Fatliquoring process on tuna fish skin tanning for the shoe upper leather

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Abstract. Fatliquoring is a part of tanning process, which is penetrating the fatliquoring agent into leather’s empty cells. The process changes the physical characteristics of leather, which make it softer, more elastic, flexible, and give smooth grain surface. This study is conducted to investigate the effects of type and dosage of fatliquors on the physical properties of tuna skin leather for the shoe upper. The types of fatliquors used are natural and synthetic, and the dosages are 3%, 6%, 9%, 12%, and 15%. Thickness increase, tear strength, tensile strength, elongation at break, and organoleptic properties of the leather are investigated. Based on this study, the types of fatliquor significantly affect the tear strength and elongation at break. The dosages of fatliquor which are nested in the type of fatliquor significantly affect tear strength, tensile strength, and elongation at break. The best treatment in this study is synthetic fatliquor with dosage of 3%. The treatment produced leather with thickness increase of 32.4%, tear strength of 95.3 N/mm, tensile strength of 27.9 N/mm², elongation at break of 45.3%, dark brown colour, smooth feel or handle, and good flexibility.

Key words: Fatliquoring, tuna skin, leather, shoe upper

1. Introduction
Tuna is one of the biggest fisheries commodities in Indonesia. The by-product of processing tuna is tuna skin. One of the uses of tuna skin is to produce leather which can be processed into various products such as bag, wallet, and shoes.

One important step in leather manufacturing is fatliquoring. Fatliquoring is part of the tanning process which aims to penetrating oil molecules into the empty space of leather fibres [1, 2]. The process causes changes in the properties of leather, i.e. the leather becomes flexible, tough, stretchy, and soft, so it is suitable for the manufacture of various products [3].

The oils used in the fatliquoring are oils that have undergone a process of sulfation or sulfitation. Sulfated or sulfited oils are widely used because they produce good oil dispersion and are not sensitive to acids [4]. Various natural oils commonly used in the fatliquoring. Nowadays, synthetic fatliquors have
also been developed which are able to produce the physical properties of the leather which are not much different from those of the natural fatliquors.

The use of the suitable type and dosage of fatliquor can produce more flexible, tough, stretchy, and soft leather so that it can be processed further and is also able to increase the efficiency of the fatliquor use. Based on these reasons, it is necessary to investigate the effect of type and dosage of fatliquor used on the physical and organoleptic properties of tuna skin leather for shoe upper.

The objectives of this study are to determine the effect of type and dosage of fatliquor on the physical and organoleptic properties of tuna skin leather for shoe upper and determine the best treatment in tuna skin tanning for the shoe upper leather.

2. Materials and methods

2.1. Materials

The materials used in this study are tuna skin and fatliquors. Tuna skin was obtained from PT Lautan Niaga Jaya, Muara Baru, North Jakarta. It was stored and preserved in freezing condition. The other materials used in the tanning process were water, chromium with 33% basicity, gambier, sodium chloride, sulfuric acid, formic acid, sodium bicarbonate, Sertan ND (dispersing agent), as well as natural and synthetic fatliquors. The fatliquors were the fatliquors with the brands Quimser, Barcelona with the product code Seroil CMT (natural) and Seroil FO (synthetic). Quimser [5] reported that both Seroil CMT and Seroil FO fatliquors are capable of producing very soft with a fairly light leather.

2.2. Equipment

The equipment used were rotary drum, shaker, jar, pH meter, thermometer, thickness gauge, baumeter, toggle dryer, tensile strength tester (UTM Instron), and glass apparatus.

2.3. Experimental procedure

Tuna skin pickled pelt with a size of 7 cm x 7 cm was tanned with a combination tanning using 8% chrome tannage and 20% gambier, then fatliquoring process was carried out. The methods of vegetable tanning and fatliquoring used were the methods reported by Suparno et al. [6]. Experimental design used in this study was a nested design with two factors and two replications. The factors observed were the type of fatliquor and the dosage of the fatliquor which was nested in the type of the fatliquor. Types of fatliquor used were natural (A1) and synthetic (A2). Dosage of fatliquors were 3% (B1), 6% (B2), 9% (B3), 12% (B4), and 15% (B5). The mathematical model is as follows:

\[ Y_{ijk} = \mu + A_i + B_{j(i)} + e_{ijk} \]  

where:
- \( Y_{ijk} \) = response value on the k replication, type level of i and dosage level of j
- \( \mu \) = general average
- \( A_i \) = effect of fatliquor type on the i-level
- \( B_{j(i)} \) = effect of fatliquor dosage on the j-level in \( A_i \)
- \( e_{ijk} \) = experimental error.

2.4. Physical and organoleptic tests

The physical properties of the leathers including thickness, tear strength, tensile strength, and elongation at break, and organoleptic properties of the leathers including colour, feel/handle, and flexibility were measured. The physical properties tests of leather used SLP 4, SLP 7, and SLP 6 for thickness, tear, and tensile strength and elongation at break tests, respectively [7]. Organoleptic test of the leather was carried
out visually and qualitatively. Flexibility was assessed using an ordinal scale of 1 - 5, where 1 was not flexible and 5 was very flexible.

2.5. Data analysis
The data were analysed using SPSS version 16.0 trial version with the calculation of analysis of variance referred to the experimental design used. If the results of the analysis of variance stated have a significant effect, then data processing was continued with Duncan's Multiple Range Test (Duncan's Test) to determine the difference in effect from each level of the experiment. The treatment which produces the physical and organoleptic properties of tuna skin leather that meet the SNI 0253:2009 [8] for the quality requirements of the goat skin leather for the footwear upper was selected.

3. Results and discussion

3.1. Thickness increase
Thickness increases of the tuna skin leathers were 31-33%, i.e. initial thicknesses of 0.5 - 2.0 mm became 0.65 - 2.5 mm after fatliquoring process (figure 1). The increases had fulfilled SNI 0253:2009 for the quality requirements of the goat skin leather for the footwear upper, i.e. minimum thickness of 0.5 mm [8]. Analysis of variance (ANOVA) showed a significance value for fatliquor type factors of 0.062 (> 0.05) and nested dosage factors of 0.186 (> 0.05). The results indicated that the type and dosage fatliquors did not significantly affect the thickness increase.

3.2. Tear strength
Tear strength test results indicated that an increase in tear strength along with an increase in the fatliquor dosage of each type of fatliquor used. Based on the analysis of variance, the significance value obtained for the type factor was 0.005 (<0.05) and the nested dosage factor was 0.000 (<0.05). These results indicated that the type and dosage of fatliquor gave significant effect on the tear strength. The highest tear strength (156.3 N/mm) was produced by 15% natural fatliquor, while the lowest (76.1 N/mm) was obtained from 3% natural fatliquor.

In the type of fatliquor, the tear strength produced by the synthetic fatliquor (121.8 N/mm) was higher than that of the natural fatliquor (114 N/mm) (figure 2). Duncan's test showed two different groups,
namely group A for synthetic fatliquor with a value of 121.8 N/mm, and group B for natural fatliquor with a value of 114 N/mm. The results stated that tear strengths of the leather treated with the synthetic fatliquor were significantly different from those of natural fatliquor.

Figure 2. Relationship of the type of fatliquor to the tear strength of the tuna skin leather.

In the nested fatliquor dosage factor (figure 3), the tear strength increased with increasing the dosage of fatliquor used. Similar results were also reported by Pahlawan and Kasmudjadi Astuti [9] who stated that increasing the dosage of fatliquor caused an increase in tear strength. The highest tear strength was produced by 15% natural fatliquor (156.3 N/mm) and the lowest was produced by 3% natural fatliquor (76.1 N/mm). The tear strengths fulfilled the SNI 0253:2009, i.e. minimum of 150 N/cm or 15 N/mm [8]. Suparno and Wahyudi [10] reported that the tear strength was influenced by many factors such as the thickness of the leather, the angle between the fibre and the grain layer, the direction of the collagen fiber, and the location of the sample on the leather.

Figure 3. Tear strength of tuna skin leathers at different type and dosage of fatliquors.
The addition of fatliquor increased the tear strength of leather. This was as a consequence of the penetration of oil molecules into the empty space among collagen fibres so that the oil molecules coat each woven collagen fibre. Woven collagen fibres that are coated by the fatliquoring agent become unsticky and more elastic causing the leather to be more difficult to tear.

3.3. Tensile strength
This study showed that the tensile strength of tuna skin leather decreased with increasing fatliquor dosages on each type of fatliquor used. Based on the analysis of variance, the significance value for the type factor was 0.117 (> 0.05) and the nested dosage factor was 0.000 (<0.05). Therefore, only fatliquor dosage factor significantly influenced the tensile strength. The highest tensile strength was produced by 3% synthetic fatliquor with a value of 27.9 N/mm², while the smallest value was produced by 15% natural fatliquor with a value of 14.9 N/mm² (figure 4). The use of 3% fatliquor fulfilled the SNI 0253:2009, i.e. minimum value of 16 N/mm² [8].

![Figure 4. Relationship between fatliquor dosage and tensile strength of tuna skin leather.](image)

According to Suparno et al. [11], the tensile strength of leather is influenced by various factors such as the type of tanning material, the direction of the fibre (parallel and perpendicular), the tanning process, the thickness of the skin and the sampling location. Purnomo [3] states that the fatliquoring is the process of penetrating oil molecules into empty spaces between skin collagen fibres. When collagen fibres are coated with oil, the collagen fibres become softer and more flexible. This is in line with the report of Palop [12] and Sivakumara et al. [13] which state that the fatliquoring is a complex process that is able to affect the physical properties of the leather such as tensile strength, tear strength, softness, and elongation. Collagen fibres that become more elastic cause the force needed to pull the skin to break up becomes smaller. Even with the same thickness, but with the reduced force needed to pull the skin to break, the value of the tensile strength will be smaller.
3.4. Elongation at break

Elongation at break test showed that the elongation increased with increasing dosage of fatliquor for each type of fatliquor used. The highest elongation at break was produced by synthetic fatliquor at a dosage of 15\% with a value of 80.8\%, while the lowest was produced by synthetic fatliquor at a dosage of 3\% with a value of 45.3 (figure 6). Based on the analysis of variance, the significance values for the type factor was 0.000 (<0.05) and the nested dosage was 0.000 (<0.05). These results showed that the type and nested dosage of fatliquor gave significant effects on elongation at break of tuna skin leather.

For the fatliquor type factor (figure 7), there was a considerable difference in the value of elongation at break between natural and synthetic fatliquors. Duncan’s further test for the fatliquor type showed that there were two different groups, namely group A for synthetic fatliquor with a value of 60.8\% and group B for natural fatliquor with a value of 55.8\%. Therefore, the natural fatliquor was significantly different from the synthetic fatliquor.

For fatliquor dosage factor, the elongation at break tended to increase with increasing dosage of the fatliquor used. The highest elongation at break (80.8\%) was produced by 15\% synthetic fatliquor, while the lowest (45.3\%) was produced by 3\% synthetic fatliquor (figure 6). Based on the results, leather samples that fulfilled the SNI 0253:2009 requirements, i.e. maximum of 55\% [8] were 3\% natural fatliquor (51.2\%), 6\% natural fatliquor (53.9\%) and 3\% synthetic fatliquor (45.3\%).

**Figure 5.** Tensile strength of tuna skin leathers at different type and dosage of fatliquors.
Figure 6. Elongation at breaks of tuna skin leathers at different type and dosage of fatliquors.

Figure 7. Relationship between the types of fatliquor and the elongation at break of tuna skin leathers.

3.5. Organoleptic test

Based on the organoleptic test, all leathers showed similar results in the colour and feel or handle, whereas there were some differences in the flexibility (table 1). The colour of the leathers obtained was dark brown (figure 8). This was caused by the gambier tanning material used. The colour of the gambier tannage was dark brown and the dosages of tannage used were the same (20%) so the colour produced were the same for each leather. Most of the treatments used in this study produces leather with soft surface and visible scales pattern. The soft surface of the leather was caused by the fatliquor used.
Both type of fatliquors resulted in leather with similar flexibility. The difference in dosage of fatliquor caused a difference in flexibility of leather. The higher the dosage of the fatliquor used, the more flexible the skin produced. Based on the organoleptic test, the flexibility of the leathers ranged from 3 to 4 in the 5 scale.

Table 1. Organoleptic properties of tuna skin leathers at different type and dosage of fatliquors.

| Type of Fatliquor | Dosage (%) | Colour          | Feel/Handle       | Flexibility* |
|-------------------|------------|-----------------|-------------------|--------------|
| Natural           | 3          | Dark brown      | Soft              | 3            |
|                   | 6          | Dark brown      | Soft, few scales pattern | 3            |
|                   | 9          | Dark brown      | Soft, clear scales pattern | 4            |
|                   | 12         | Dark brown      | Soft, clear scales pattern | 4            |
|                   | 15         | Dark brown      | Soft              | 4            |
| Synthetic         | 3          | Dark brown      | Soft, clear scales pattern | 3            |
|                   | 6          | Dark brown      | Soft              | 4            |
|                   | 9          | Dark brown      | Soft, clear scales pattern | 4            |
|                   | 12         | Dark brown      | Soft              | 4            |
|                   | 15         | Dark brown      | Soft              | 4            |

*1 – 5 scale, where 1 = not flexible and 5 = very flexible.

4. Conclusion
In conclusions, this study shows that the type of fatliquor affects the tear strength and elongation at break of the tuna skin leather significantly. Fatliquor dosage gives a significant effect on tear strength, tensile strength, and elongation at break of tuna skin leather. The treatment of 3% synthetic fatliquor is the best treatment for the fatliquoring process, that results in thickness increase of 32.4%, tear strength of 95.3 N/mm, tensile strength of 27.9 N/mm², and elongation at break of 45.3%, evenly and naturally dark brown colour, soft feel, and good flexibility.
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