The Use of Various Concentrations of Acetic Acid with a Soaking Time of 96 Hours on the Proximate Quality of Gelatin from Etawa Crossbred Goat Skin

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Abstract. One source for making gelatin is goat skin. Goat skin has not been optimally utilized; goats are mainly used for their meat and milk.The main raw materials in this study were the skin of 2-year-old Etawa crossbred male goats and acetic acid. Gelatin was produced from Etawa crossbred goat skin using acetic acid treatments of 0, 1.5, 3, 4.5%, and soaked for 96 hours, using a randomized block design (RAK) with 5 (five) groups. The data were analyzed using analysis of variance (ANOVA). If the results of the analysis of variance showed a significant effect, it was followed by Duncan's test. Parameters observed: chemical quality (yield, pH, moisture content, protein, fat, and ash) The results of the analysis of variance showed no significant differences (P>0.05) between acetic acid concentrations and the pH, moisture content, protein, fat, and carbohydrate content of the gelatin produced. The analysis of variance showed significant differences (P<0.05) between acetic acid concentrations and the yield and ash content produced. The yield of goat skin gelatin was 1.74–2.96%. Higher acetic acid concentrations (4.5%) resulted in higher yields compared to without acetic acid (0%). Gelatin pH was 5.04–5.76. Higher acetic acid concentrations (4.5%) resulted in more acidic pH (5.04). Water content 8.13–9.11%, protein content 84.78–86.78%, fat 1.94–2.25%. Ash content 2.33–3.74%. Ash content in treatments T0 (2.38%) and T3 (2.33%). Conclusion of this study: goat skin from Etawa crossbreeds treated with a 4.5% acetic acid solution for 96 hours produces goat skin gelatin from Etawa crossbreeds. This gelatin complies with SNI standards, with a yield of 2.96%, pH 5.04, water content 9.11%, protein 85.96%, fat 2.17%, carbohydrates 0.67%, and ash 2.33%.

1 Introduction

Goat skin is one potential raw material for producing gelatin. However, its use has not yet been maximized, as goats are primarily raised for their meat and milk. Based on data from (1), goats are widely distributed across Indonesia, with a population of 18,560,835, making

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them one of the country's major ruminant species. This large population indicates a promising supply of goat skin that can be processed into valuable products like gelatin. Supporting this, (2) reported that the skin of Peranakan Etawa goats can yield high-quality gelatin. (3) described Peranakan Etawa goats as a native Indonesian breed, resulting from a cross between Etawa and Kacang goats. Peranakan Etawa goats aged 1–5 years have a high collagen content, which can be easily converted into gelatin through hydrolysis (4) stated that mammals such as cows, buffaloes, goats, and yaks (or Tartar cattle) serve as sources of gelatin. Mammalian sources of gelatin are cowhide (29.4%), cow and pig bones (23.1%), and pigskin (46%). Gelatin derived from mammalian hides is superior to fish gelatin due to its higher gel strength and yield . Gelatin production from goat skin using acetic acid leverages the fact that acetic acid is a weak acid. It does not cause further hydrolysis, thereby maximizing gelatin yield. The resulting gelatin is odorless (no pungent smell) and light in color.According (5), acids convert the collagen triple helix structure into single chains, whereas alkaline soaking solutions only produce double chains. However, a drawback of acetic acid is its significant reduction in gelatin pH, which can affect stability and halal food applications. Organic acids such as acetic, citric, fumaric, ascorbic, malic, succinic, and tartaric acids are used, alongside inorganic acids like hydrochloric, phosphoric, chloride, and sulfuric acids. (14) states that acid soaking breaks the triple helix bonds into single chains. Similarly, (2) found that soaking goat bligon skin in 3% acetic acid for 96 hours provides the optimal combination for food applications.

2 Materials and Methods

2.1 Goat Skin Hair Removal Method (Modified from (2))

The goat skin is washed with running water until clean, removing all dirt and blood from the skin for 30 minutes. The skin is then soaked in a 1% teepol solution (50 ml of teepol in 5 liters of water with 2.5 kg of goat skin), stirred, and washed with running water for 15 minutes.Any meat and fat still attached to the skin is removed using scissors. The hair removal process uses a 2% lime (100 gram) solution plus 3% sodium sulfide (Na_2S) (250 gram) in 5 liters of water with 2,5 kg of goat skin and is washed for 15 minutes. It is then neutralized by soaking in water until the skin has a pH of 7-7.5. The skin is then cut into pieces ($5x5cm_2$) and is ready to be made into gelatin.

2.2 Production of Goat Skin Gelatin (According to (6))

Raw skin material total of 500 grams of raw skin material was placed in a glass beaker where the skin was immersed in 1 liter an acetic acid solution at concentrations of 0, 1.5, 3, and 4.5% and soaked for 96 hours.

The raw skin material was then weighed as the initial weight of the raw material to determine the yield value. The raw skin materials, whose weight is known, are then placed in a glass beaker and aquades is added until all raw skin materials are completely submerged with a ratio raw skin to aquades of 1:1. The glass beaker containing raw skin materials and aquades is covered with aluminum foil and then placed in a water bath to undergo the extraction process.

The overall leather extraction process lasts for 4 hours at a temperature of 60°C. Then, the filtrate and solids were separated. Next, the filtrate was heated again in a water bath at a temperature of 50°C for 2 hours. Then, it was dried in an oven at a temperature of 60°C (5 days). After that, the gelatin was refined using a grinder with 18,000 RPM for 10 minutes. Then, the results obtained were weighed to determine the yield.

2.3 Research Design

The first stage of the research was the production of gelatin from Etawa crossbred goat skin using acetic acid treatments of 0, 1.5, 3, and 4.5% and soaking for 96 hours.
The research design used is a 4 x 5 randomized block design (RAK) using 4 (four) acetic acid treatments and 5 (five) replicates. The treatments in this study are: T0 : Using 0% acetic acid; T1: Using 1.5% acetic acid; T2: Using 3% acetic acid;T3: Using 4.5% acetic acid

The mathematical model used for the Randomized Block Design is:

$$Yij = \mu + \alpha i + \beta j + \epsilon ij. \qquad (1)$$

Explanation:
Yij = Observed response in treatment i and replicate/group j
μ = Overall mean
i = Effect of treatment i
βj = Effect of the jth group
€ij = Experimental error effect from the ith treatment and jth replicate
According to (13)

2.4 Research Design

The parameters observed in the first stage of the study were: Yield, pH, moisture content, ash, fat, protein, and carbohydrates

3 Results and Discussion

Table 1. Duncan Test Results for Research Parameters

Parameter	Treament			
	T0	T1	T2	T3
Yield (%)	$1,74^{a}$	$2,12^{ab}$	$2,,58^{ab}$	$2,96^{b}$
pH	$5,76^{a}$	$5,74^{a}$	$5,24^{b}$	$5,04^{c}$
Moisture content (%)	8,13	8,94	9,46	9,11
Protein (%)	86,78	85,1	84,78	85,69
Fat (%)	2,25	1.94	2.04	2.17
Carbohydrates (%)	0,44	0,26	0,711	0,67
Ash (%)	$2,38^{a}$	$3,74^{b}$	$2,99^{ab}$	$2,33^{a}$

Note: Different lowercase superscripts in different columns indicate significant differences (P<0.05).

3.1 Yields

The analysis of variance showed a significant difference (P<0.05) between acetic acid concentration and yield. The yield results (%) of 1,74 - 2,96 % (Table 1) show the gelatin yield from goat skin in different experiments, where higher numbers indicate better extraction efficiency from the initial raw material weight. The superscript values (a, ab, b) indicate the results of statistical tests such as the Duncan Multiple Range Test (DMRT), where different letters (a vs. b) are statistically significant (p<0.05), while ab indicates no significant difference between the two. Treatment 4 (2.96b) provided the highest yield, possibly due to the optimal acetic acid concentration or longer soaking time. Low yields (1.7-3%) are typical for goat skin gelatin because collagen only accounts for 25-35% of the wet skin weight, plus losses during hair removal, liming, and extraction. These differences may be due to variations in teepol method or the conditions of the Vishal grinder (20,000 RPM) for homogenization. The yield produced was low because the Etawa crossbred goat hides used were 2 years old. According to (7), goats that are 2 years old or older produce lower yields than young goats because their collagen structure is stronger and more difficult to break down. that goats aged 2+ years produce lower gelatin yields due to stronger collagen structures matches findings in goat skin studies, where mature collagen cross-links (via lysyl oxidase) resist acid/acetic extraction more than in young goats (<1 year). Yields drop from 12-16% (young) to 1-3% (adult), as in your data (1.74-2.96%), because triple helices in older animals require harsher alkaline pre-treatments. In the research, the raw skin material was weighed to determine its initial weight, which was used to calculate the yield value. The optimum gelatin yield is usually achieved at a concentration of 2–4% acetic acid with a soaking time of 24–72 hours, depending on the raw material. The yield produced is also influenced by the particle size of the skin, the type of water, the solvent, and the storage of the raw material before extraction (8). Accoding to (9) the use of 1 M acetic acid for 72 hours produces a gelatin yield of 1.42% from buffalo skin.In this study, fresh skin was used without drying because it was easier and more practical to handle.

3.2 pH

The analysis of variance showed significant difference (P<0.05) between the acetic acid concentration and the pH of the gelatin produced. The pH of the gelatin in this study was 5.04–5.76 (Table 1). The higher the acetic acid concentration (4.5%), the more acidic the pH (5.04). In this study, acetic acid was used in the extraction of goat skin, so the resulting pH was also acidic because acetic acid is a weak acid. The pH in (10) is 4.5–6.5, so the pH in this study is still in accordance with (10).

3.3 Moisture Content

The analysis of variance showed no significant difference (P>0.05) between the acetic acid concentration and the water content of the gelatin produced. Acetic acid concentration does not significantly affect gelatin water content because the standard drying process (60°C oven) dominates water molecule loss, not collagen hydrolysis variation from acid concentration. The water content of goat skin gelatin in this study was 8.13–9.11% (Table 1). (10) specifies a maximum gelatin water content of 16%. In this goat skin gelatin study, the moisture content was still below the maximum moisture content limit of (10).According (4) gelatin treated with acid has a lower moisture content (8–10%) compared to gelatin treated with base (10–12%). because acid processes produce more compact molecular structures with weaker water-binding sites.Acid treatment (like acetic acid) hydrolyzes collagen into shorter peptide chains with fewer hydrophilic amino acids exposed, reducing hygroscopicity and water retention during drying

According to (11), the average moisture content of goat skin gelatin is 9.15%, which aligns with commercial gelatin standards. Meanwhile, according (12), goat skin gelatin (8–12%) has a lower moisture content than bovine gelatin because its collagen fibers are denser and the dehydration process is more efficient.

3.4 Protein

The analysis of variance showed no significant difference (P>0.05) between acetic acid concentration and gelatin protein content. Acetic acid concentration does not significantly affect gelatin protein values because its main role in the gelatin extraction process is to dissolve minerals (demineralization) from the collagen matrix without substantially altering the protein composition. Within the typical concentration range (such as 2-17% or 0.25-0.75 M), acetic acid works optimally to break the calcium phosphate bonds in animal bones or skin, allowing the release of collagen which is then hydrolyzed into gelatin, but does not cause excessive protein peptide degradation (5). The gelatin protein content in this study was 84.78–86.78% (in Table 1). According to (11), the protein content in goat skin gelatin is high, and its functional properties are similar to those of cow skin gelatin, making it suitable for use in the halal food and pharmaceutical industries. Meanwhile, according to (9), a temperature of 60–70°C and an extraction time of 4–6 hours do not affect the protein content. This study used a temperature of 60°C and an extraction time of 6 hours. Additionally, the use of a soaking agent before extraction, specifically acid, produces gelatin with a higher protein content compared to using a base (12). In this goat skin gelatin study, acetic acid was used.

In (10), the protein content is not explicitly specified; a good protein content is in the range of 80–90%, which indicates good purity. Meanwhile, according to (11), mammalian skin (cattle and goat) generally contains higher protein than fish and chicken due to its denser collagen fiber composition. Gelatin with a pH of 4.5–6 produces high protein (12).

3.5 Fat

The results of the analysis of variance showed no significant difference (P>0.05) between the acetic acid concentration and the gelatin fat content produced. Konsentrasi asam asetat tidak secara signifikan memengaruhi kadar lemak pada gelatin karena proses demineralisasi utamanya menargetkan mineral seperti kalsium fosfat, sementara pengurangan lemak lebih bergantung pada langkah defatting awal (misalnya dengan pelarut organik) dan pencucian pasca-perendaman yang menghilangkan residu lemak terlepas. The gelatin fat in this study was 1.94–2.25% (Table 1). The gelatin fat content in this study still meets the requirements of (10) with a maximum gelatin fat content of 5%. Low fat content indicates that the gelatin produced is of good quality (14).

This study used acetic acid (CH_3COOH), which is an acid that can hydrolyze the triple helix chain, thereby optimizing the level of fat extraction in the cells and reducing the fat content. The duration of soaking also affects the fat content; the longer the soaking time, the more fat is broken down and dissolved in the soaking solution (5).

3.6 Carbohydrates Content

The analysis of variance showed no significant difference (P>0.05) between acetic acid concentration and gelatin carbohydrate content. Acetic acid concentration does not significantly affect the carbohydrate content of gelatin because gelatin is naturally a pure protein product of collagen (90-96% protein) with a very low intrinsic carbohydrate content (<1-2%) in raw materials such as animal bones or skin, so acid fluctuations do not change the carbohydrate composition. The gelatin carbohydrate content of goat skin in this study was 0.26-0.711% (Table 1). According to (10), goat skin gelatin has a very low carbohydrate content (< 1%) because gelatin is mainly composed of collagen hydrolysis proteins rather than polysaccharides. Carbohydrates < 1% usually come from glycosaminoglycans such as hyaluronic acid and chondroitin sulfate, which are small parts of the extracellular matrix.

According to (9), glycosaminoglycans (GAGs) are most commonly found in connective tissues such as skin, cartilage, tendons, and corneas. Glycosaminoglycans (GAGs) such as hyaluronic acid, chondroitin sulfate, and dermatan sulfate function to maintain the moisture and elasticity of collagen tissues. Meanwhile, according to (7), glycosaminoglycans (GAGs) are more abundant in young goat skin than in old goat skin. Glycosaminoglycans (GAGs) can decrease during skin processing, such as gelatin processing.Glycosaminoglycans (GAGs) in adult animal skin, including goat skin, range from 0.5 to 2% of the dry weight of the skin. Meanwhile, according to (3), goat skin aged 2 years has glycosaminoglycans (GAGs) of 0.5–1% of dry skin weight.

3.7 Ash Content

The results of the analysis showed a significant difference ($P<0.05$) between the concentration of acetic acid and the ash content produced. The higher the concentration of acetic acid, the lower the ash content because Higher concentrations of acetic acid during gelatin extraction generally lead to lower ash content. Acetic acid facilitates demineralization by dissolving minerals like calcium from the raw material, such as animal skins or bones, reducing residual inorganic matter.The ash content in this study was 2.33-3.74% (Table 1). The ash content of goat skin gelatin ranges from 2–3% (12). In this study, the corresponding values were found in treatments T0 (2.38%) and T3 (2.33%). According to (7), the ash content of gelatin is influenced by the soaking method (acid/base) and extraction time, with the use of acid resulting in a lower ash content compared to the use of base because acid processing in gelatin production typically results in lower ash content compared to alkaline processing. Acids effectively dissolve minerals like calcium and phosphates during demineralization, leaving less inorganic residue.. The extraction time used for gelatin processing is 5-8 hours because it is sufficient to dissolve collagen without dissolving excessive minerals. In addition, the ash content is also influenced by the age of the goat skin, where older goat skin has high mineral content (calcium and phosphate) (12).

4 Conclusion

This study concludes that Etawa crossbred goat skin treated with 4.5% acetic acid solution for 96 hours produces Etawa crossbred goat skin gelatin This gelatin meets SNI standards with a yield of 2.96%, pH 5.04, water 9.11%, protein 85.96%, fat 2.17%, carbohydrates 0.67%, and ash 2.33%. The use of 4.5% acetic acid concentration resulted in the highest yield and lowest ash content, as ash content is a determining factor in the purity of the goat skin gelatin studied

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