CHARACTERISTICS OF PHYSICAL TEST OF PUFFER FISH (*Arothon reticularis*) LEATHER WITH VARIOUS TYPES OF TANNING MATERIALS

FP-11

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Abstract

Tanning aims to avoid stiffness and hardness of leather, so leather will be flexible when it is dry and it can also be durable. Tanning will directly change the characteristics of leather, especially its appearance, handling and smell. With tanning, leather is expected to endure heat better than skin or raw leather. In Indonesia, puffer fish leather tanning is still being studied, so initial research by using three types of tanning, i.e. vegetable, chrome, and formalin, is required. The physical characteristics of the three types of tanning were tested, i.e. tensile strength, elongation, sewing strength, and tear strength. The results of comparison of tensile strength and elongation in skip group; and tear strength and sewing strength in leather group of tanning (vegetable, wet blue and formalin) show significance scores of 0,001; 0,000; 0,000; and 0,000 <0,05, respectively. It showed that there were differences in tensile strength, elongation, sewing strength, and tear strength. The research entitled Characteristics of Physical Test of Puffer Fish (*Arothon reticularis*) Leather with Various Types of Tanning Materials is expected to contribute required data in puffer fish leather tanning in order to produce tanned puffer fish leather for desired purposes.

Keywords: chrome, formalin, physical test, puffer fish, tanning, vegetable

Introduction

Indonesia is a country with leather tanning industries that have been growing rapidly, especially those making use of animals such as buffalo, cows, goats and sheep. The resulting products were diverse, such as shoes, bags, jackets and other products that have a quality which was not inferior to foreign products. The success of leather product exports has occurred in between 1986-1996. At that time, the government managed to shift the leather products from upstream to downstream so that the export of leather products such as jackets, boots and gloves was growing rapidly.

But the fact, Indonesia is currently suffering from a shortage of supply of raw materials in order to meet even the domestic demand. Imports of raw materials and finished leather in order to meet the needs of the industry continue to increase. Based on these facts the government should anticipate the problems above, for example by finding the raw material to substitute skin or leather raw materials derived from cattle. As an alternative the raw materials are derived from fish skin, considering that Indonesian marine is greater than its land area, reaching 5.8 million km^2; making fish production in Indonesia quite large, as well as many species of fish (commodities) were arrested.

Leather tanning industries use raw materials of fish skin which are still in slight number. Thus, the alternatif way to do is to use fish skin as a raw material for tannery. Leather from fish skin is very potential to be developed but the progress is very slow. Fish skin tanning business does not only add value to waste but also as an alternative to suffice raw materials in the leather industry in Indonesia, which has been applied to the manufacture of leather-based products, such as bags, shoes, slippers.

The utilization of the fishery products as the source for tanning industry still faces some obstacles and problems; one of which is because the fishery products are rapidly decaying commodities including fish skin. Chemical composition and physical structure of the fish skin is different from the skin of land animals. Fish skin is more susceptible to damage. Consequently, the fish skins which can be tanned must be obtained from fish with excellent freshness. Thus, the fish handling should be done in a good method. Likewise, fish skin that has been removed from the body of the fish requires good handling and should be processed as quickly as possible. Scarcity of supply in the fish skin for tanning industry mainly lies in the difficulty of getting a decent quality of fish skin for tanning.

Purpose of this study is to determine the characteristics of various tanning materials including vegetable tanning, chrome and formalin towards physical strength of puffer fish skin as an alternative raw material for leather industries.

Materials and Methods

The materials used in the study were 40 pieces of puffer fish skin taken from Rembang. As many as 12 sheets were vegetable; 12 chrome and 12 formalin tanned leather. Then the physical tests were done towards crust leather, including tensile strength, elongation, tear strentgh and sewing strentgh, each with three replicates respectively, while the 4 sheets of the skin were used for histological observation. In making histological preparations, skin tissue of fish that will be observed was preserved with formalin, then sliced thin (thickness of several microns), affixed to glass objects, colored and then covered with a cover glass. Samples that have been processed were more easily observed and would not be damaged in many years, making it easier to learn further (Suntoro, 1983).

Tests for tensile strength and elongation were done based on SNI 06-1795 -1990; sewing strength based on SNI 06-1117-1989 and tear strength based on SNI 06-1794-1990.

Results and Discussion

Testing Result

Skins have different physical properties and chemical compositions. Physical properties are those including physical strength and condition or structure, while chemical properties are the chemical compositions or concentrations of chemical substances contained in them (Kanagy, 1977). Physical strength according to Roddy (1978) is the power to environment, such as the effect of storage power. Physical strength can be measured quantitatively, e.g. tensile strength, elongation, temperature wrinkles and rigidity. The physical strength according to Tuck (1981) correlates with tissue structure and the levels of chemicals in the skin, so the skin physical strength can be estimated from the tissue structure and the levels of chemicals skin.

Table 1. Physical Test Results of Puffer fish Skin

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Tensile Strength	Between Groups	5289.997	2	2644.999	31.801	.001
	Within Groups	499.038	6	83.173		
	Total	5789.036	8			
Elongation	Between Groups	2076.204	2	1038.102	319.824	.000
	Within Groups	19.475	6	3.246		
	Total	2095.679	8			
Tear Strength	Between Groups	3645.880	2	1822.940	265.994	.000
	Within Groups	41.120	6	6.853		
	Total	3687.000	8			
Sewing Strength	Between Groups	2664.472	2	1332.236	384.021	.000
	Within Groups	20.815	6	3.469		
	Total	2685.287	8			

Table 1 shows the physical strength test results of puffer fish skin, including tensile strength, elongation, tear strength and sewing strength. Comparison Results of tensile strength, elongation, tear strength, and sewing strength towards tanned leather (vegetable, formalin, and wet blue/chrome) provide significant value of each 0,001; 0,000; 0,000; and 0.000 <0.05. This shows that there are differences in tensile strength, elongation, tear strength, and sewing strength on the skin group. The discrepancies are then tested further using Post Hoc.

Result Post Hoc shows the physical tests comparison of tensile strength, elongation and tear strength between vegetable and formalin tanned fish leather which gives significant value of 0.000 <0.05. This means that there is a difference in tensile strength, elongation and tear strength in both types of the fish leather. The result of the comparison between formalin and chrome tanned fish leather provides significant value of 0.000 <0.05. This means that there is also a difference in tensile Strength of both types of the fish leather. By using graph, the result can be described below, as seen in Fig. 1.

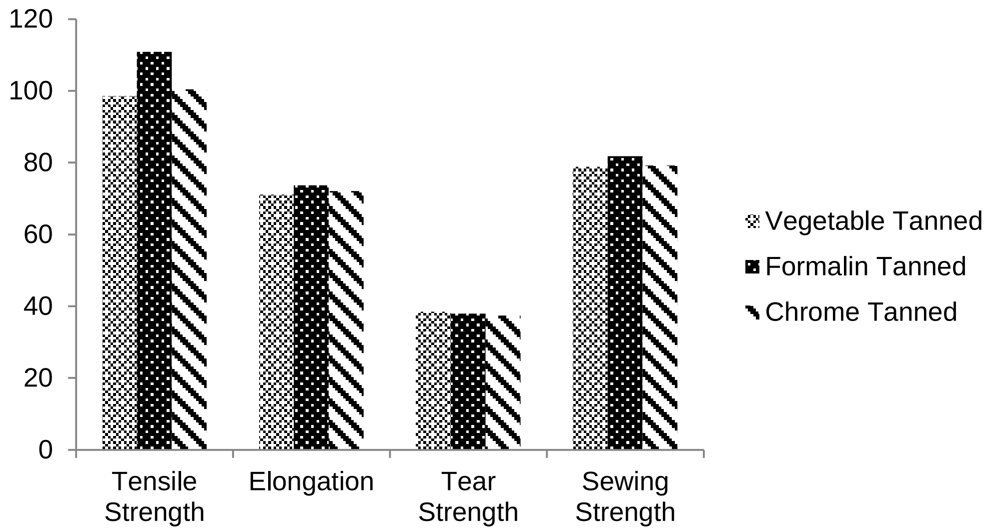


Figure 1. Physical Tests Results of Tanning Processes

Tanning with formalin will raise the shrinkage temperature from not standing the heat into being resistant to 70°C temperature and the tanned leather has less affinity compared to several basic substances of chrome or vegetable tanned leather. Aldehyde binds to the alkaline amino groups of skin proteins in slightly alkaline conditions, responses faster and several large molecules condensate giving the skin more properties than the tanned leather. The amount of cross-linkage formed will determine the shrinkage temperature of aldehyde-tanned leather. The more oxymethylene bridge, the higher shrinkage temperature will be. The increase of shrinkage temperature is very significant to the amount of aldehyde-bound, while the aldehyde bound depends on the pH liquid of tannin (Purnomo, 2009).

Leather tanning, in order to add formaldehyde bond to skin collagen, requires high pH concentrations, suitable formaldehyde liquid, and also above room temperature, and turning quickly. Physical properties of formaldehyde are such as having a boiling point of 21°C, infinite solubility in water, and the ability to form hydrogen bonds. Formaldehyde is more reactive than other aldehydes due to the lack of steric hindrance in formaldehyde. This steric hindrance is determined by an addition reaction of carbonyl groups, besides, the carbon has a large positive charge, as well as in there is no formaldehyde alkyl group to form a spreading positive charge.

Fig. 1 shows the results of tensile strength testing of puffer fish skin which has been tanned with formaldehyde tanning material and the value of the test shows a higher value compared to that of tanned leather using vegetable or chrome tanning materials.

Leather tanned with chrome tanning materials also has a high shrinkage temperature thereby produces high tensile strength as well. Besides, the skin tanned with chrome tanning has a high shrinkage temperature as described by Covington (2009), that the chrome tanning gives a high hydrothermal stability, so that the chrome tanned leather will reach a shrinkage temperature of 110°C. Whereas, shrinkage temperature is the temperature when the collagen structure of skin experiencing shrinkage. Shrinkage occurs due to the rupture of collagen fibers weave because of extreme conditions such as heating at high temperatures (Astrida et al., 2008).

According to Purnomo (1985), chrome tannin materials are those of most important mineral tannin. This is caused by special-quality related to molecular structure of chromium which allows trivalent chromium salts to form materials that have a strong allure for complex skin material. Chrome has a high tanning power shown through its binding to the carboxyl group of skin so that its structure becomes more compact and strong as seen in Fig. 2 below:

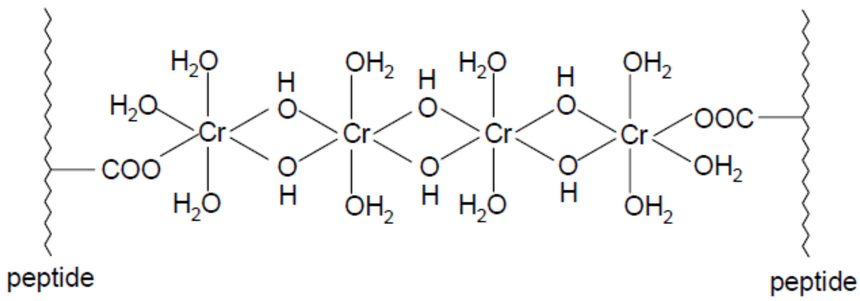


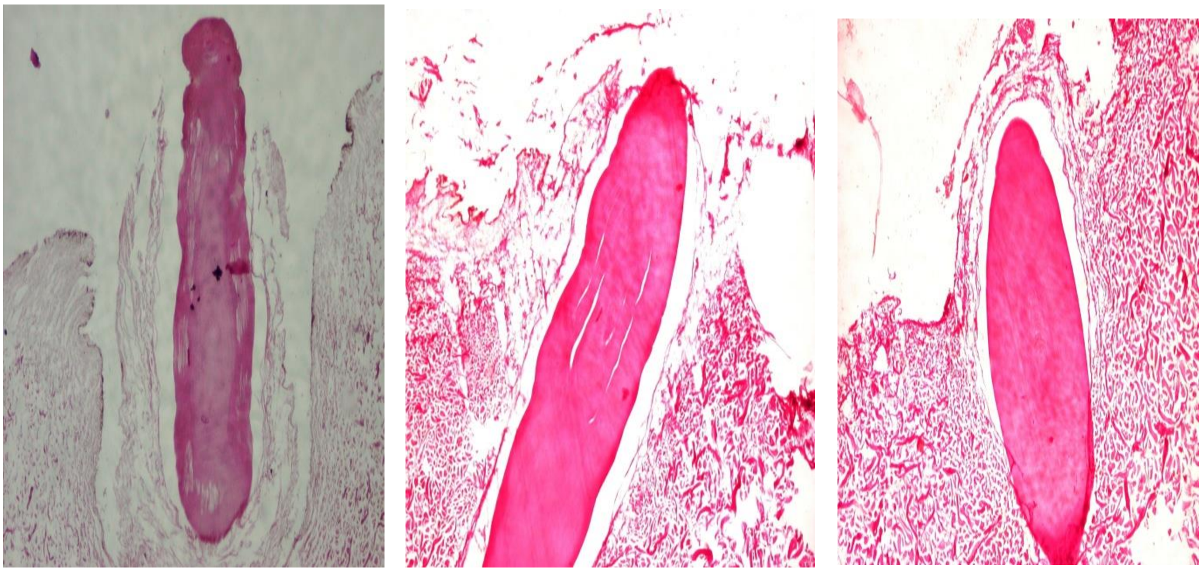
Figure 2. The reaction between chromium and carboxylic acid in the skin collagen (Covington, 2009).

Test results on tensile strength of puffer fish skin tanned with vegetable tannin materials indicates that the test value is lower than the puffer fish skin tanned with chrome tannin materials. The low tensile strength values might be caused by the bonding that occurs in vegetable tanned leather is hydrogen bonding so that the skin tanned with vegetable tanning so that its shrinkage temperature is lower than the chrome tanned. In the tanning process for vegetable leather, the shrinkage temperature is 53.27%, while for chrome tanned leather it is 81.60%.

Histological Structure of Puffer-fish Skin

Generally, fish skin contains of 69.6% water, 26.9% protein, 2.5% ash and 0.7% fat. Quality requirements of fish skin for tanned leather, e.g. stingray, according to SNI 6-6121-1999 include 1 mm thick, minimum shrinkage temperature of 70°C, minimum tensile strength of 2,000 N, tear strength of at least 300 N, a maximum moisture content of 20%, a maximum oil content of 12%, the appearance of the skin is not wrinkled and the skin is strong. Basically, fish skin has typical fingertips or natural markings that differ from each other.

Long et al. (1996) suggest that naturally, the structure of fish skin dermis can make its tensile strength is quite high due to the parallel trans structure. The dermis is composed and organized as parallel fiber layers which tend to form an angle (helically oriented) in the opposite direction. In histological observation of puffer-fish skin with three types of tanning, the images obtained can be seen as below:



(a) (b) (c)

Figure 3. (a) Microstructure of vegetable puffer fish leather: spines of fish are not sharp with soft shapes (b) Microstructure of chrome puffer fish leather: the thorns are still straight and sharp; (c) Microstructure of formalin puffer fish leather

Fig. 3 explains that the vegetable tanning affects the spines on its surface, i.e. not as sharp as that of chrome tanning. Although the chrome tanning stated that it gives good softness properties but has no effect on the prickly softness, proved by the fact that the thorns are still sharp compared to that tanned with vegetable tannin. This is possible since, with vegetable tanning, collagen parts that can react with the tanning agent are peptide side chains that are free, so it is able to form hydrogen bonds with the active group structure contained in the tanning substances.

In tanning guidelines, there is a famous term known as the "golden -rule". This principle states that tanning must be preceded by the rapid penetration of tanning substances, but with slow binding. Whereas at the end of tanning, the action should be the opposite, i.e. slow penetration but rapid bonding. To meet this principle, the concentration and pH solution should be managed. At high pH values, vegetable tanning materials have finer substances than tanning materials at low pH, as well as viscosity. At low concentrations, particle size is smaller than the high density. Of these properties at the beginning of vegetable tanning, the pH must be set high enough, i.e. approximately 5, so that the tannin particles can easily penetrate the skin fiber tissue.

Fig. 3c shows that the pufferfish thorns are still protected by the epidermis, due to formaldehyde tanning which functions as the skin preservative as well. According to Sarkar (1995), adding that the skins tanned using aldehyde also has resistance to sweat. This feature is due to the effects of natural polymerization of tanning materials that make skin fiber structural separate and subsequently form hydrogen bonds in the form of a polymer.

Conclusions

1. Puffer-fish skin when seen from its histological structure can be used as an alternative leather raw material.
2. Tensile Strength, elongation, tear strength and sewing strength of formalin tanned puffer-fish leather has the highest value, followed by chrome tanned and then the last, vegetable tanned.

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