



The Effect of Aluminum Sulfate Concentration on The Physical and Chemical Quality of Rabbit Tanned Fur

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Abstract | The research aims to determine the effect of aluminum sulfate concentration on the physical and chemical quality of rabbit tanned fur. chemical quality of rabbit tanned fur. The material used is local rabbit fur. The research method was Experimental, counting used Completely Randomized Design (CRD) with 4 treatments and 5 repetitions. Treatment consists of using 250 g of aluminum sulfate (T1); 300 g (T2); 350 g (T3) and 400 g (T4). Parameters include physical quality (elongation, thickness, tensile strength, ductility, tear strength and water absorption) and chemical quality (water content, fat content, protein content and water activity (Aw)). The research results showed that the highest average values were elongation ($56.02 \pm 6.29\%$), thickness (0.50 ± 0.08 mm), tensile strength (33.91 N/mm²), weakness (8.63 ± 0.48 mm), tear strength (18.28 ± 0.43 Kg/cm), water absorption (185.81 ± 8.96 for 2 h and 229.57 ± 16.77 for 24 h), water content ($13.98 \pm 0.11\%$), protein content ($20.28 \pm 3.79\%$), fat content ($17.03 \pm 0.46\%$) and Aw (0.613 ± 0.004). The conclusion is that the addition of aluminum sulfate concentration in rabbit tanned fur has an influence on the physical quality (thickness, elongation, ductility, tear strength and tensile strength).

Keywords | Animal waste, Animal fur waste, Livestock waste, Physicochemical, Tanned fur product, Tanning

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INTRODUCTION

Fur is one of the by-products of animal slaughter which can still be processed because it has many ben-

efits such as being a raw material for making clothes, furniture, handicrafts, drums, belts and many more (Setyaningsih, 2017). Rabbit fur is one type of livestock fur that is rarely used compared to other livestock fur. Rabbit fur is

considered exotic animal fur, this is because its fur is soft and has various colors and patterns even though it is the same breed (Maryati and Nugroho, 2021). *Livestock and Animal Health Statistics* (2020), shows that in 2020 the population of rabbits in Indonesia was 1.254.946, respectively in East Java Province with 394.629, Central Java 324.049 and West Java 276.552. This makes the potential for rabbit fur abundant. However, the increase in the number of rabbit livestock has not been accompanied by proper processing of rabbit fur waste. Farmers tend to throw away livestock waste, including hides, rather than using it into products that have marketable value. Utilization of rabbit fur is still low, so a processing process is needed to increase the selling value of rabbit fur into tanned fur.

Fresh rabbit fur is susceptible to chemical, physical and biological damage. Curing and tanning the fur is necessary after the fur is separated from the rabbit's body, before being processed into products. Tanned fur or commonly called tanning is the process of changing raw animal fur so that the fur becomes resistant to chemical, physical and biological influences due to the activity of microorganisms by adding tanning agents. Tanning agents are divided into vegetable, chemical, mineral and combination tanning agents. Tanning materials for tanning animal fur are divided into two types, namely tanning without fur and tanning with fur (Faishal et al., 2017; Prasannena et al., 2019).

Chrome is one of the tanning materials commonly used in the fur industry. Tanned fur that uses chrome tanning materials will produce higher quality and more stable fur. Chromium compounds (Cr) are carcinogenic compounds that can cause itching, irritation and inflammation if they come into contact with the fur (Sutyasmi, 2015). Tanning with chrome produces hazardous and toxic waste (B3), because the resulting liquid waste contains around 30–40 m³ of chrome per ton of raw hide (Sutyasmi et al., 2016). The use of aluminum sulfate can be an alternative as a tanning agent that is safer for people and does not pollute the environment. Alum or aluminum sulfate has the chemical formula Al₂(SO₄)₃. Alum is a chemical substance that belongs to the double salt group with the molecular formula K₂SO₄. Al₂(SO₄)₃·12H₂O (Manda et al., 2022). The aim of this research is to determine the effect of the concentration of aluminum sulfate on the physical and chemistry of rabbit tanned fur.

MATERIALS AND METHODS

RESEARCH MATERIALS

The material used in this research was rabbit tanned fur using 80 pieces of local male and female rabbit fur. Tanning materials aluminum sulfate or alum (Al₂(SO₄)₃) and coarse salt without iodine, clothes freshener and water.

RESEARCH EQUIPMENTS

The equipment used in this research was analytical scales (Mettler Toledo MS 204TS), gloves, plastic buckets, wooden stirrers, ropes and clothes hangers, pipe or scout sticks, scissors and plastic bags. The test equipment used for physical quality testing uses a thickness gauge (Mitutoyo) (measuring the elasticity and thickness of fur), a tensile strength instrument (Hongjin HJ-854) (measuring elongation, tear strength and tensile strength of fur and fabric) and a water absorption instrument (STM 473) (measuring water absorption of fur and fabrics). Drying plates, desiccators, ovens and analytical scales are used in the gravimetric assay method. The equipment used in the Kjeldahl method protein content test is a Kjeldahl flask, dropper pipette, fume cupboard, analytical scales and distillation equipment. The Soxhlet method for testing fat content is an analytical scale, filter paper, oven and a series of extraction tools such as a heating mantle, fat flask, rotary evaporator, Soxhlet and condenser. The tool used in the water activity (Aw) test is the Aw meter (Landtek WA-60A).

RESEARCH METHOD

The method used an experimental method with calculations using a Completely Randomized Design (CRD) consisting of 4 treatments and 5 replications. The research treatments were using 300 g of coarse salt in all treatments (w/w), using aluminum sulfate in T1: 250 g (w/w), T2: 300 g (w/w), T3: 350 g (w/w) and T4: 400 g (w/w). The test parameters are the physical and chemical quality of rabbit tanned fur. Physical qualities consist of elongation, thickness, tensile strength, ductility, tear strength and water absorption. Chemical quality consists of water content, fat content, protein content and Aw.

RABBIT TANNED FUR PREPARATION

The tanning process is based on research that has been carried out, the fur tanning procedure is according to (Mustakim et al., 2007). The procedure starts from preparing fresh rabbit fur, alum, salt and water, washing, soaking, fleshing, soaking, rinsing, drying, stacking and buffing. More detailed procedures can be seen through the flow diagram in Figure 1.

Then washing, cleaning the fat and remaining meat on the inside of the rabbit fur by hand, adding aluminum sulfate and salt according to the treatment. and add water to the bucket, then stir until homogeneous or dissolved, add the rabbit fur until it is submerged and stir, soak for up to 1 week (stir 4-5 times per day using a wooden stirrer by turning the fur or fur on top and bottom alternately), after soaking for 1 week, washed and rinsed with water until clean, soaked in water scented with clothes for 10 minutes, hung on a clothes hanger (hairy part outside and fur part outside), aired indoors (not can be under direct sunlight). Pull the fur so that it doesn't fold and become stiff. Don't pull the fur too hard so that the fur doesn't tear. The fur is softened

by rubbing the inside of the fur on a piece of wood or stick. The fur results were obtained with characteristics that were limp, soft, smooth and did not fall out, followed by tests for elongation, thickness and tensile strength.

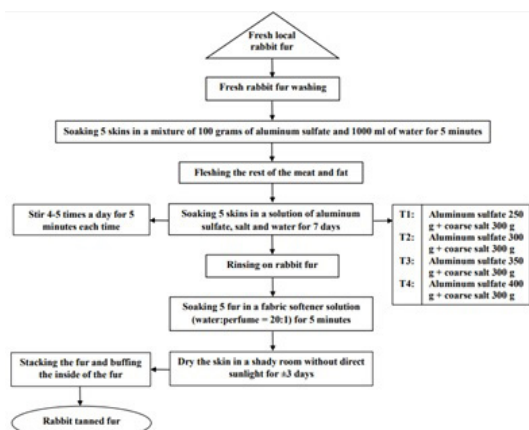


Figure 1: Flow chart of processing rabbit tanned fur.

MEASURED PARAMETER

Tanned fur is tested for chemical quality including the parameters of water content by the Gravimetric method, protein content by the Kjeldahl method and protein content by the Soxhlet method based on AOAC (2005), as well as water activity (Aw) according to research (Rifani et al., 2015). Physical quality tests include elongation and tensile strength (SNI 06-1795-1990), thickness (SNI 06-7128-2005), ductility (ISO 17235:2015), tear strength (SNI 06-174-1990) and water absorption (SNI 06-0997-1989).

STATISTICAL ANALYSIS

Statistical analysis was performed and visualization of experimental results using Microsoft Excel. ANOVA with a 95% interval was used to determine the effect of treatment on the response. The Duncan test was performed to establish significant differences between mean values ($\alpha = 0.05$).

RESULT AND DISCUSSION

PHYSICAL QUALITY OF RABBIT TANNED FUR

ELONGATION: Data on average of elongation can be seen in Table 1. Elongation is the increase in length of the fur when it is pulled until it breaks, divided by the original length and expressed as a percentage (%). Elongation is influenced by the fiber protein composition in the fur or the initial condition of the fur, so that the tanning agent does not affect the elongation of the fur and the bating process (Sutyasmi, 2015). Fur elongation is an indicator that determines the quality of the fur. The elongation value can be influenced by the tanning process and the elongation of tanned fur is also influenced by the type of livestock fur being tanned. Products that have too high elongation value will experience additional length (length

and shape change) caused by the high concentration of added ingredients. The elasticity or elongation of tanned fur is due to finishing processes such as stretching and softening. Fur that has high elasticity will produce a higher elongation value. The age of the animal can also affect the tensile resistance of the fur tissue structure.

Table 1: Average elongation (%) of tanned from rabbit fur.

Treatment	Elongation (%)	Elongation Standards (%) SNI 0253-2009
T1	39.97 ± 1.75 ^{ab}	Maximum 25%
T2	30.45 ± 8.47 ^a	
T3	43.40 ± 3.00 ^{bc}	
T4	56.02 ± 6.29 ^c	

Explanation: Different superscripts show a highly significant effect (p value <0.01) on the elongation (%) of rabbit tanned fur.

The elongation of rabbit fur has an average comparison which can be seen in Table 1. The average elongations obtained is T1: 39.97 ± 1.75%, T2: 30.45 ± 8.47%, T3: 43.40 ± 3.00%, T4: 56.02 ± 6.29%. The highest value of the elongation test on rabbit tanned fur was obtained in the T4 56.02 ± 6.29% and the lowest value of the elongation test was obtained in the T2 30.45 ± 8.47%. The high elongation value is due to the fat content in rabbit fur. Another study by Nurdiansyah (2012) in his research showed that the effect of using sulfite fish oil on the physical quality of rabbit fur with the addition of T1 (2%), T2 (4%), T3 (6%), T4 (8%) and T5 (10%) namely getting results of 22.66%, 31.48%, 47.51%, 55.14%.

The best results for fur elongation values were obtained in T2 30.45 ± 8.47%. According to SNI 06-1795-1990, the maximum elongation value of rabbit tanned fur is 30%. From these results it can be concluded that the elongation value of rabbit tanned fur using aluminum sulfate and salt can fulfill the requirements of SNI 06-1794-1990. There is a comparison with previous research based on Maryati et al. (2021) studied the effect of fatliquor levels of 5,10,15, 20, and 25% on salted Indonesian local rabbit fur leather resulting in elongation of 81.48-175.55%. The best treatment using 20% fatliquor on the fatliquoring process of rabbit fur leather tanning with an elongation of 154.03%. Wibowo et al. (2021) elongation fur tanning of Indonesian local rabbit fur using egg yolk of 8.10 and 12% as an alternative fatliquoring agent is 68.47-77.10%. The best treatment using 12% with an elongation of 11.10%.

THICKNESS: Data on average of thickness can be seen in Table 2. The thickness of the tanned fur is very important to pay attention to because it affects the quality of the fur product and the purpose of making the product. According to Hak (2013), fur is a by-product that has the potential

to be used as raw material for the tanning industry because it has a specific shape and surface pattern that is different from other fur, has a thickness and area that allows it to be made into fur products such as wallets, bags, shoes and more. Hayati (2013) in their research showed that tanned gourami fur from *Rhizopus* sp. T1 (0.5%), T2 (1.0%) and T3 177 (1.5%) and T4 (1.0%) respectively, 0.41 mm, 0.38 mm, 0.43 mm and 0.41 mm.

Table 2: Average thickness (%) of tanned from rabbit fur.

Treatment	Thickness (mm)	Thickness standards (mm)
T1	0.43 ± 0.05 ^b	SNI 06-7128-2005
T2	0.50 ± 0.08 ^c	
T3	0.40 ± 0.00 ^{ab}	
T4	0.33 ± 0.05 ^a	

Explanation: Different superscripts show a highly significant effect (p value <0.01) on the thickness (%) of rabbit tanned fur.

The results of analysis of variance showed that the use of aluminum sulfate with different concentrations had a very significant effect (p value <0.01) on the thickness of rabbit tanned fur. This shows that the use of aluminum sulfate with different concentrations has an influence on the thickness of rabbit tanned fur. The greater the aluminum sulfate concentration, the lower the fur thickness value. The average thickness of rabbit tanned fur is T1: 0.43 ± 0.05 mm, T2: 0.50 ± 0.08 mm, T3: 0.40 ± 0.00 mm, T4: 0.33 ± 0.05 mm. The lowest result from the thickness test on rabbit tanned fur was obtained in T4: 0.33 ± 0.05 mm and the highest result from the thickness test on rabbit tanned fur was obtained in T2: 0.50 ± 0.08 mm. Another research by Hayati (2013) in their research showed that gourami fur was tanned from treatment with *Rhizopus* sp. T1 (0.5%), T2 (1%) and T3 (1.5%) respectively: 0.41 mm, 0.38 mm, 188, 0.43 mm and 0.41 mm.

The thickness of the rabbit fur produced by each treatment is uneven, because the main factor that causes differences in rabbit fur thickness values is the process of separating the fur from the meat and remaining fat. This process is still carried out manually, so to measure whether the thickness of the fur is even or not, it can see with the naked eye and using your hands by feeling whether there are still wrinkles on the rabbit's fur. The process of separating the meat from the fur can affect the thickness test because if the process is not carried out correctly it can result in aluminum sulfate and salt cannot enter thoroughly and evenly, resulting in a low thickness test value. This is in accordance with the opinion of Nur *et al.* (2017) that the process of separating the meat from the fur aims to remove the remaining meat that is still attached to the raw fur so as not to block the entry of tanning substances during the tanning process. The process of removing the meat has a real influence on testing

the thickness of the fur, because the process is still carried out manually so that the thickness of the fur is not even, both on the same sheet of fur and on different sheets of fur. The average thickness in this study meets the requirements of SNI 06-7128-2005 with a minimum value of 0.20 mm. Factors that can influence the chemical composition of the fur includes the use of aluminum sulfate as a tanning agent.

There is a comparison with previous research based on Andini *et al.* (2023) studied fur tanned rabbit skin using gambier (*Uncaria gambir* Roxb.) 3-6% resulting in a thickness of 1.08-2.33 mm. The best treatment being using gambier 6% showing a thickness of 2.33 mm. Kanuri *et al.* (2019) explained that rabbit fur from different tannages produced a thickness of 0.4-0.6 (belly) and 1-1.2 mm (butt) using mimosa tanning materials, while 0.4-0.5 mm (belly) and 0.9-1 mm (butt) using chrome tanning materials.

TENSILE STRENGTH: Data on average of tensile strength can be seen in Table 3. Tensile strength is the maximum force required to pull the fur until it breaks, expressed in kg/cm² or N/mm². The tensile strength of fur describes the strength of the bond between the collagen fibers that make up the fur and the tanning agent (Kasim *et al.*, 2012). A good tanning processes will produce fur with high tensile strength. The physical properties of fur can be influenced by several factors including the quality of raw fur, fur preservation, the liming process, protein erosion, tanning, oiling and finishing processes such as stretching and stretching rabbit fur (Pahlawan and Kasmudjiastuti, 2012).

Table 3: Average tensile strength (%) of tanned from rabbit fur.

Treatment	Tensile Strength (N/mm ²)	Tensile strength standards (N/mm ²) SNI 06-1795-1990
T1	25.04 ± 0.48 ^{bc}	Minimum 22.06 N/mm ²
T2	33.91 ± 4.43 ^c	
T3	24.99 ± 2.28 ^b	
T4	14.12 ± 2.18 ^a	

Explanation: Different superscripts show a highly significant effect (p value <0.01) on the tensile strength (N/mm²) of rabbit tanned fur.

The high or low tensile strength of tanned fur is influenced by several factors including the type of tanning material, duration of tanning, species and age of the animal. The protein composition of the fibers in the fur will also influence the tensile strength of the fur. The tensile strength of tanned fur is influenced by the thickness of the fur, the content and density of collagen protein, the angle of the interwoven bundles of collagen fibers and the thickness of the corium (Mustakim *et al.*, 2007). The tensile strength of tanned fur is also influenced by the fat content. The width and

thickness of the fur, the higher the oil or fat content, the lower the tensile strength of the tanned fur. High levels of oil or fat will cause the fur to become weak and stretch easily and the fur will sag. So, this condition results in the fur's ability to withstand tensile loads decreasing (Sumarni and Triatmodjo, 2013).

The tensile strength test results of rabbit tanned fur with the concentration level of aluminum sulfate used in the tanning process in the T1 showed a tensile strength of 25.04 N/mm². T2 showed a tensile strength of 33.91 N/mm², T3 showed a tensile strength of 24.99 N/mm² and T4 showed a tensile strength of 14.12 N/mm². In treatments that do not meet the standards of SNI 06-1795-1990, only T4: 14.12 N/mm² with a minimum standard of 22.06 N/mm². In other research of Ardinal and Salmariza (2019) found that the use of aluminum sulfate as a tanning agent affects the color of tanned fur, namely producing a reddish yellow color and also affects the physical quality with tensile strength.

There is a comparison with previous research based on Kanuri *et al.* (2019) explained that rabbit fur produces a tensile strength of 15.97 N/mm² using mimosa tanning material and 17.09 N/mm² using chrome tanning material. Maryati *et al.* (2021) the effect of fatliquor levels of 5,10,15, 20, and 25% on salted Indonesian local rabbit fur produces a tensile strength of 0.96-3.19%. The best treatment using 20% fatliquor on the fatliquoring process of rabbit fur leather tanning with a tensile strength of 1.77%. Andini *et al.* (2023) studied fur-tanned rabbit skin using gambier (*Uncaria gambir* Roxb.) 3-6% produced a tensile strength of 28.25-34.43 N/cm². Maryati and Nugroho (2021) explained the tensile strength of 1.7 N/mm² in tanned rabbit fur under medium fat liquor level (15%).

Table 4: Average ductility (mm) of tanned from rabbit fur.

Treatment	Ductility (mm)	Ductility standards (mm) SNI 4593:2011
T1	7.00 ± 0.67 ^{ab}	5.0-7.0
T2	8.63 ± 0.48 ^b	
T3	8.13 ± 0.79 ^b	
T4	6.80 ± 1.05 ^a	

Explanation: Different superscripts show a significant effect (p value <0.05) on the ductility (mm) of rabbit tanned fur.

DUCTILITY: Data on average of ductility can be seen in Table 4. Rabbit fur ductility has an average comparison which can be seen in Table 4. The average ductility obtained is T1: 7.00 ± 0.67 mm; T2: 8.63 ± 0.48 mm; T3: 8.13 ± 0.79 mm; T4: 6.80 ± 1.05 mm. The highest value of the elasticity test on rabbit tanned fur was obtained in T2 8.63 ± 0.48 mm and the lowest value of the elasticity test was

obtained in T4 6.80 ± 1.05 mm. The fur of the Zemleer rabbit undergoes a process of calcification and erosion of the fur protein so that the elastin is reduced and the tanned fur becomes weak (Anggraini and Maryati, 2023). Elastin is a fibrous protein that has amino acid chains that form corners to form elastic fibers. Fur with high laxity is caused because there are spaces between collagen fibers that are not filled with tanning material, the incoming tanning material binds less fur collagen amino acids, so that the tanned fur structure is less dense and produces softer fur. The fur will become stiffer if too much tanning agent is added (Setiawan *et al.*, 2015).

The thickness of the fur is also a factor that determines weakness. Based on research by Ikhwan (2020) on chrome goat tanned fur, it is known that the thicker the fur, the stronger the resistance provided and vice versa for thin fur. Fur with a higher thickness tested with the softness fur test ST 300 will produce a smaller softness value. Thinner fur has collagen fibers that are less dense and horizontal. The average weakness in this study was only 2 treatments that met the requirements of SNI 4593:2011 with a value range of 5.0-7.6 mm. T1 and T4 meet the requirements while T2 and T3 do not. Fur thickness that is not the same in each treatment can affect weakness, so that the weakness value does not decrease sequentially from T1 to T4 as the aluminum sulfate concentration increases. The process of removing remaining fat and meat from imperfect fur can cause the fur to be thicker and less limp.

There is a comparison with previous research based on Anggara *et al.* (2013) the use of acid types (HCl, H₂SO₄ and HCOOH) in the pickle process for tanning rabbit fur on the chemical quality of New Zealand White crossbred rabbit fur resulted in the use of 2% HCl providing the best chemical quality, with a pH of 2.73; water content of 75.73% and ductility of 7.28%.

Table 5: Average tear strength (Kg/cm) of tanned from rabbit fur.

Treatment	Tear strength (Kg/cm)	Tear strength standards (Kg/cm) SNI 06-3536-1944
T1	16.03 ± 0.34 ^a	Minimum 150
T2	17.87 ± 1.28 ^a	
T3	15.73 ± 0.36 ^a	
T4	18.28 ± 0.43 ^b	

Explanation: Different superscripts show a highly significant effect (p value <0.01) on the ductility (mm) of rabbit tanned fur.

TEAR STRENGTH: Data on average of tear strength can be seen in Table 5. The results of the analysis of variance showed that the treatments had a highly significant effect (p value <0.01) on the tear strength of rabbit fur tan. The

tear strength of rabbit fur has an average comparison which can be seen in Table 5. The average tear strength obtained is T1: 16.03 ± 0.3 Kg/cm; T2: 17.87 ± 1.28 Kg/cm; T3: 15.73 ± 0.36 Kg/cm; T4: 18.28 ± 0.43 Kg/cm. The highest value from the tear strength test on rabbit tanned fur was obtained in the T4 18.28 ± 0.43 Kg/cm and the lowest value from the elasticity test was obtained in the T3 15.73 ± 0.36 Kg/cm.

The tear strength of tanned fur can be influenced by its collagen content and density. Based on Kusmaryanti *et al.* (2016), fur thickness is one of the factors that influences the tear strength of the fur of the Mondol stingray (*Himantura gerrardi*). Collagen fibers are looser in thin fur so the tear strength is less than in thicker fur. Thick fur has more collagen fibers bound together which increases the compactness of the fur resulting in high tear strength. The average tear strength of rabbit tanned fur from this study with the addition of 300 g of coarse salt and aluminum sulfate of 250, 300, 350 and 400 g still does not meet the SNI 06-3536-1994 standar a minimum of 150 Kg/cm. Based on Ramadhan *et al.* (2016) the tear strength of tanned fur can be influenced by several factors, namely the concentration of tanning material used, duration of tanning, age of the fur and thickness of the fur based on the structure of the fur tissue. High fat content can also reduce the tear strength of tanned fur. These factors result in the tear strength value not increasing sequentially from T1 to T4 along with increasing aluminum sulfate concentration.

There is a comparison with previous research based on Maryati *et al.* (2021) the effect of fatliquor levels of 5,10,15, 20, and 25% on salted Indonesian local rabbit fur produced a tear strength of 9.35-36.82 Kg/cm. The best treatment using 20% fatliquor on the fatliquoring process of rabbit fur tanning with a tensile strength of 1.77%. Andini *et al.* (2023) studied fur-tanned rabbit skin using gambier (*Uncaria gambir* Roxb.) 3-6% produced a tear strength of 5.85-8.25 Kg/cm.

WATER ABSORPTION: Data on average of water absorption can be seen in Table 6. The results of the analysis of variance showed that the treatments had no effect (p value >0.05) on the water absorption of rabbit tanned fur. Rabbit fur water absorption has an average comparison which can be seen in Table 6. T2 has the lowest value, namely 162.83 ± 22.11% for 2 hours of water absorption and 194.06 ± 21.20% for 24 hours of water absorption.

The water absorption of tanned fur is quite large because the tanning material used is generally hydrophilic, so it has a good affinity with water. The water absorption of tanned fur can be reduced at the processing and finishing stages by adding treatment modifications to the surface of the fur. Tanned fur can be treated with a fur sealing treatment with

a waterproof layer during the finishing process. Closing gaps between fur tissue with a closed waterproofing process can also be done using water repellent materials, or with open waterproofing, the formation of a hydrophobic net around the tissue without surface filler (Prayitno and Kasmudjiastuti, 2017).

Table 6: Average water absorption (%) of tanned from rabbit fur.

Treatment	Water absorption (%)		Water absorption standards (%) SNI 06-17752-1990
	2 hours	24 hours	
T1	174.52 ± 12.93	202.42 ± 14.74	2 hours (minimum 100%) 24 hours (minimum 200%)
T2	162.83 ± 22.11	194.06 ± 21.20	
T3	185.81 ± 8.96	229.57 ± 16.77	
T4	174.57 ± 16.62	209.45 ± 19.29	

The average water absorption in this study almost entirely meets SNI 06-1752-1990 standards. Only T2 with a value of 194.06 ± 21.20% in water absorption for 24 hours does not meet the SNI. The water absorption value at 24 hours was higher than at 2 hours in all treatments. These results are in accordance with research by Pancapalaga *et al.* (2021) on rabbit tanned fur with corn oil tanned material of 10%, 20% and 30%, that tanned fur has a lower water absorption capacity at 2 hours and higher at 24 hours, but when it reaches the saturation point, the water absorption capacity will remain the same. Water absorption increases as the concentration of the tanning material increases. Based on Anggraini and Maryati (2023) in rabbit tanned with 15%, 20% and 25% castor oil, the water absorption value is high due to the density of fur collagen. The non-uniformity of water absorption by tanned fur is caused by the stages before tanning such as soaking, removing fat, removing non-collagenous substances which affect the density of the collagen fiber structure of the tanned fur. This resulted in it not increasing sequentially from T1 to T4 along with increasing aluminum sulfate concentration.

There is a comparison with previous research based on Anggarini and Maryati (2023) studied the water absorption of rabbit Zeemler fur tanned using percentage (15.20 and 25%) of castor oil resulting in water absorption of 333.62-469.45% (2 h water absorption) and 358.68-475.09% (24 h absorption). Mustakim *et al.* (2007) water absorption of Indonesian local rabbit fur tanned using percentage (6, 8 and 10%) of chromosal B resulting in water absorption of 233.81-236.82% (2 h water absorption) and 252.60-255.48% (24 h absorption).

CHEMICAL QUALITY OF RABBIT TANNED FUR

WATER CONTENT: Data on average of tear strength can be seen in Table 7. The results of the analysis of

variance showed that the four treatments given the total concentration of aluminum sulfate had a highly significant effect (p value <0.01) on the water content of rabbit fur tan. From the research results, the highest water content value was obtained in T4 was $13.98 \pm 0.11\%$, while the lowest water content value was obtained in T1 was $12.32 \pm 0.21\%$. Furthermore, the average water content in T2 was $13.17 \pm 0.15\%$ and in T3 was $13.94 \pm 0.11\%$. The average value of water content successively increased gradually at T1 ($12.32 \pm 0.21\%$), T2 ($13.17 \pm 0.15\%$), T3 ($13.94 \pm 0.11\%$) and T4 ($13.98 \pm 0.11\%$) due to increasing aluminum sulfate concentration during the soaking process. Adding alum can reduce the water content of a material because alum is able to act as a dehydrated agent so that an osmosis event occurs because the alum salt solution will draw water out of the cells of the collagen fiber network. The research results showed that adding alum concentration actually increased the water content. Increased water content due to reverse osmosis or hyperfiltration events caused by the administration of tanning agent that exceeds the limit. This event causes the water content to increase as the alum content increases, where the solution from a high concentration will actually move to a solution with a lower concentration. Increasing the concentration of aluminum sulfate will produce rabbit tanned fur that is more easily damaged due to the growth of spoilage microorganisms, bacteria and fungi due to the increased water content in the fur.

Table 7: Average water content (%) of tanned from rabbit fur.

Treatment	Water content (%)	Water content standards (%) SNI 06-17752-1990
T1	12.32 ± 0.21^a	$\leq 18\%$
T2	13.17 ± 0.15^b	
T3	13.94 ± 0.13^c	
T4	13.98 ± 0.11^c	

Explanation: Different superscripts show a highly significant effect (p value <0.01) on the water content (%) of rabbit tanned fur.

A low water content value indicates that tanned fur is able to withstand the activity of damaging microorganisms. On the other hand, a high water content value indicates that tanned fur will be susceptible to damage due to microorganisms that grow due to the existing water content. Microorganisms are able to reproduce on animal fur because there is a source of nutrition, high water content, pH and suitable temperature in the tanning environment (Rahmawati *et al.*, 2021). Raw fur has a water content of 60-65%, protein 30%, fat 0.5-7%, minerals, carbohydrates, enzymes and color pigments 0.5% (Amertan-ingtyas *et al.*, 2011). Fresh rabbit fur has a water content of 64% (Soeparno *et al.*, 2011). The water content value

will have both a physical and chemical effect which will affect the quality of the tanned fur produced. Salt as a dehydrated agent can draw water from the fur so that tanned fur becomes stable against water absorption (Mustakim *et al.*, 2007). There is a comparison with previous research based on Souza *et al.* (2016) tanned rabbit fur with plot treatments (fur regions: R1=dorsal and R2=flank) and subplots directions (S1=longitudinal and S2=transversal) the leather analysis revealed low moisture (31.76%), and a high ash content (8.58%).

PROTEIN CONTENT: Data on average of protein content can be seen in Table 8. The results of various studies showed that of the all treatments, the data of aluminum sulfate treatment on protein levels did not have a significant effect (p value >0.05). The highest average protein content results were shown by the average of the T2 with the addition of 300 g aluminum sulfate and 250 g salt, namely 20.28%, followed by T4 with 400 g and 250 g salt were 19.78%. Furthermore, protein levels decreased in T1 14.86%, and T3 17.54%.

Table 8: Average protein content (%) of tanned from rabbit fur.

Treatment	Protein content (%)	Protein content standards (%) Soeparno <i>et al.</i> (2011)
T1	14.86 ± 0.84	$\pm 80\%$
T2	20.28 ± 3.79	
T3	17.54 ± 3.54	
T4	19.78 ± 4.24	

The results of the average protein content of rabbit fur tanned fur showed results that did not require the protein content standards according to Soeparno *et al.* (2011) the result was $\pm 80\%$. The addition of alum concentration showed fluctuating results between T1 ($14.86 \pm 0.84\%$), T2 ($20.28 \pm 3.79\%$), T3 ($17.54 \pm 3.54\%$), and T4 ($19.78 \pm 4.24\%$). Adding alum and coarse salt to the soaking solution will reduce the pH of the water to acidic. The more alum and salt solution added, the more the pH of the solution will drop to become strongly acidic. The low results in protein content research is caused by the pH value of the solution being too acidic due to the addition of alum which will affect the protein structure of the fur. Proteins in the fur will experience denaturation which will cause changes in protein structure resulting in damage to secondary, tertiary and quaternary structures. The decrease in protein levels is due to protein solubility at high alum salt concentrations where the protein in the fur will also separate into a precipitate (salting out). Damage to the protein structure also reduces the functional ability of the protein to absorb water, so that the texture of the tanned fur will become denser, harder and tear easily. Apart from being caused by the tanning agent, the high or low levels of protein in the fur

can also be influenced by the condition of the rabbits while they are still alive.

The high or low levels of protein in rabbit fur can be caused by the feed given by the breeder, the age of the rabbit, the gender of the rabbit and diseases experienced by the rabbit such as scabies. [Mustakim et al. \(2007\)](#) there must be a limit on the use of tanning materials in the rabbit fur tanning process so that there is no reduction in quality. A decrease in protein levels can be caused by the addition of aluminum sulfate that exceeds reasonable limits, resulting in protein denaturation. Aluminum sulfate has acidic properties which can drastically reduce the pH value of the solution ([Ningsih and Harmawan, 2022](#)). Adding aluminum sulfate will create a solution in the process of soaking rabbit fur tan in an acidic or low pH environment so that it can affect the protein content of rabbit tan fur. The drying process can expose the rabbit's tanned fur to solar radiation, where the radiation can damage the protein structure of the rabbit's fur if it is continuously exposed to radiation ([Marfira et al., 2018](#)). There is a comparison with previous research based on [Souza et al. \(2016\)](#) tanned rabbit fur with plot treatments (fur regions: R1=dorsal and R2=flank) and subplots directions (S1=longitudinal and S2=transversal) the leather analysis revealed protein (46.48%).

Fat content: Data on average of fat content can be seen in [Table 9](#). The results of the analysis of variance showed that the four treatments had a highly significant difference (p value <0.01) on the fat content of hairy rabbit fur. The lowest results were shown in T1 with an average fat content of $8.69 \pm 1.78\%$. Furthermore, the fat content increased successively, in T2 $10.14 \pm 1.22\%$ and T3 $10.26 \pm 0.91\%$. The highest fat content results were shown in T4 $17.03 \pm 0.46\%$. The fat content value in the study increased significantly as the tanning agent used increased. The results of this research exceed the quality standard [SNI 06-4568-1998](#) which requires a minimum fat content limit in tanned fur 3% and a maximum of 8%.

Table 9: Average fat content (%) of tanned from rabbit fur.

Treatment	Fat content (%)	Fat content standards (%) SNI 06-4568-1998
T1	8.69 ± 1.78^a	3-8
T2	10.14 ± 1.22^b	
T3	10.26 ± 0.91^b	
T4	17.03 ± 0.46^c	

Explanation: Different superscripts show a highly significant effect (p value <0.01) on the fat content (%) of rabbit tanned fur.

The results of the average fat content increased as the tanning agent was added, which was 408 shown in T1 (8.69 ± 1.78), T2 (10.14 ± 1.22), T3 (10.26 ± 0.91) and

T4. (17.03 ± 0.46). The addition of alum can dissolve the fat contained in the fur. Alum is a flocculant where alum will bind oil particles in the fur and fat so that these particles will bind to each other and form larger particles and will settle to the bottom of the solution. However, as the amount of alum concentration used increases, the results show an increasingly higher average fat content. The increase in fat content due to the addition of alum concentration is because a solution with an alum concentration that is too concentrated will actually prevent the tanning agent from being able to enter (penetrate) into the fur fibers.

The low levels of fat contained in tanned fur are due to the effects caused during the fat cleaning process ([Ardinal and Salmariza, 2019](#)). The process of cleaning fat (fleshing) is done manually, namely cleaning only using your hands. The liming process will cause the dissolution of fur fat, even though the composition of fur fat is very complex ([Pancapalaga, 2008](#)). The fat cleaning process involves separating the raw rabbit fur from the fat, meat and blood that is still attached. There is a comparison with previous research based on [Souza et al. \(2016\)](#) tanned rabbit fur with plot treatments (fur regions: R1=dorsal and R2=flank) and subplots directions (S1=longitudinal and S2=transversal) the leather analysis revealed fat content (24.95%). [Prasennena et al. \(2019\)](#), Indonesian local rabbit tanned with mimosa concentration: 5%, 10%, 15%, 20% show the highest fat concentration on 5% of 12.42% and the lowest on 20% of 7.41%

Table 10: Average water activity (Aw) of tanned from rabbit fur.

Treatment	Water activity (Aw)	Water activity standards (%) (Ratnawati et al., 2021)
T1	0.568 ± 0.005^a	>0.7 (Mold)
T2	0.590 ± 0.012^b	>0.8 (Khamir)
T3	0.600 ± 0.007^{bc}	>0.9 (Bacteria)
T4	0.613 ± 0.004^c	

Explanation: Different superscripts show a highly significant effect (p value <0.01) on the water activity (Aw) of rabbit tanned fur.

WATER ACTIVITY (Aw): Data on average of water activity can be seen in [Table 10](#). The results of the analysis showed that the four treatments with different concentrations of aluminum sulfate had a very significant effect (p value <0.01) on the water activity (Aw) of rabbit fur tanned fur. From the research results, the highest water activity (Aw) value was obtained in the T4 with results of 0.613 ± 0.004 . The lowest water activity value (Aw) was shown in T1 0.568 ± 0.005 , then respectively the value of Aw in T2 was 0.590 ± 0.012 and T3 was 0.600 ± 0.007 . Based on the research results, it can be seen that as the concentration of aluminum sulfate increases, the average water activity

increases, respectively T1, T2, T3 and T4.

The results of the Aw test are comparable to the results of the water content test. This is because the higher the water content in the tanned material or fur, the higher the ability for destructive microorganisms to reproduce. The minimum for the growth of microorganisms is 0.6 for mold, yeast 0.7 and bacteria 0.9 (Ratnawati *et al.*, 2021). The addition of alum and coarse salt will reduce the water content in tanned fur so that water is free the content contained will be lower, resulting in destructive microorganisms dying due to dehydration. The higher concentration of alum used shows a higher water activity value due to alum and salt as tanning materials having the property of binding water, but the addition of higher tanning materials will result in a reverse osmosis event so that water will move from a high concentration to a higher concentration. low. The higher water activity is directly proportional to the growth of microorganisms (Mataragas *et al.*, 2015).

CONCLUSIONS AND RECOMMENDATIONS

Based on the research results, it can be concluded that the addition of aluminum sulfate with different concentrations in the rabbit fur tanning process have an influence on the physical quality (thickness, elongation, ductility, tear strength and tensile strength) and chemistry (water content, fat content and water activity (Aw)) and has no effect on water absorption and protein content.

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NOVELTY STATEMENT

The novelty in this research is carried out has resulted in rabbit tanned fur production, especially in Indonesia, is still rarely done compared to tanning cow, goat or buffalo skin. In fact, rabbit fur has a unique and exotic fur color. The results of rabbit tanned fur production can be used as raw materials for various accessories/crafts, such as bags, shoes, cap and others. Simple tanning can use alum (aluminum sulfate), where as a tanning material, alum is a safe and environmentally friendly material that can reduce the risk of environmental pollution. Therefore, this study explores the potential of alum as a tanning material for rabbit fur, by examining various concentrations of alum on the quality of rabbit tanned fur. The results of the study are expected to be applied in the community, especially in areas with

potential for rabbit farming and can be developed on an industrial scale.

AUTHORS'S CONTRIBUTIONS

Alia Salsabilla Putri, Nur Rohman Rizqi Pudya Permana, Silvia Rosa Al Rahma: Contributed to the data collection, data analysis and manuscript preparation.

Dedes Amertaningtyas, Premy Puspitawati Rahayu, RLM. Satrio Ari Wibowo, Ragil Yuliatmo, Eko Nuraini, Risha Amalia Saleha: Had the role of designing and generating the concept, supervising, monitoring and controlling the research, data analysis and interpretation and manuscript preparation.

Dedes Amertaningtyas: Contributed to supervise the research.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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