Sivakumar, 2015; Ahmed *et al.*, 2016), ball milling method (Maamoun and Khairy, 2013), electrochemical method (Viorel *et al.*, 2012), chemical reduction (Zhang *et al.*, 2014; Rohaeti and Rakhmawati, 2017). The method most often used is the chemical reduction method. Research in nanotechnology can use environmentally friendly processes for the synthesis of nanoscale materials such as "green" chemistry (Nanda and Saravanan, 2009; Abd-Elnaby *et al.*, 2016; Buszewski, 2016; Gopinath *et al.*, 2016). Among the many methods of nanoparticle synthesis, the biosynthetic method is more environmentally friendly, cost-effective, and safer for therapeutic use in humans (Salem *et al.*, 2015; Rohaeti *et al.*, 2020).

Plant extracts that can be used for the preparation of the synthesis of silver nanoparticles are leaves of *Cyperus kyllinga* as a reducing agent. Until now, *Cyperus kyllinga* leaves are still not widely used by many researchers. However, *Cyperus kyllinga* has been reported to have compounds that are antioxidants. Antioxidant compounds contained in *Cyperus kyllinga* extract included polyphenolic compounds, flavonoids, and tannins. The tannin compounds contained in this *Cyperus kyllinga* leaf extract were thought to play an essential role in the process of reducing Ag^+ to Ag^0 (Sindhu *et al.*, 2014).

To get a self-cleaning leather (hydrophobic) can use compounds that can give rise to the water contact angle of the material. Compounds that are often used to obtain self-cleaning properties are silane compounds and their derivatives. A material that is deposited by silane compounds with low surface energy has been shown to increase the hydrophobicity of a material. In this study, silane compounds (methyltrimethoxysilane/MTMS) are used because these compounds can produce hydrophobic leather surfaces.

Antimicrobial testing methods in a sample are divided into several types, namely the diffusion method (Kirby-Bauer and Stokes), the dilution method, and the diffusion and dilution method (Guzmán *et al.*, 2009). The antimicrobial testing method that is often done in several studies is the diffusion method. This study also used the diffusion method by measuring the diameter of the inhibitory zone or clear zone, which is used as an indicator of the effectiveness of the sample in inhibiting microbial activity. The microbial used were *Escherichia coli* as gram-negative bacteria and *Staphylococcus epidermidis* as gram-positive bacteria, and *Candida albicans* as fungi.

This research aimed to synthesize silver nanoparticles using *Cyperus kyllinga* leaf extracts to utilize the use of *Cyperus kyllinga* in improving the quality of goat leather. Characterization techniques performed on goat leather material included UV-Vis and particle size analysis to analyze the success of silver nanoparticle formation, mechanical properties (tensile strength) test, contact angle test to determine its hydrophobicity, and antibacterial and antifungal activity tests.

2. MATERIALS AND METHODS:

The types of equipment used in this study were a UV-Vis spectrophotometer, particle size analyzer (PSA), analytical scales, hot plates, magnetic stirrers, shakers, glassware, Petri dishes, autoclaves, inoculating loop, tensile test machines, cameras, and calipers. The materials used included pickle goat, turf leaves, solid AgNO_3 , starch, MTMS, distilled water, nutrient agar (NA), nutrient broth (NB), Potato Dextrose Agar (PDA), Potato Dextrose Broth (PDB), *Escherichia coli* FNCC 0048, *Staphylococcus epidermidis* DNCC 6018, *Candida albicans* ANCC 0048.

2.1. Procedure

2.1.1. Preparation of silver nanoparticle

The silver nanoparticle was prepared by biosynthesis methods using the extract of leaves. AgNO_3 solution was changed by the extract of *Cyperus kyllinga* leaves. The *Cyperus kyllinga* leaves acted as a bioreductor. The preparation of silver nanoparticles has used the leaves of *Cyperus kyllinga* begins with the preparation of a *Cyperus kyllinga* leaf extract. The *Cyperus kyllinga* leaves were washed clean and weighed as much

as 25 grams. Then put in a beaker glass and added 250 mL of distilled water, and boil for 15 minutes at a temperature of 80 °C. The cold boiled water is filtered using Whatman No.42 filter paper. The *Cyperus kyllinga* leaf extract was used to reduce silver nitrate. A total of 10 mL of turf leaves extract was put into a 100 mL Erlenmeyer, then 65 mL of $0.5 \cdot 10^{-3}$ M AgNO_3 solution was added.

Furthermore, the solution was allowed to stand for ± 2 hours to react. After that, 25 mL of 0.05% starch solution was added to the mixture while stirring for ± 2 hours. The solution was allowed to stand for two days to form a colloid and continued to be characterized using a UV-Vis spectrophotometer and PSA at a wavelength of 200-500 nm.

2.1.2. Application of silver nanoparticles on pickle goat leather (K-NP-E and K-NP-I)

Pickle goat leather was cut to size 20 x 10 cm. The deposit of silver nanoparticles was carried out by *in situ* and *ex situ* methods. In the *in situ* method, pickle goat leather was put into a mixture of 5 ml of *Cyperus kyllinga* leaf extract and then added 200 ml of $0.5 \cdot 10^{-3}$ M silver nitrate, which is placed in a 500 ml beaker glass. Pickle goat leather and mixture are heated in a temperature range of 40 °C (Ibrahim, 2015) while stirring using a stirrer. When heating takes place 15 minutes, a 0.05% starch solution of 60 ml is added to the mixed solution. The heating process is carried out for 30 minutes. In the existing method, the leather of the pickle goats soaked in colloidal silver nanoparticles is then carried out a shaker for approximately 24 hours at a speed of 154 rpm. Then the leather is dried under room temperature conditions.

2.1.3. Modification of pickle goat leather surface with MTMS compounds (L-M-e and L-M-i)

The coating of MTMS compounds on the surface of pickle goat leather is done by immersion method *in situ* and *ex situ*. Pickle goat leather is immersed in 3% ethanol-MTMS solution in 100 mL Erlenmeyer, then shaker for 1 hour with a speed of 154 rpm, then the pickle goat leather is dried at room temperature.

2.1.4. Modification of pickle goat leather surface with silver nanoparticles and MTMS compounds (L-PM-e and L-PM-i)

Pickle goat leather that has been deposited with silver nanoparticles is added with a

3% ethanol-MTMS solution. The coating of MTMS compounds in this modification was done by two methods, namely the *ex situ* and *in situ* methods. In the existing method, the leather of the pickle goat, which in the process of depositing silver nanoparticles for 30 minutes, was then added with a 3% ethanol-MTMS solution to the mixture. Immersion continued for 30 minutes, accompanied by stirring using a stirrer. Whereas *in situ* method, pickle goat leather from the deposit of silver nanoparticles was immersed in 3% ethanol-MTMS solution for 30 minutes and warmed with a temperature range of 40 °C. The same stage is continued with the addition of silver nanoparticles that will be obtained (L-MP-e and L-MP-i).

2.1.5. Contact angle test

Characterization of the hydrophobic properties of pickle goat leather is using the sessile drop method. The leather sample is placed on a table or board with a flat surface, and then the liquid is dripped from a height of approximately 1 cm from the leather sample by using a dropper. After that, the picture was taken with a camera. The photos are processed using the Corel Draw program.

2.1.6. Antibacterial and antifungal activity test

Antibacterial and antifungal activity tests are performed using the diffusion method by observing the inhibited or clear zones that form around the leather sample. A total of 9 variations of pickle goat leather were cut round using a paper hole ($d = 0.5$ cm) on the cultures of *Escherichia coli* and *Staphylococcus epidermidis* as well as on *Candida albicans* that had been planted in Petri dishes. Measurement of bacterial inhibition zone is done every 3 hours for 24 hours, while the measurement of the inhibition zone of the fungal is done every 6 hours for 72 hours of incubation time.

2.1.7. Test of mechanical properties

Mechanical properties testing is done by using a Tensile test machine. For this purpose, the leather is cut according to the standard method in Indonesia (Indonesia National Standard/SNI 06-1795-1990). The leather sample is placed on the device up to a distance of 50 mm. The withdrawal was made at a speed of 25 cm/min until the leather breaks or, if desired, only to crack the leather. Also, the stretch of the leather at the time of breaking can be calculated as a percent of its elongation. The test of mechanical properties was carried out three times for each variation of the leather sample.

3. RESULTS AND DISCUSSION:

Silver nanoparticles were synthesized using the reduction method with the principle of biosynthesis. The leaves of the puzzles (*Cyperus kyllinga*) after adding AgNO_3 solution and starch, undergo a change in color from the original colorless to brownish-orange on storage for 48 hours. The color change indicates that the nanoparticles have formed (Aldujaili and Banoon, 2020). There has been a silver nitrate reduction process that is from Ag^+ ions to Ag^0 ions (Rohaeti and Rakhmawati, 2018), and colloidal silver nanoparticles have also been formed, shown in Figure 1. The formation of nanoparticle could be caused by the H radicals formed in tannin compounds (Devi *et al.*, 2014). The hydroxyl and carboxyl groups in tannin also could form the chelate metal (Michalak, 2011). The *Cyperus kyllinga* extract effectively changed silver ions to nano-size because silver ions have high positive electrochemical potentials (Makarov *et al.*, 2014).

Figure 1. A mixture of a solution of the *Cyperus kyllinga* leaf extract + AgNO_3 solution $0.5 \cdot 10^{-3}$ M + Starch 0.05% (a) 0 hours, (b) 4 hours, (c) 48 hours, (d) 144 hours

Silver nanoparticles that had been left for 48 hours were then characterized using a UV-Vis spectrophotometer. In the measurement of the UV-Vis test, the measured absorption peak was 406.60 nm, as shown in Figure 2. This result was in line with the result of the previous study (Zhang *et al.*, 2014).

Figure 2. UV-Vis spectrum of silver nitrate solution and silver nanoparticles

From these results, the *Cyperus kyllinga* leaf extract has succeeded in reducing silver nitrate solution. *Cyperus kyllinga* leaf extracts have been known to contain chemical compounds, namely tannins. Tannin compounds are compounds that are thought to act as reducing agents, solvents, and stabilizers in the production of nanomaterials (Rohaeti and Rakhmawati, 2018; Kuppusamy *et al.*, 2016).

The results of the analysis using PSA showed that the size distribution of silver nanoparticles synthesized by the extract of *Cyperus kyllinga* leaves had an average size of nanoparticles around 200.1 nm. According to Nagarajan (2008), the optimal size of silver nanoparticles has a size range of 1 nm - 100 nm. From the measured silver nanoparticle data, it is known that silver nanoparticles have agglomerated. Silver nanoparticle solutions tend to undergo aggregation to form larger sizes (Haryono *et al.*, 2008; Rohaeti *et al.*, 2019; Shateri-Khalilabad *et al.*, 2010).

Modified pickle goat leather samples with silver nanoparticles produce brownish-orange pickle goat leather. The color change is derived from the leaves of the *Cyperus kyllinga*, a solution of silver nanoparticles. Silver nanoparticles stick to the leather surface, a possible interaction that occurs between silver nanoparticles with pickle goat leather. Goat leather has an amino-functional group ($-\text{NH}_2$) and carboxylate ($-\text{COOH}$) when silver nanoparticles interact with the surface of the goat leather, Ag^+ turns into Ag^0 , which can then interact with the NH group or O atom of the goat leather so that the surface of the goat leather is coated by nanoparticles silver (Montazer and Nia, 2015).

Table 1. The contact angle of pickle goat leather before and after modification

Methode	Contact angle value (°)				
	L0	L-P	L-PM	L-MP	L-M
<i>Ex situ</i>	25.57	73.79	66.33	90.55	50.05
<i>In situ</i>		70.16	90.46	78.82	65.29

Based on the contact angle test results in Table 1, it is known that there is a significant difference in the contact angle values in K0 samples with eight leather samples modified using silver nanoparticles, MTMS compounds, or modification of the two compounds (K-NP-MTMS and K-MTMS -NP). Unmodified leather samples only have a contact angle value of 20.57°. From the measurement results of contact angle values, all modified pickle goat leathers have higher contact angle values than the contact angle values on pickle goat leather without modification (K0). Therefore, it can be seen that the addition of silver nanoparticles (AgNP) and the addition of MTMS compounds can influence the surface properties of the leather of the goat leather, which can increase the contact angle of the leather of the goat leather.

Based on the observation of inhibition zones in the two bacteria tested showed that inhibition zones began to form, on average, at an incubation time of 3 hours. Silver nanoparticles used in this study play a role in enhancing the antimicrobial properties of pickle goat leather samples. According to Rohaeti and Rakhmawati (2017), silver nanoparticles can inhibit the growth of *Escherichia coli* and *Staphylococcus epidermidis* bacteria. Also, the antibacterial activity of 8 samples of modified goat leather of *S. epidermidis* showed an average inhibition zone that was greater than that of *E. coli*. According to Rohaeti (2017), there is a difference in the antibacterial activity between materials with modification and without modification of *E. coli* and *S. epidermidis*. This difference is influenced by the characteristics of Gram-positive and gram-negative bacterial cell walls. *S. epidermidis*, as gram-positive bacteria, has several layers of peptidoglycan, which combine to form a thick and stiff structure. At the same time, *E. coli* is a gram-negative bacterium that has a thin layer of peptidoglycan and a protected outer membrane. This results in a more effective sample of goat leather antibacterial activity against *Staphylococcus epidermidis*. Likewise, in the antifungal test, the inhibitory mechanism of bacteria and fungus has no difference. Silver nanoparticles will interfere with enzymes

(proteins) in bacterial cells and fungal cells. The difference is only in the structure of protein molecules owned by bacteria and fungi. Bacteria have a simpler structure than fungus.

The observation of inhibition zone diameter on the leather of the pickle goats against *Escherichia coli* and *Staphylococcus epidermidis* bacteria and *Candida albicans* fungus in this study carried out statistical tests which included ANOVA test and LSD advanced test using SPSS version 25.

Based on the ANOVA test results listed in Table 2 which is the test results of the *Escherichia coli* bacteria known to have a significant value of the interaction test between an incubation time and type of sample is 0,000 ($p < 0.05$), interpretation of the value of $p < 0.05$ means that there is an effect of the interaction between the incubation time with the type of sample on the antibacterial activity of *E. coli*. Whereas in the *Staphylococcus epidermidis* and *Candida albicans*, the significance value of the interaction test between the incubation time and the type of pickle goat leather sample were 0.942 and 0.762 ($p > 0.05$), the interpretation of the value of $p > 0.05$ that means no the effect of the interaction between incubation time with the type of sample on the antibacterial activity of *Staphylococcus epidermidis* and antifungal *Candida albicans*.

The advanced statistical test is the LSD test between variations of sample types against antimicrobial activity shown in Table 3. The results of the research data show a significant difference to the leather without modification (L0) with some samples of the modified goat leather in inhibiting the antibacterial and antifungal activities such as in L-P-e and L-P-i. At the same time, the L-M-e and L-M-i samples on L0 leather showed no significant difference in inhibiting antibacterial or antifungal activity.

Tensile strength, elongation, Young modulus, and toughness are mechanical properties of a material. Tensile strength indicated the strength of a material when given a vertical pull (Savitri *et al.*, 2015). The toughness of a material could be determined by using the graph of the relationship between tensile strength and elongation. The L-M-i (leather with modification by adding MTMS via *in situ*) the longest elongation at break and the highest toughness. The L-M-i has the biggest curve under the area. The highest tensile strength is shown by a sample of pickle goat leather modified by silver nanoparticles with the addition of MTMS compounds using an *in situ* preparation method (L-PM-i) as much as 5.09

MPa.

According to Sumaryono (2012), a polymer material has different physical properties, including brittle, plastic, and elastomer (highly elastic). Based on the curve of stress-strain as shown in Figure 4, samples leather with modification by adding MTMs and nanoparticle via *in situ* method (L-MP-i) is the soft and weak material, their strength at break and also elongation is very low. The leather without modification shows the lowest tensile strength and elongation compare to others. The samples L0, L-P-e, L-P-i, L-M-e, and L-M-i have soft and tough properties because stretching in a large enough plastic area and modulus Young that is not too large. The L-M sample is a sample that is very elastic compared to the others because it has the largest area of the curve. In comparison, the L-PM-i leather sample has a hard or strong nature in holding a load and is strong because it has a value of elongation that is not too small but not too big too (moderate). Furthermore, the L-MP-i leather samples are soft and weak because they have a very small area of under curve.

Figure 5. The curves of stress-strain of leather before and after modification.

The percentage elongation analysis is a percentage increase in the length of a test specimen when carried out vertically. Percent elongation shows the elasticity of a material, which is indicated by the elongation of the test specimen when given a certain force (Savitri *et al.*, 2015). The L-M-i leather sample had the largest elongation value, with a value of 64.82%.

Based on these results, pickle goat leather before and after the modification has different

physical and mechanical properties based on its toughness. The order of toughness in this sample variation is L-M-i > L-M-e > L-PM-e > L-PM-i > L0 > L-P-e > L-P-i > L-MP-i > L-MP-e.

4. CONCLUSIONS:

The silver nanoparticles prepared by using *Cyperus kyllinga* extract were formed at a wavelength of 406.60 nm, with their particle size were 200.1 nm. The results of the antimicrobial test showed that modified goat leather using two methods of preparation had a different significance to inhibit the *S. epidermidis* and *E. coli*, and also fungi of *C. albicans*. The leather, after modification with nanoparticle via *in situ* method, had the highest antibacterial activities against *S. epidermidis* and *E. coli*. However, leather after modification with adding nanoparticle and MTMS via *ex situ* method has the highest antifungal activity against *C. albicans*. The leather after modification nanoparticle and MTMS via *in situ* method has the highest tensile strength and the largest toughness. However, all samples of pickle goat leather after modification by impregnating silver nanoparticles have antibacterial activities, antifungal, strength at break, elongation, toughness, and also contact angles the better compared to pickle goat leather without modification.

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Leather	Leather - nanoAg

Leather – MTMS	Leather- nanoAg – MTMS

Leather – MTMS – nanoAg	

Figure 3. Images of leather before and after modification

(a)

(b)

(c)

Figure 4. The diameter of the inhibition zone to Incubation time of leather before and after modification against (a) *E. coli*, (b) *S. epidermidis*, (c) *C. albicans*

Table 2. The results of the ANOVA test for antimicrobial activity of leather against *Escherichia coli*, *Staphylococcus epidermidis*, and *Candida albicans*

<i>Escherichia coli</i>					
Variable	Sum	Df	Average	F	Sig.
Incubation	14,451	8	1,806	22,669	0,000
Pickle Leather	85,513	9	9,279	116,449	0,000
Incubation*Pickle	21,303	72	0,296	3,713	0,000
<i>Staphylococcus epidermidis</i>					
Variable	Sum	Df	Average	F	Sig.
Incubation	46,748	8	5,844	3,896	0,001
Pickle Leather	149,723	89	16,636	11,092	0,000
Incubation*Pickle	75,574	72	1,050	0,700	0,942
<i>Candida albicans</i>					
Variable	Sum	Df	Average	F	Sig.
Incubation	24,825	7	3,546	20,562	0,000
Pickle Leather	6,153	9	0,684	3,964	0,000
Incubation*Pickle	9,138	63	0,145	0,841	0,762

Table 3. Interpretation of significant differences of antimicrobial activity between 2 samples of leather against *E. coli*, *S. epidermidis*, and *C. albicans*

Variation type of leather	Interpretation		
	<i>E. coli</i>	<i>S. epidermidis</i>	<i>C. albicans</i>
L0 - LP-i	Significant	Significant	Significant
L0 - LP-i	Significant	Significant	Significant
L0 - L-PM-e	No Significant	Significant	Significant
L0 - L-PM-i	Significant	No Significant	No Significant
L0 - L-MP-e	Significant	No Significant	Significant
L0 - L-MP-i	Significant	Significant	Significant
L0 - LM-e	No Signifikan	No Significant	No Significant
L0 - LM-i	No Signifikan	No Significant	Significant