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Physical and chemical characteristics of tanned chicken feet skin from freshly slaughtered and dead on arrival chickens

Karakteristik fisik dan kimia kulit kaki ayam tersamak dari ayam segar yang disembelih dan ayam mati sebelum penyembelihan

Dian Nur Amalia, Laili Rachmawati*, Mustafidah Udkhiyati, Nur Mutia Rosiati, Nais Pinta Adetya, and Emiliana Anggriyani

Department of Leather Processing, Politeknik ATK Yogyakarta, Bantul, Yogyakarta, Indonesia. 55188
*Corresponding author: laili.rachmawati@atk.ac.id

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ABSTRACT

Dead on arrival (DOA) animals, particularly poultry, refer to animals that die during the pre-slaughter phase and are generally considered waste, despite their potential as raw materials for leather production. However, scientific information regarding the quality of leather produced from DOA chicken feet skin remains limited. Therefore, this study aimed to evaluate the feasibility of utilizing DOA chicken feet skin by comparing its physical and chemical properties with those of fresh chicken feet skin after tanning. Chicken feet skin from both sources was processed through beamhouse operations, tanning, post-tanning, and finishing stages before quality evaluation. Physical properties analyzed included thickness, softness, shrinkage temperature, elasticity, tensile strength, tear strength, and seam strength, while chemical properties included pH, moisture content, and oil/fat content. Differences between treatments were analyzed using an independent samples t-test for parameters with sufficient replicates. The results showed that thickness, softness, and shrinkage temperature were not significantly different (P>0.05). Fresh and DOA leather showed comparable seam strength values of 602.52 N/cm and 600.23 N/cm, respectively. Chemical properties were also similar, with pH of 4, moisture contents of 15.16% and 13.82%, and oil/fat contents of 14.94% and 14.05%. Overall, DOA chicken feet skin showed comparable characteristics and potential for leather production.

ABSTRAK

Hewan mati kemarin (tiren), khususnya unggas, merujuk pada hewan yang mati selama fase pra-penyembelihan dan umumnya dianggap sebagai limbah, meskipun memiliki potensi sebagai bahan baku produksi kulit. Namun, informasi ilmiah mengenai kualitas kulit yang dihasilkan dari kulit kaki ayam tiren masih terbatas. Oleh karena itu, penelitian ini bertujuan untuk mengevaluasi kelayakan pemanfaatan kulit kaki ayam tiren dengan membandingkan sifat fisik dan kimianya dengan kulit kaki ayam segar setelah proses penyamakan. Kulit kaki ayam dari kedua sumber diproses melalui tahap beamhouse operation, penyamakan, pasca-penyamakan, dan finishing sebelum dilakukan evaluasi kualitas. Sifat fisik yang dianalisis meliputi ketebalan, kelembutan, suhu kerut, elastisitas, kekuatan tarik, kekuatan sobek, dan kekuatan jahit, sedangkan sifat kimia yang dianalisis meliputi pH, kadar air, serta kadar minyak/lemak. Perbedaan antar perlakuan dianalisis menggunakan independent samples t-test untuk sebagian parameter. Hasil penelitian menunjukkan bahwa ketebalan, kelembutan, dan suhu kerut tidak berbeda nyata (P>0,05). Kulit kaki ayam segar dan tiren menunjukkan nilai kekuatan jahit yang sebanding, masing-masing sebesar 602,52 N/cm dan 600,23 N/cm. Sifat kimia juga menunjukkan hasil yang serupa, dengan pH sebesar 4, kadar air 15,16% dan 13,82%, serta kadar minyak/lemak 14,94% dan 14,05%. Secara keseluruhan, kulit kaki ayam tiren menunjukkan karakteristik yang sebanding dan berpotensi dimanfaatkan sebagai bahan baku produksi kulit.

Kata kunci:
Bahan baku alternatif
Fatliquoring
Kulit kaki ayam
Sifat fisik
Sifat kimia

INTRODUCTION

The demand for leather raw materials continues to increase along with the growth of the leather industry and the diversification of leather-based products. Traditionally, the leather industry relies heavily on hides from large animals such as cattle, goats, and sheep. However, the availability of these conventional raw materials is often limited and competes with the meat industry. Therefore, the exploration of alternative sources of leather raw materials has become increasingly important to support sustainable production and resource efficiency.

The one of potential alternative source is poultry waste generated from the broiler chicken industry. Broiler chickens are widely farmed due to their rapid growth rate and high feed conversion efficiency. However, broilers are highly susceptible to bacterial and viral infections, especially during the early stages of rearing. At 30–34 days of age, the immune system of broiler chickens is not yet fully developed, making them more vulnerable to disease and requiring ad adequate nutritional support to maintain physiological function and endurance (Song et al., 2021). In addition, sensitivity to heat stress tends to decrease as chickens age (Fadare & Famuyide, 2021). Various farms have reported mortality among chickens before they reach slaughter age, caused by disease, heat stress, and predator attacks. Chickens that die before slaughter are generally categorized as culled chickens or dead on arrival (DOA) animals. Based on the type of housing system, the mortality rate of broilers was reported to be 1.84% in closed houses, 3.60% in postal houses, and 3.47% in stage houses (Vanda et al., 2023). This mortality not only causes economic losses for farmers but also generates poultry waste that still has the potential for further utilization.

Among the by-products generated from poultry mortality, chicken feet skin has potential to be utilized as a raw material for leather production. Anatomically, chicken feet consist of a bone structure covered by skin containing collagen fiber that can potentially be processed through tanning. However, the characteristics of chicken feet skin vary depending on whether the chickens are fresh or dead prior to be slaughtered. Chicken feet skin from DOA typically appears reddish-yellow, thinner, wrinkled, and produces an unpleasant odor. In contrast, fresh chicken feet skin is generally white, has normal thickness, a smoother texture, and the typical odor of fresh meat. These differences can influence the skinning process and the subsequent processing stages. The skin of fresh chicken feet is usually easier to separate from the bone, whereas the skin from dead chickens tends to adhere more strongly to the bone structure.

The utilization of chicken feet from culled or dead chickens as a raw material for leather tanning is considered more appropriate than using chicken feet from properly slaughtered chickens intended for human consumption. Using edible materials for non-food industrial purposes may potentially create competition with the food sector. Therefore, utilizing chicken feet contribute to reduce livestock waste while simultaneously generating additional economic value. More broadly, the utilization of poultry skin waste as an alternative raw material for the tanning industry aligns with the concept of a circular economy, which emphasizes resource efficiency and waste reduction. Through the tanning process, raw skin can be converted into a stable material that is resistant to microbiological degradation (Wang et al., 2024), and possesses mechanical properties suitable for various applications.

Despite its potential, scientific references discussing the characteristics and utilization of chicken feet skin, particularly from DOA, remain limited. Comparative studies evaluating the quality of leather produced from fresh chicken feet skin and chicken feet skin from dead chickens are still rarely reported. Such evaluations are important to determine whether chicken feet from poultry mortality can serve as a feasible alternative raw material for leather production while meeting established quality standards such as the Indonesian National Standard (SNI). Physicochemical parameters such as moisture content and fat content are widely used to evaluate the quality characteristics of poultry raw materials (Amalia et al., 2025). Therefore, this study aims to compare the physical and chemical properties of tanned leather produced from fresh chicken feet skin and DOA chicken feet skin. The results of this study are expected to provide insight into the feasibility of utilizing poultry mortality waste as an alternative raw material for leather production and to support sustainable resource utilization in the poultry and leather industries, while addressing challenges related to post-mortem collagen degradation.

MATERIALS AND METHODS

Materials

The main materials needed are frozen chicken feet (100 grams DOA chicken feet and 1000 grams freshly slaughtered chicken feet). Materials were used in the tanning process included a stainless steel drum operated at 15 rpm, stainless steel cutting knives, measuring cups, basins, spoons, cutting boards, plastic measuring cups, buckets, a thickness gauge for measuring skin thickness, a pH meter, BCG indicators, a digital scale (Henherr, ACS-H1 LED; Kitoma Indonesia), a timer, a thermometer, wooden boards, plastic sheets, sandpaper, a staking machine used to soften the leather, a toggling machine used to stretch and widen the leather, a platting embossing machine used to improve leather surface uniformity, a spray gun used to evenly apply finishing chemicals, and a measuring device used to determine the leather surface area.

The chemicals used in the tanning process included H_2O, wetting agent (Peramit® MLN) from Pulcra Chemicals, Na_2S (Natrium Sulfida), acid batting (Feliderm® Bate AB) from Stahl, glutaraldehyde (Rellugan® GT 50) from BASF, degreasing agent (Ginsol ND), resin (TERGOTAN® RD-IN POWDER) from Stahl, Anti jamur (preventol® CR), $Ca(OH)_2$, $(NH4)_2SO_4$, HCOOH (formic acid), tannins (Mimosa ME extract) from EXTRACT DONGEN B.V., salt solution, sulphited fish oil (Derminol® SPE) from Stahl, $(COOH)_2$ (oxalic acid), lanolin oil (Provol 100) from ZSCHIMMER & SCHWARZ, penetrating agent (Greibotan TFS), $NaHCO_2$, $NaHCO_3$, Na_2CO_3, anti-fungi (Preventol Cr) from LANXESS.

Methods

Frozen chicken feet (100 grams of DOA feet and 1,000 grams fresh chicken feet) were thawed by soaking them in water at a temperature of 25–28°C until completely thawed (Arshad et al., 2023; Zhang et al., 2017). The skin was separated from the bones using scissors and pliers. The skin obtained after separation was subsequently ready for the tanning process. The tanning process was divided into two types based on the raw materials used, namely chicken feet from DOA and chicken feet from chickens that were properly slaughtered. The tanning of raw skin into leather involves several stages, the first of which was the Beamhouse Operation (BHO). This was where acid-cured hides, also known as pickled skins were intended to be produced. The second stage of the process was the tanning that served to improve the resistance of damage caused by bacterial activity, temperature shock, pH alteration on raw skin. The third phase was the post-tanning process, which aimed to refine and improved the properties of the tanned leather and to shape the desired characteristics of the leather according to its intended use, such as wallets, bags, shoes, belts, and other products (Rachmawati et al., 2023). The final stage in the leather tanning process was leather refinement, also known as finishing. The stages of the research were presented in Figure 1.

The formulation and process parameters used in this study were developed and generated based on the authors' own experimental research. The following was a description of each process, as well as the formulation and processing time, presented in Table 1.

Data Analysis

The skin quality evaluated was focused on physical properties, including tensile strength, elongation, tear strength, and shrinkage temperature. The physical quality data obtained were analysed using SPSS version 27.0 for macOS. Data analysis was conducted using a t-test to compare the mean values between the two treatments. Data thickness, softness, and seam strength were presented as the mean ± standard deviation from limited replication. Other parameters were obtained from a single test and therefore did not include standard deviation values.

RESULTS AND DISCUSSION

The tanning process was carried out through to the finishing stage, after which physical and chemical testing was conducted. Raw chicken feet skin and the results of the tanning process up to the finishing stage were shown in Figure 2.

Based on the visualization in Figure 2, it can be seen that the skin of chicken feet (a) appeared more wrinkled than the skin of fresh chicken feet (b). Meanwhile, after the tanning process, more precisely the finishing process on both chicken feet and fresh chicken feet, there was almost no difference in appearance. Chicken feet skin

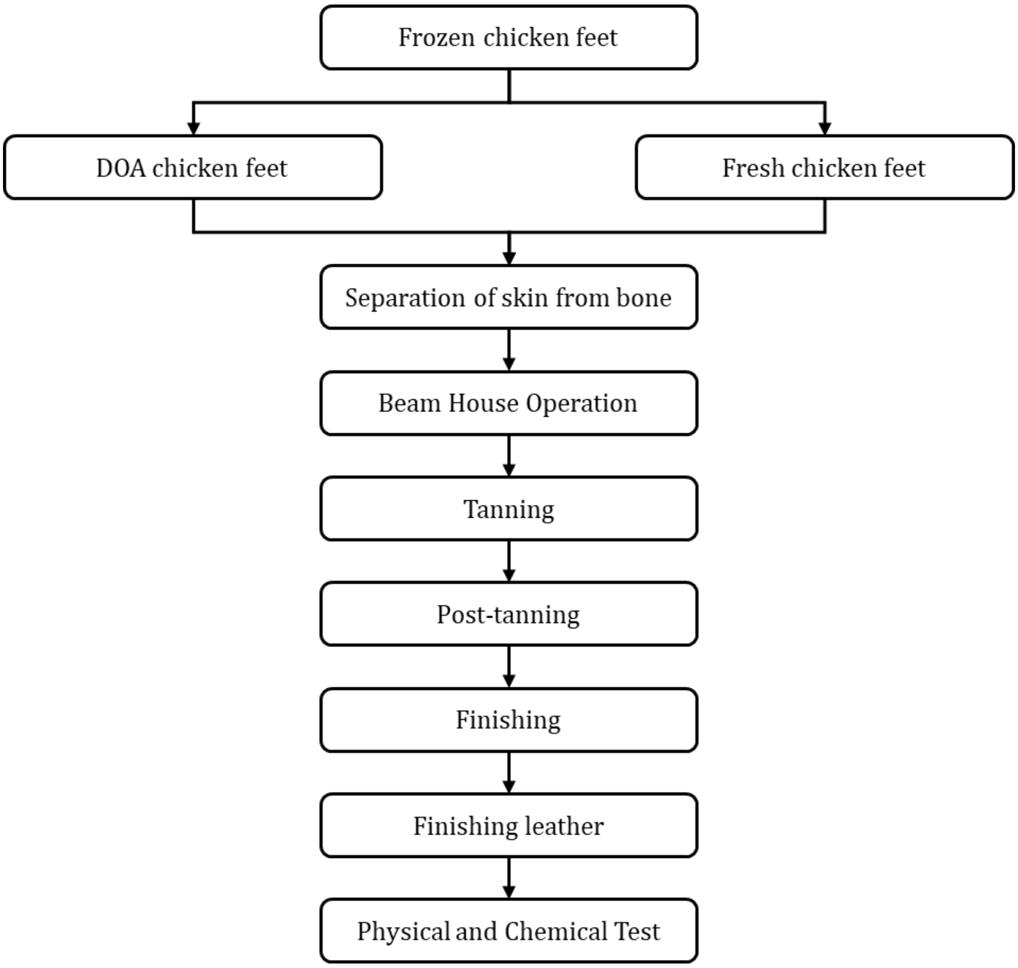

Figure 1. Research stages.

obtained from chickens that died prior to slaughter often showed visual differences compared with fresh chicken feet skin. DOA chicken feet skin typically appeared reddish-yellow, thinner, wrinkled, and emits an unpleasant odor, whereas fresh chicken feet skin was generally white, smoother, and had the typical odor of fresh meat. The wrinkled and thinner appearance of DOA skin is likely associated with moisture loss and the early onset of autolytic processes, which can disrupt the organization of collagen fibers within the dermal matrix (Covington et al., 2019). In contrast, fresh chicken feet skin, which retained a smoother and more compact structure, indicates minimal structural degradation at the time of processing After death, autolytic processes and microbial activity may initiate the degradation of connective tissue components, including collagen fibers, which can weaken the structural stability of the skin (Lawrie et al., 2006). In addition, biochemical reactions and microbial metabolism during post-mortem conditions may contributed to discoloration and the formation of unpleasant odor in animal tissues (Falowo et al., 2014). Such structural and biochemical changes may influenced the processing characteristics of skin and potentially affected the quality of leather produced.

Nevertheless, these by-products still present an opportunity for utilization, particularly in the production of tanned leather for functional products. To evaluate the feasibility of DOA chicken feet skin as a raw material for leather production, it is necessary to assess whether the resulting leather meets established quality requirements. Therefore, specific testing of physical and chemical properties was conducted. The following section presents the results of quality testing of tanned leather produced from fresh chicken feet skin and DOA chicken feet skin (Table 2).

The t-test results showed that there was no significant differences between treatment 1 and treatment 2 in terms of thickness (t (8) = 0.526; p

Tabel 1. Formulation and process parameters of the tanning materials

Process	% Materials (based on skin weight)
Thawing	Treatment 1: Fresh chicken feet skin Treatment 2: DOA chicken feet skin 1500% H_2O
Beam house operation (BHO)	
Soaking	200% water; 2.5% wetting agent (Peramit MLN)
Liming	200% water; 2% Na_2S; 3% $Ca(OH)_2$
Fleshing	-
Deliming	200% water; 2% $(NH_4)_2SO_4$
Bating	200% water; 2% bating agent (Feliderm)
Degreasing	1% degreasing agent (Ginsol ND)
Pickling	300% salt solution; 2.5% HCOOH
Tanning	
Tanning	100% spent pickling solution (consist of water + formic acid = 1:20); 3% glutaradehyde (Relugan GT50)
Netralisasi	1% $NaHCO_2$; 0.5% $NaHCO_3$; 1.5% Na_2CO_3
Post-tanning	
Retanning	3% penetrating agent (Greibotan TFS); 3% resin melamin 3%; resin akrilik; 6% tannin (Mimosa ME extract)
Fatliquoring	50% Air; 6% sulphited fish oil (Derminol SPE); 2% lanolin oil (Provol 100); 0.5% emulsifier (Peramit MLN)
Fixing	2.5% HCOOH; 1% $(COOH)_2$; 0.25% anti fungi (Preventol Cr)
Drying	-
FINISHING	
Quality test of finish leather	

Table 2. Quality test results and SNI for fresh chicken feet skin and DOA chicken feet skin

Quality test[ns]	Treatment		SNI physical and chemical quality	SNI Codes
	Fresh chicken feet skin	DOA chicken feet skin		
Physical properties				
Thickness (mm)	0.67±0.10	0.64±0.08	0.50	06-4362-1996
Softness (mm)	5.70±0.62	5.90±0.82	5.00 – 7.50	4593:2011
Shrinkage temperature (°C)	82.00±1.00	82.60±0.55	Min 95°C	06-4362-1996
Elasticity (%)	31.27	22.81	Max 70	06-4362-1996
Tensile strength (N/mm^2)	7.15	5.20	Min 15	06-4362-1996
Tear strength (N/mm)	14.36	13.30	Min 12.5	4593:2011
Seam strength (N/cm)	602.52	600.23	Min 200	06-0253-1989
Chemical properties				
pH	4.00	4.00	3.50 – 7.00	06-4362-1996
Moisture (%)	15.16	13.82	Max 18	06-4362-1996
Oil/Fat (%)	14.94	14.05	3.00 – 6.00	06-4362-1996

Note: ns = not significant

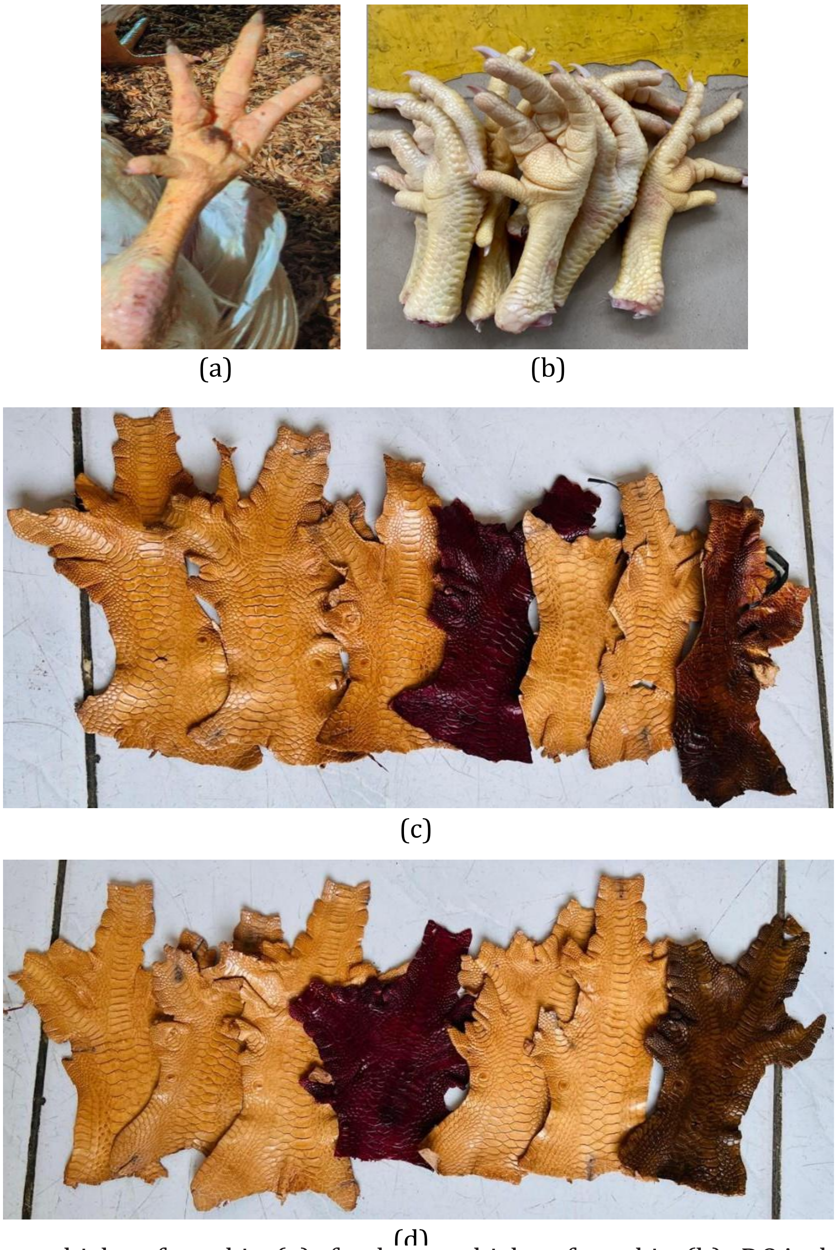

Figure 2. DOA raw chicken feet skin (a); fresh raw chicken feet skin (b); DOA chicken feet skin after finishing (c); and fresh chicken feet skin after finishing (d).

= 0.613), flexibility ($t(8) = -0.434$; $p = 0.675$), and shrinkage temperature ($t(8) = -1.177$; $p = 0.273$). Meanwhile, t-tests were not performed for the physical properties (elasticity, tensile strength, tear strength, and stitch strength) and chemical properties (pH, moisture content, and oil/fat content) because the number of measurements was less than three.

Physical Properties

Thickness

Skin thickness was measured in accordance with SNI 06-7128-2005 using a thickness gauge. Based on the t-test, there was no significant differences ($P>0.05$) between the thickness of fresh chicken feet skin and DOA feet skin after the tanning process. Nevertheless, leather made from fresh chicken feet skin (0.67 mm) was slightly thicker than leather made from DOA feet skin (0.64 mm), with an average difference of 0.03 mm. This suggests that despite post-mortem changes such as autolysis and microbial activity, the collagen structure responsible for maintaining skin thickness remains relatively intact during the tanning process.

Skin thickness varies depending on the type of skin, the anatomical location of the skin, and the processing method used during tanning.

The structural composition of animal skin, particularly the arrangement and density of collagen fibers within the dermal layer, played an important role in determining the final thickness and mechanical properties of leather (Covington et al, 2019). Previous studies have also reported the poultry skin, including chicken feet skin, contained collagen fibers that can form a stable matrix during the tanning process, allowing it to be processed into thin leather suitable for small-sized leather products (Kanagaraj et al., 2006). The thickness of both fresh and DOA feet leather, which were not markedly different, indicated that DOA feet skin also has potential as a raw material for tanning. According to SNI 06-4362-1996 concerning monitor lizard skin for shoe uppers, the minimum required skin thickness was 0.5 mm; therefore, the thickness of both fresh and DOA feet skin meet the specified standard.

Softness

Skin softness was measured in accordance with SNI 06-1796-1990 using a softness tester. Tanned leather produced from fresh chicken feet skin showed a slightly lower average softness value (5.7 mm) compared to leather produced from DOA chicken feet skin (5.9 mm). However, the difference was not statistically significant ($P>0.05$). Based on SNI 4593:2011, which specifies a softness range of 5.0–7.5 mm for sheep or goat jacket leather, both materials meet the required standard.

The slightly higher softness observed in DOA leather may be attributed to post-mortem changes, such as autolysis and early microbial activity, which can partially degrade collagen structure and result in a looser fiber network. Enzymatic processes, particularly during bating, can modify collagen and influence leather elasticity. Increased collagen hydrolysis tends to produce a more open fiber structure, thereby enhancing softness (Song et al., 2019). A higher degree of collagen hydrolysis results in a looser collagen tissue structure, which affects the final softness of the leather.

However, the use of the same bating enzyme (Feliderm PB) in both treatments likely contributed to the relatively small variation observed. This indicates that the collagen framework in DOA skin remains sufficiently stable to withstand processing and produce leather with acceptable physical properties. Therefore, DOA chicken feet skin has comparable potential to fresh skin as a raw material for tanned leather, supporting its utilization as a value-added by-product.

Shrinkage temperature

Skin shrinkage temperature testing was conducted in accordance with SNI 06-7128-2005. The shrinkage temperatures of leather produced from fresh chicken feet and DOA chicken feet showed no significant difference, ranging from 82.0°C to 82.6°C. These results indicated that chicken feet skin from DOA chickens had strong potential for processing into tanned leather, as its shrinkage temperature was comparable to that of leather produced from fresh chicken feet skin. Shrinkage temperature was widely recognized as an important indicator of the thermal stability of collagen in tanned leather and reflected the effectiveness of the tanning process in stabilizing collagen fibers (Das et al., 2022). During tanning, tanning agents interact with collagen molecules to form cross-links within the collagen matrix, which increased resistance to heat-induced shrinkage and enhanced the thermal stability of the leather structure (Covington et al., 2019). Therefore, the similar shrinkage temperature values observed between the two treatments suggested that the tanning process applied in this study was able to stabilize the collagen structure of both fresh and DOA chicken feet skins to a comparable extent.

According to SNI 06-4362-1996 for monitor lizard skin used in shoe uppers, the minimum required shrinkage temperature was 95°C. The shrinkage temperatures of both fresh and DOA feet leather were below this requirement. However, this difference was expected because the referenced standard was specifically developed for reptile skins used in shoe uppers, which require high thermal stability and durability due to intensive mechanical stress during use. In contrast, the chicken feet leather produced in this study was intended for small leather products such as clutches and accessories, which generally required thinner and more flexible leather and did not demand the same level of thermal resistance as shoe upper leather. Therefore, the SNI standard for monitor lizard skin was used only as a general benchmark to provide a reference point for comparison.

The shrinkage temperature of leather was influenced by several factors, including the type and concentration of tanning agents, pH conditions during processing, and the quality and integrity of collagen fibers in the raw material (Thanikaivelan et al., 2004). Among these factors, collagen quality was the primary parameter originating from the raw material. As discussed in the section on skin elasticity, the elasticity values did not differ significantly between treatments, suggesting that the collagen structure of DOA chicken feet skin was not substantially degraded compared with that of fresh chicken feet skin. This similarity in collagen integrity may explained why the shrinkage temperature values of leather produced from both raw materials were also not significantly different.

Elasticity

Elasticity was tested in accordance with SNI 06-1795-1990. The elasticity values of leather produced from fresh and DOA feet skin were 31.27% and 22.81%, respectively. According to SNI 06-4362-1996 for monitor lizard skin used in shoe uppers, the maximum allowable elasticity was 70%; therefore, both fresh and DOA feet leather met the specified requirement. Factors affecting skin elasticity include the type of vegetable tanning agent used, the amount of oil added during the fatliquoring process, and the effectiveness of the tanning agent in binding with skin collagen (Abid et al., 2020; Cheloti et al., 2023; Nugraha et al., 2025). The raw materials used in this study were fresh chicken feet obtained from slaughtered chickens and DOA. Although the tanning process, the type of tanning agent, and the amount of oil applied were relatively similar, the elasticity values of the resulting leathers differed by 8.46%. However, this study did not include direct analysis of collagen structure, such as microscopic or histological examination. Therefore, the observed differences in elasticity should be interpreted cautiously, although previous studies have reported that the mechanical properties of leather were closely related to the condition and arrangement of collagen fibers in the dermal layer.

As discussed in the elasticity and shrinkage temperature analyses, the collagen structures of both skin types were not considered to differ significantly. Therefore, this considerable difference in flexibility values is likely to be influenced more by differences in the effectiveness of the interaction between the tanning agent and the collagen fibers. The initial condition of the raw material, particularly the freshness level of the skin and the potential for tissue degradation in tanned skin, is also thought to play a role in reducing the ability of the tanning agent to bond optimally with collagen, thereby affecting the elasticity properties of the resulting tanned leather.

Tensile strength

Tensile strength was tested in accordance with SNI 06-1795-1990. The tensile strength of leather produced from fresh chicken feet skin and DOA feet skin were 7.15 N/mm^2 and 5.20 N/mm^2, respectively. When subjected to tensile loading, leather produced from fresh chicken feet skin exhibited higher strength than that produced from DOA feet skin. This difference may be attributed to more effective interactions between collagen fibers and tanning agents in leather derived from fresh chicken feet skin. The type and structure of the skin as a raw material, the type and concentration of the tanning agent, the duration and conditions of the tanning process, the composition of collagen fibrils, and the chemical bonds between collagen and the tanning agent all play an important role in determining the tensile strength of tanned skin (Rachmawati et al., 2023; Zhang et al., 2023; Mutiar et al., 2024; Susanto et al., 2024). Based on SNI 06-4362-1996 concerning monitor lizard skin for shoe uppers, the minimum tensile strength requirement was 15 N/mm^2. This indicated that both fresh and DOA skin were below the required standard. This condition may be caused by the thin structure of chicken feet skin and the lower density of collagen fibers compared to conventional leather materials. In addition, the quality of raw materials, particularly in DOA skin, may decreased due the post-mortem biochemical changes that weaken the collagen structure, resulting in lower tensile strength.

Tear strength

Tear strength was tested in accordance with SNI 06-1795-1990. The tear strength test results for fresh chicken feet skin and DOA chicken feet skin were 14.4 N/mm and 13.3 N/mm, respectively. There was no established standard for the tear strength of chicken feet skin used in clutch articles; therefore, sheep or goat jacket leather was used as a reference. The differences in tear strength between fresh and DOA feet skin was 1.1 N/mm. Fresh chicken feet skin was more resistant to tearing than DOA chicken feet skin. This was likely due to its greater thickness and denser collagen structure, which enhance its resistance to tearing. This observation was further supported by the higher tensile strength of fresh chicken feet skin compared to DOA feet skin. Factors that played an important role in determining tear strength included the orientation of collagen fibrils (Sizeland et al., 2013), the thickness of the skin (Wulandari et al., 2024), and the overall tanning process (Tournier & Lado, 2021). Based on SNI 4593:2011 for sheep and goat jacket leather, the minimum tear strength requirement was 12.5 N/mm. Therefore, the tear strength of both fresh and DOA feet leather meets this standard.

Seam strength

Seam strength testing of the skin was conducted in accordance with SNI 06-1117-1989. The seam strength values for fresh and DOA feet skin were 602.52 N/cm and 600.23 N/cm, respectively. The tanning process can alter the physical and chemical properties of collagen tissue, so the concentration and the type and concentration of the tanning agent have the potential to affect the tear strength and seam strength of the resulting leather. Tensile strength and seam strength show a strong correlation (≥0.90), indicating that leather with good tensile properties also tends to exhibit good seam performance in terms of sew-ability (Phebe et al., 2011). This finding was consistent with the results of the present study, where relatively high tensile strength values in both treatments were accompanied by high seam strength values, indicating good resistance of the leather to stitching stress. Based on SNI 06-0253-1989 concerning quality requirements for chrome-tanned shoe uppers, the minimum stitch strength was 200 N/cm. Therefore, the stitch strength of both fresh and DOA feet skin meets the requirements for shoe uppers and is suitable for use in lighter products.

Chemical Properties

pH

pH testing was conducted in accordance with ISO 4045:2008, Leather—Chemical Test—Determination of pH. The pH measurements of fresh chicken feet skin and chicken skin samples showed the same average value of 4. This indicated that the condition of the chicken feet skin prior to slaughter did not affect its pH after the tanning process. In addition, this similarity may also be attributed to the tanning process applied to both raw materials being the same. The final pH value of tanned leather is influenced by several factors, including the pH of the raw material after pre-treatment and the type and concentration of the tanning agents, and pH control during the tanning process. Based on SNI 06-4362-1996 concerning monitor lizard skin for shoe uppers, the acceptable pH range for skin is 3.5–7.0; therefore, the pH of both fresh chicken feet skin and chicken feet skin from DOA meets the required standard.

Moisture content

Moisture content was tested in accordance with SNI 06-0644-1989. The moisture content of tanned leather made from fresh chicken feet was 15.16%, while that of tanned leather made from DOA feet was 13.82%. Based on SNI 06-4362-1996 regarding monitor lizard leather for shoe uppers the maximum moisture content requirement was 18%; therefore, the moisture content of both fresh and DOA feet leather meets the standard. The two levels of moisture content both meet the quality needs and have promising stability of mechanical properties and wearing comfort, because proper moisture content was essential to keep flexibility-stability balance of collagen structure in leather (Kelly et al., 2019).

Oil and fat

Oil and fat content was tested in accordance with SNI 06-0564-1989. The oil and fat content of fresh and DOA feet skin was 14.94% and 14.05%, respectively. The oil and fat content was relatively high compared to the SNI 06-4362-1996 standard for monitor lizard skin used for shoe uppers, which ranges from 3% to 6%. This may be attributed to the use of oil during the fatliquoring process, with the oil percentage adjusted according to the fatliquoring formulation typically applied to lizard skin, whereas chicken feet skin is smaller and thinner in both size and thickness. In addition, its use requires a lower fat content because the intended product—a clutch—does not prioritize softness. Therefore, adjustments to the fat content should be made in subsequent leather formulations according to the intended end product. Adjusting the fat content is important for achieving a balance between the mechanical and functional properties of the leather. Leather with excessively high oil or fat content tended to be softer and more elastic but may exhibit reduced tensile and tear strength, which can also affect the quality of stitching in the final product (Mahboob, 2022; Razzaq et al., 2024).

CONCLUSION

This study showed that tanned chicken feet skin from dead on arrival (DOA) poultry exhibits physical and chemical characteristics comparable to those of leather produced from freshly slaughtered chicken feet. No significant differences were observed in thickness, softness, and shrinkage temperature, while seam strength and chemical properties were also similar between treatments. These results indicate that DOA chicken feet skin can be considered a potential alternative raw material for leather production.

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