

Physicochemical Characteristics of Sodium Hydroxide (NaOH) Pretreated Chicken Head Gelatin with Variation of Soaking Time

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Abstract. Chicken head, an abundant poultry by-products, serve as a viable alternative source for gelatin extraction due to their high collagen content accounted for 15%, yet the study about it remains limited. This study specifically focused on optimizing the alkaline pre-treatment step, a standard method for Type B gelatin. The study aimed to analyse the effect of increasing 3% sodium hydroxide (NaOH) soaking time (18, 14, 30, and 36 hours) on the physicochemical characteristics of chicken head gelatin. Data analysis utilized One-Way Anova ($\alpha = 5\%$) followed by DMRT. The optimal yield (2.31%) was achieved after 24 hours of soaking. The highest gel strength was reached after 30 hours soaking (77.95 g Bloom). Viscosity increased with longer soaking times, the highest value was 10.05 mPa.s. Melting point and gel point increased as soaking time increased, the highest value (31.85°C) and (18.82°C), respectively, both was observed after 36 hours soaking. The moisture content ranged from 1.97% (lowest, at 18 hours) to 3.6% and all value were well below the maximum limit set by the SNI. However, ash content (13.43%-29.81%) exceeds the 3% minimum limit set by the SNI.

1 Introduction

Broiler chickens (*Gallus domesticus*) are a type of poultry with very high economic value [1]. Statistics Indonesia (BPS) recorded national broiler consumption of 3,765,573.09 tons in 2022, rising to 3,835,917.00 tons in 2024 (an increase of 70,34 tons over two years). High consumption of chicken meat also increases the volume of by-products such as skin, esophagus, gizzard, neck, and feet [2]. The head is generally not preferred by consumers and its utilization remains limited, yet it is edible and can provide added market value. Chicken heads are a potential raw material for gelatin production because they can deliver high added value and profit. The chemical composition of chicken heads includes 78.32% moisture, 4.64% ash, 10.58% protein, and 9.37% fat. The high protein content, particularly collagen at around 15% makes chicken heads a viable alternative raw material for extraction products such as gelatin [3].

Gelatin (gelatus) is obtained by hydrolyzing collagen (the principal protein in meat/skin/bone) [4]. Globally, gelatin production is derived 45.80% from pig skin, 28.40% from bovine hide, and 24.20% from bovine bone [5,6]. This underscores the importance of

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developing halal, affordable, safe, and high-quality gelatin that can be consumed by all segments [7]. According to Hastuti and Sumpe [8], gelatin utilization in the food industry is 169,708 tons and in the confectionery industry 68,000 tons [9]. Gelatin is highly versatile and is applied in many foods as a binder, thickener, emulsifier, and even as an edible coating or wrapper [8,10]. Leveraging available commodities such as chicken heads can thus increase value and utility.

The unique challenge of using the entire chicken head as a source for gelatin lies in its highly complex composition marked by substantial levels of undesirable impurities [3][11]. Chicken heads contain bones, resulting in a relatively high ash content (e.g., 4.64% on a wet weight basis or 16.1% on dry matter basis) due to the presence of minerals in head bones. Raw chicken heads contain a significant amount of fat (e.g., 9.37% wet content or 33.1% fat content in dry matter). Efficient separation of this fat is fundamental for good quality control, as modern broiler skin alone can contain close to 50% fat, which must be efficiently removed prior to collagen extraction [12]. In addition, chicken head encompasses brain tissue, which, compared to other meat by-products, has the highest levels of cholesterol (1,352-2,195 mg/100g) and phospholipids [13]. Its inclusion adds to the complexity of purification when producing edible or pharmaceutical grade gelatin.

Pretreatment is crucial step because it ensures the material is properly conditioned for high-quality gelatin extraction by systemically removing non-collagenous materials and breaking down collagen structure [3]. The pretreatment process targets the removal of non-collagenous proteins and other impurities. The use of NaOH is a critical step in producing type B gelatin, typically derived from raw materials containing matured collagen with complex cross-links, such as bones, cattle hide splits, or poultry parts [14–17]. Chicken heads, being primarily bones and skin, fit this category and require intensive treatment. Using NaOH in the soaking step as the gelatin extraction pretreatment can further maximize degreasing after boiling by chemically removing fat, oils, and other contaminants from the raw material. NaOH solution can cleave peptide bonds in protein chains to an optimal extent, thereby increasing yield [18].

The concentration of NaOH used was 3% because it provides a sufficient alkaline strength to cleave the complex cross-links and remove non-collagenous protein and fat characteristic of the chicken head raw material optimizing collagen conversion, but remains mild enough to prevent excessive collagen degradation that would severely compromise the yield and functional properties like gel strength. The optimal NaOH concentration for achieving maximum yield heavily depends on the specific raw material used and the extraction methodology. In a study on bovine bone gelatin, immersion with 3% NaOH during a 4-hour extraction time resulted in the highest yield (7.081%) compared to other concentrations tested (2%, 4%, 5%, and 6%) [19]. In a study on duck feet gelatin, the 3% NaOH concentration was found to be the best, resulting in the highest yield (4.77%) among the concentrations tested (3%, 5%, and 7%) [20]. For other source of collagen (yellowfin tuna skin, rainbow trout skin, lizardfish skin, smooth-hound shark skin) needs lower NaOH concentration to get higher yield ([17,21–23]. In bovine bone gelatin extraction, the viscosity measured at 3% NaOH (1.257 cP for 4h extraction and 1.236 cP for 6h extraction) was higher than the viscosity obtained using 4%, 5%, or 6% NaOH concentration [19]. For duck feet gelatin extraction, the 3% NaOH concentration resulted in the lowest average ash content (3.48%) when compared to higher concentration (5% and 7%)[20]. This suggest that at 3% concentration, mineral removal during demineralization was most effective, as higher concentration risked excessive hydrolysis, causing protein loss and precipitation of unwanted minerals, resulting in higher ash content. Using 3% NaOH consistently yields moisture content within the acceptable range. For chicken leg skin soaked in 3% NaOH for 72 hours, the moisture content was 7.11%, meeting the required standard [24]. For duck feet gelatin, the 3% NaOH concentration produced the lowest moisture content (7.20%) compared to

higher concentrations (5% and 7%) [20]. The concentration of 3% NaOH thus chosen to maximize this preparatory cleavage. The varied long soaking represent an attempt to optimize the hydrolysis duration, seeking the sweet spot where weakening of the structure is maximal but detrimental degradation is avoided [25]. Testing different time points aims to determine the processing window that maximizes the release of high molecular weight gelatin precursor (for better quality and yield) while mitigating this risk of protein loss [26,27].

In the gelatin extraction, degreasing temperature is also an important parameter. In this study, degreasing is performed by boiling in hot water at 90°C so that fat dissolves and separates from the raw material; stirring during boiling helps release fat from bone [18]. The temperature of 90°C is used in degreasing step, because this high heat efficiently melts and separates fats from the raw material, and drives the conversion of collagen into gelatin [13]. Using this temperature should be coupled with time control. Excessive high temperature exposure will cause the degradation of the collagen's peptide chain which lead to an irreversible decrease in viscosity, a loss of gelling power and inferior organoleptic properties. The exposure of 90°C during degreasing should be maintained for only a few minutes [14]

This study employed a completely randomized design with soaking times of 18, 24, 30, and 36 hours. The measured parameters included yield, viscosity, moisture content, ash content, melting point, gel strength, and gel point. This research applies NaOH pretreatment to chicken heads with different soaking durations, targeting the best performance based on the Indonesian National Standard (SNI) for gelatin. The objective is to analyze the effect of NaOH pretreatment soaking time on the physical and chemical characteristics of chicken-head gelatin.

2 Methodology

2.1 Chicken head gelatin production

250 g of chicken heads were prepared and soaked in water at 90°C for 10 minutes. The chicken heads were then cut into 1–2 cm pieces and transferred into a container. The demineralization step was performed by soaking the samples in 200 mL of 3% NaOH solution for different durations (18, 24, 30, and 36 hours). After soaking, the samples were filtered to separate the residue from the filtrate and subsequently washed with running water. Neutralization was conducted by soaking the samples in acetic acid for 10 minutes, followed by washing with running water and filtering. The treated chicken heads were then transferred into a 250 mL beaker, filled with distilled water, and extracted using a water bath shaker at 70°C for 5 hours. The gelatin filtrate was separated using a 200-mesh filter cloth, with the waste residue discarded, and the filtrate collected in a heat-resistant dish. The filtrate was then dried in an oven at 70°C for 72 hours. The dried gelatin sheets obtained from this process were ground into powder using a blender and stored in sealed plastic containers for further analysis [3,14,17,24,28,29].

2.2 Determination of yield [30]

Yield determination was used to evaluate the amount of compound successfully extracted by the solvent. Gelatin extraction yield was calculated using the following equation:

$$\text{yield (\%)} = \frac{\text{weight of extracted gelatin (g)}}{\text{Wet weight of chicken head (g)}} \times 100$$

2.3 Moisture content analysis [31]

Porcelain cup dried at 105 °C for 15 minutes. Then cooled and weighed. Plates contained 2 g of sample is dried in oven at 105 °C for 6 hours until its weight is constant.

2.4 Ash content analysis [31]

Approximately 2 g of sample was weighed and placed in a porcelain cup, then heated on a hotplate until no smoke was observed. Then put into furnace at 600 °C until the sample change color to gray. Then cooled in a desiccator for 30 min and weighed

2.5 Viscosity analysis [32]

A total of 6.67 g of sample was dissolved in distilled water in a 100 mL beaker. Viscosity was measured using a Stormer viscometer (Brookfield CSR-10) at 60 °C and 60 rpm.

2.6 Melting point analysis [32]

The melting point analysis was carried out according to the British Standard. Gelatin solution was prepared with distilled water, and the melting point was determined by heating the gelatin gel in a water bath. A steel ball was placed on top of the gel, and the melting point temperature was recorded when the ball sank to the bottom of the gelatin gel

2.7 Gelling point analysis [32]

6.67 g of gelatin was weighed and dissolved in distilled water in a 100 mL beaker. The beaker was connected to a digital thermometer, and crushed ice was placed evenly around the outer surface of the beaker. The gelation point of the gelatin was determined when the solution began to form a gel.

2.8 Gel strenght analysis [32]

Gel strength analysis was performed by preparing a 6.67% gelatin solution, which was stirred with a magnetic stirrer until homogeneous. The solution was then heated at 60 °C for 15 min, poured into Bloom jars, and allowed to stand for 15–20 min until reaching room temperature. The samples were incubated at 10°C for 17 ± 1 h and measured using a texture analyzer with a probe speed of 0.05 mm/s and a penetration depth of 4 mm. Gel strength was expressed in g Bloom.

2.9 Statistical analysis

The study began with a preliminary experiment using a Completely Randomized Design (CRD) with four treatments of 3% NaOH soaking duration (18, 24, 30, and 36 h), each conducted with two replications and analyzed in duplicate. The experimental data obtained were statistically analyzed using One-way Analysis of Variance (ANOVA) with SPSS software. When the F-value was greater than the F-table value, Duncan's Multiple Range Test (DMRT) was performed at a 5% significance level.

3 Result and Discussion

3.1 Gelatin yield

Figure 1. shows the yield of the gelatin. Results of the One-way ANOVA showed that the soaking duration in sodium hydroxide (NaOH) solution had a significant effect on the yield of gelatin ($p < 0.05$). The DMRT test indicated that soaking times of 18, 24, 30, and 36 hours differed significantly from one another.

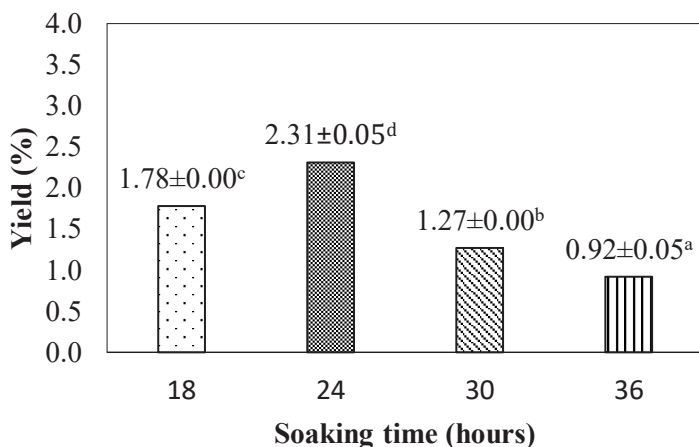


Fig 1. Yield of chicken head gelatin with various of NaOH soaking times

Soaking for 18 hours produced a yield of 1.78%. At 24 hours, the yield increased to 2.31%, which is higher than at the previous soaking time. However, soaking for 30 and 36 hours resulted in lower yields of 1.27% and 0.92%, respectively. Thus, the highest gelatin yield was obtained at 24 hours; soaking beyond 24 hours led to progressively lower yields.

Yield tended to increase with longer soaking time until reaching an optimum at 24 hours; beyond 24 hours, the yield decreased due to compound degradation. During extraction, NaOH soaking helps remove inorganic substances such as mineral salts that are not proteins, rendering them more water-soluble. A 24-hour soak with a yield of 2.31% was more effective at removing non-collagen proteins while maintaining minimal collagen solubility, resulting in a distinctly higher yield [33]. An increase in yield can be associated with the extent to which collagen is converted into the final gelatin product. Using a strong base (NaOH) during soaking increases the concentration of OH^- and accelerates hydrolysis [19].

The decrease in gelatin yield at longer times might be attributed to the solubility and leaching of collagen or gelatin into processing solutions. Excessive treatment with alkali (NaOH) such as with the longer immersion, could cause the collagen to become soluble in

cold water. Because the highly soluble collagen/gelatin dissolves readily in the aqueous phase, the loss or leaching of loose collagens during swelling and washing processes are enhanced [34]. Consequently, during the series of washing steps, the solubilized collagen will dissolve in the aqueous phase, contributing to lower yields [35]

3.2 Moisture content

The One-Way ANOVA results showed that soaking time in sodium hydroxide (NaOH) solution significantly affected the moisture content of gelatin from broiler chicken heads ($p < 0.05$). The DMRT test indicated that the 18-hour treatment did not differ significantly from 36 hours, but both differed significantly from 24 and 30 hours. At 18 h soaking is considered as early stage of alkali penetration, which lead to uneven penetration alkali to the substrate. In this stage, collagen not fully opened leads to low water binding or lower gel network, yielding a relatively low moisture value.

Figure 2. presents the moisture content values obtained in this study. An effective pretreatment that thoroughly removes impurities contributes indirectly to making the material easier to dry. Reliably dissolving and washing out non-protein substances during conditioning leads to a more purified raw material [14]. A high-purity gelatin solution resulting from optimized pretreatment allows this essential moisture content target to be met efficiently. However, if soaking is excessively prolonged, the protein structure can be damaged, affecting the final quality of the gelatin—though its use will still depend on needs and on the raw material used.

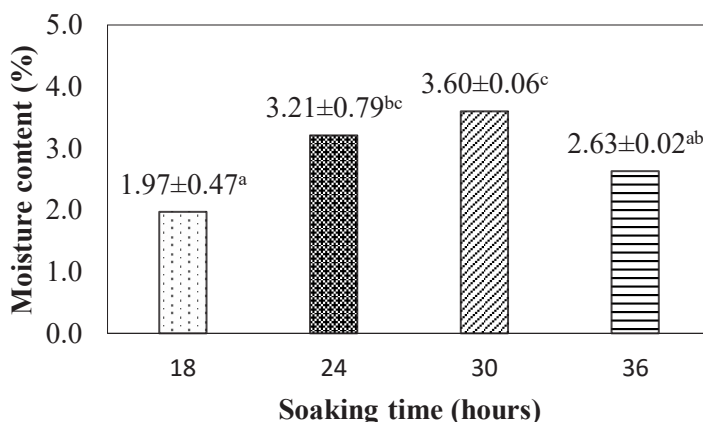


Fig 2. Moisture content of chicken head gelatin with various NaOH soaking times

The data indicate that the moisture content of chicken-head gelatin increased at 24 and 30 hours with longer NaOH soaking, but decreased at 36 hours. This decline occurs might be attributed to loss of hygroscopic groups such as guanidine and arginine groups [36]. The destruction of these groups consequently reduces the hygroscopic properties (water-retaining ability) of the gelatin, meaning the final dried product will exhibit a lower equilibrium moisture content. Despite the decrease at 36 hour, all moisture content values obtained in this study (1.97%–3.6%) are well below the maximum limit set by the SNI (16%), indicating excellent drying quality [7].

3.3 Total ash content

The One-way ANOVA results further showed that NaOH soaking time significantly affected the ash content of gelatin from broiler chicken heads ($p < 0.05$). The DMRT test indicated that all samples differed significantly. The ash-content test results for gelatin from broiler chicken heads in Figure 3 shows that prolonging NaOH immersion increased ash content, from 13.43% at 18 h to 29.81% at 36 h.

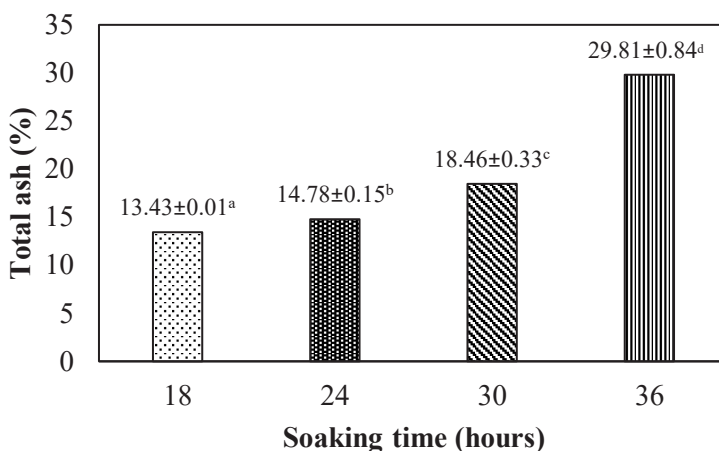


Fig. 3 Total ash of chicken head gelatin with various NaOH soaking times

Beside collagen-rich tissues (skin, connective tissue, periosteum, cartilage) that become gelatin, a chicken head also contains bones and cartilage which are rich in calcium-phosphate mineral (the main source of ash). In addition, it also contains brain and eye tissue that are lipid-rich and can complicate extraction [3,14]. Brain tissue which contain phospholipids add phosphate species to the liquor; in presence of Ca^{2+} they can form calcium-phosphate complexes that survive into drying. This leads to the increase of ash content [14].

NaOH extracts organic matrix (ossein) from bone, making bone brittle; agitation releases micro-fragment ($\approx 75 \mu\text{m}$) that can pass a 200-mesh cloth and ride along the filtrate. At high pH, dissolved Ca^{2+} and phosphate/carbonate tend to re-precipitate (e.g., $\text{Ca}_3(\text{PO}_4)_2$, CaCO_3) especially during neutralization and drying, becoming insoluble salts embedded in the gelatin film, which leads to increased ash content [14]. During soaking, NaOH saponifies triacylglycerols which resulted in soaps formation. Soaps form emulsion that trap mineral fines and proteins, making them harder to remove by simple cloth filtration and carrying mineral into gelatin solution.

The preparation procedure used a 200-mesh ($\approx 75 \mu\text{m}$) filter cloth to separate the hot gelatin extract from solid residues. However, overlong NaOH soaking rendered the bone matrix very brittle, producing fine ossein powder. Such fine collagen/mineral particles can readily pass through even fine filter media. In this study, the 200-mesh cloth may have been insufficient to retain all particulate matter: tiny bone fragments or hydroxyapatite crystals smaller than $75 \mu\text{m}$ would have flowed through into the filtrate. Any remaining mineral particles thus stayed suspended in the gelatin solution and ended up in the dried product. In short, the filtration steps in this process were inadequate to remove all mineral debris. More rigorous clarification (for example, multi-stage filtration or centrifugation) would be needed

to capture the fine ossein fragments and solubilized salts; without that, minerals carried through to drying directly elevate the ash [19,37].

3.4 Viscosity

Viscosity is a parameter used to express the thickness (flow resistance) of a fluid [38]. This test is crucial for determining the viscosity level of gelatin solutions [38]. The higher the viscosity of the gelatin raw material, the longer its stability in water [39]. The One-way ANOVA results showed that soaking time in sodium hydroxide (NaOH) solution significantly affected the viscosity of chicken-head gelatin ($p < 0.05$). The DMRT test indicated that all samples differed significantly. Gelatin viscosity values are shown in Figure 4. Based on the viscosity of broiler chicken-head gelatin, longer soaking times produced higher viscosities. The NaOH soaking duration in this process is critical in determining the final product's viscosity. However, viscosity typically reaches a peak at a certain soaking time, and excessive soaking damages the gelatin. High or low viscosity is strongly influenced by the distribution of gelatin peptide molecules in solution; as molecular motion slows, the measured viscosity increases [40].

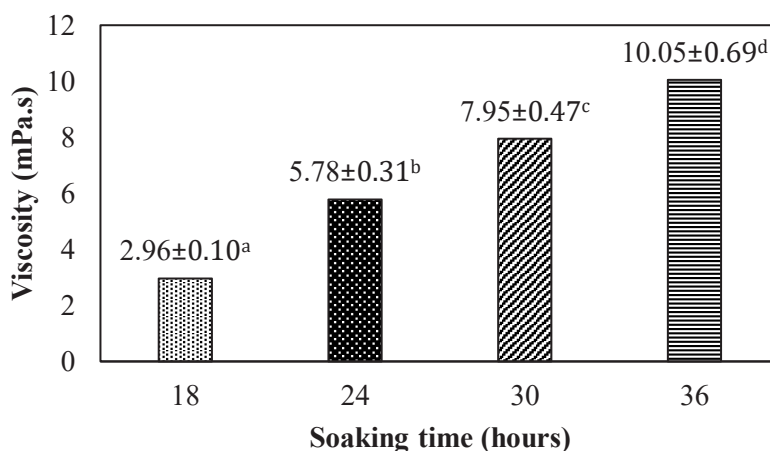


Fig 4. Viscosity of chicken head gelatin with various NaOH soaking times

Multivalent cations like Ca^{2+} can bridge gelatin chains and promote micro-aggregation; together with suspended fines, this raises apparent viscosity even when the true polymer molecular weight is falling [41,42]

The viscosity of broiler chicken-head gelatin ranged from 2.96 mPa·s to 10.05 mPa·s, increasing with longer soaking. Viscosity values at 18 and 24 h complied with the standard set by GMIA (2019) [32], namely 1.5–7.5 mPa·s. Viscosity values at 30 and 36 h exceeded the upper limit of the standard (7.95 mPa·s and 10.05 mPa·s, respectively). At 18 and 24 h the viscosity values were lower because NaOH hydrolysis of collagen peptides was not yet maximal, so gelatin molecular weight was not high enough to yield greater viscosity. Furthermore, viscosity is influenced by the average molecular weight of gelatin, which

relates to polypeptide chain length and molecular distribution [43]. The longer of NaOH soaking (at 30 and 36 h) resulted in higher viscosity values. These findings are in line with Erin et al. [33], who reported that longer soaking has a synergistic effect on increasing viscosity, due to complete unfolding of polypeptide chains into random coils and hydrodynamic interactions among the long, flexible chains.

These intermolecular attractions form transient networks that slow solution flow, thereby increasing viscosity. The implication of this excess is that the gelatin solution exhibits high internal friction [14] and possesses a higher proportion of high molecular weight components (such as longer chains or polymer aggregates) than desirable for a standard quality product within the 1.5–7.5 mPa·s range. While higher viscosity generally correlates with tougher, more extensible gels, such excessive viscosity, particularly when associated with the high ash content previously noted, suggests that the product's flow properties are dictated by undesirable, highly degraded fragments, or high molecular weight non-collagen protein fractions [44].

Correlate this to the yield and ash content result, to definitively resolve what actually happened to the collagen and gelatin molecule in the final product (inconsistent result with the lower result of the yield), where low yield usually signifies extensive degradation leading to low viscosity, Molecular Weight (MW) analysis, such as SDS-PAGE, is necessary to determine whether the measured high viscosity is sustained by a small, influential fraction of high molecular weight components (e.g., surviving beta- or gamma-chains) that resist flow despite the overall loss of protein material due to excessive hydrolysis [45][46].

3.5 Melting point

This test measures the temperature at which gelatin, in gel form, begins to melt into a liquid or solution. This parameter is used to determine product applications [47]. Gelatin melts at temperatures below 35 °C and can melt in the mouth; hence it is often called a “miracle food” [48]. The One-way ANOVA results showed that soaking time in sodium hydroxide (NaOH) solution had a significant effect on the melting point of gelatin from broiler chicken heads ($p < 0.05$). The DMRT test indicated that all samples differed significantly. Melting-point values are shown in Figure 5.

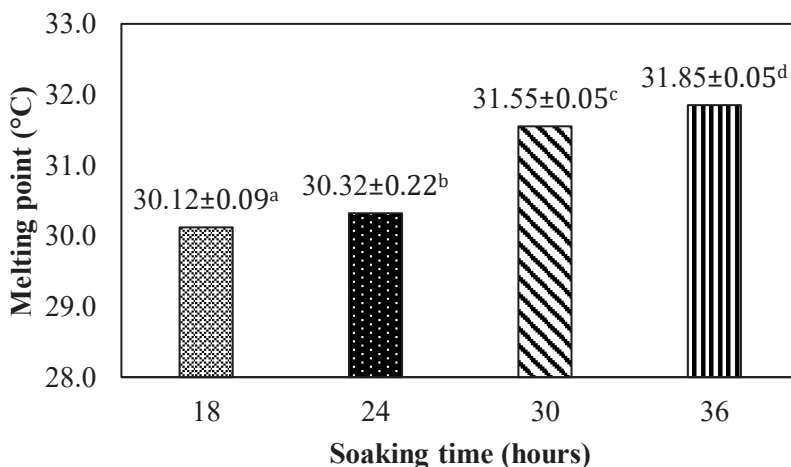


Fig. 5 Melting point of chicken head gelatin with various NaOH soaking times

Based on the melting-point tests, varying soaking times produced values between 30.12 °C and 31.85°C. The analysis showed an increase in melting point as soaking time increased. The highest melting point, 31.85 °C, was attributed to higher levels of the amino acids glycine and hydroxyproline, which increase the number of hydrogen bonds formed between gelatin and water in solution [49]. Longer soaking promotes the formation of gelatin chains with an optimal molecular length, thereby raising the melting point. The lowest melting point occurred at 18 hours of soaking, likely due to lower glycine and hydroxyproline contents; with fewer hydrogen bonds between gelatin and water in solution, the melting point decreases. Comparable trends (longer alkali pretreatments preserving high-MW components and boosting gel properties until an over-hydrolysis threshold) are reported for skin/camel gelatin and in alkaline/acid pretreatment comparisons [45,46]. Similarly to the previous discussion, to justify reasoning melting point correlated to the MW of the final product, the analysis of molecular weight is necessary.

These melting-point results show that soaking time influences the increase in the melting temperature of broiler chicken-head gelatin. The findings are consistent with M. Hasdar [49], who concluded that gelatin melting point rises with longer soaking times (29.77 °C–30.74 °C). The melting temperatures obtained here (30.12 °C–31.85 °C) fall within the Food Chemicals Codex (1996) range indicating that products melt below 35 °C and liquefy in the mouth. From the melting point perspective, it is not a limiting factor to choose the optimal time for NaOH soaking as the pretreatment.

3.6 Gelling point

The gel point is a parameter used to determine the temperature at which gelatin begins to transition into a gel. At this temperature, gelatin molecules start forming cross-links via hydrogen bonds, creating a stable gel structure. The gel point is crucial because it defines the temperature for applying gelatin in food and non-food products [47]. The One-way ANOVA results showed that soaking time in sodium hydroxide (NaOH) solution significantly affected the gel point of gelatin from broiler chicken heads ($p < 0.05$). The DMRT test indicated that all samples differed significantly. Gel-point values are presented in Figure 6.

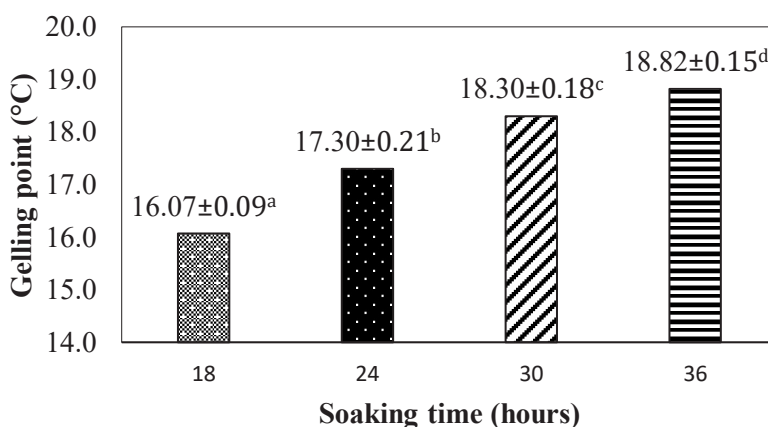


Fig 6. Gelling point of chicken head gelatin with various NaOH soaking times

Based on the tests, NaOH soaking produced gel points ranging from 16.07°C to 18.82°C. The results indicate that gel point and melting point are proportional; if the gel point is lower,

the gelatin melting point is also lower [50]. The gel point increased with longer soaking time. The highest value, 18.82 °C at 36 hours of soaking, suggests that higher hydroxyproline and proline contents increased the number of hydrogen bonds between gelatin molecules, strengthening the gel structure [47]. Soaking duration during extraction influences collagen degradation and gelatin composition, thereby affecting both gel point and melting point. An optimal soaking time improves gel quality, whereas excessive treatment can lower the gel and melting points due to gelatin structural damage [43,49]

The gel point is also influenced by soaking time, molecular weight, and the amino acid hydroxyproline, which promotes hydrogen-bond formation. The lowest gel point, 16.07 °C at 18 hours of soaking, might be attributed by a smaller amount and lower level of hydroxyproline, resulting in fewer hydrogen bonds in the gelatin and reduced quality. To understand the amino acid content such as hydroxyproline in gelatin, a test such as LCMS is needed. Overall, these gel-point tests show that NaOH soaking time increases the gel point of broiler chicken-head gelatin.

3.7 Gel Strength

Gel strength is a test used to determine the optimal treatment conditions during gelatin production. The ability of gelatin to reversibly transform a liquid into a solid is one of its key properties [43]. The One-way ANOVA results showed that soaking time in sodium hydroxide (NaOH) solution had a significant effect on the gel-point results of gelatin from broiler chicken heads ($p < 0.05$). Gel strength results are presented in Figure 7. Based on the analysis, gel strength for chicken-head gelatin ranged from 52.52 to 77.95 g Bloom. The values are lower than those of bovine-based commercial gelatin (410.39 g Bloom). Other factors influencing gel strength include the raw material used, soaking time, extraction process, and solution concentration [[51,52].

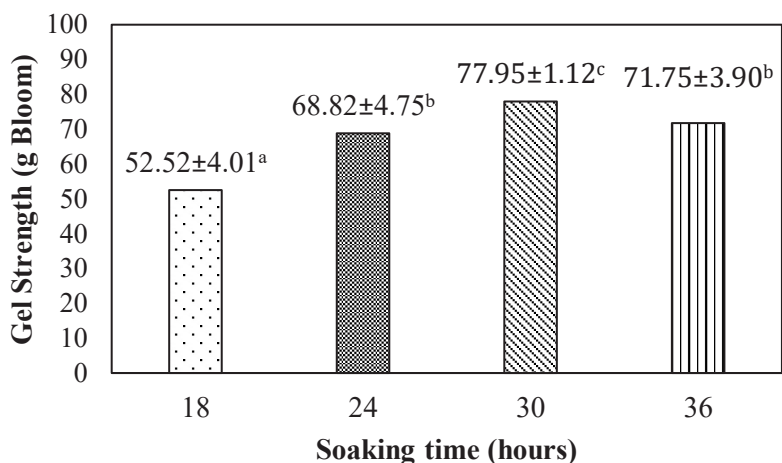


Fig 7. Gel strenght of chicken head gelatin with various NaOH soaking times

From these data, the highest gel strength occurred at a soaking time of 30 hours (77.95 g Bloom), attributed to higher molecular weight and gel-forming amino acids. The greater the number and length of these chains, the higher the molecular weight and the greater the gel strength [53]. At 36 hours, gel strength decreased to 71.75 g Bloom, eventhough according

DMRT this value was not significantly different from gel strength at 24 hours (68.82 g bloom). Gel strength increased with soaking time up to 30 h (optimum), then decreased at 36 h due to impurity carry-over (relevant to the ash content).

In general, longer soaking times and higher concentrations can increase gel strength up to an optimum, after which gel strength could decline. Gel strength increases when the constituent amino-acid chains are longer. These chains become longer and more compact when collagen is more extensively hydrolyzed and when gelatin has a greater water-absorption capacity [52]. The gel strength observed here (52.52–77.95 g Bloom) is similar to previous findings for free-range chicken-feet gelatin (67.54–72.34 g Bloom) [54]. According to the GMIA industrial standard, soaking times of 18–36 hours fall within the acceptable range of 50–300 g Bloom. Gel strength, or Bloom value, is the most important quality criterion for gelatin and is highly correlated with the intrinsic properties of the original collagen, particularly the content of amino acids (proline and hydroxyproline)[44,55].

4 Conclusion

Based on the data analysis in this study, the soaking duration in sodium hydroxide (NaOH) had a significant effect ($p < 0.05$) on yield, moisture content, ash content, viscosity, melting point, gel strength, and gel point. Chicken-head gelatin treated with NaOH showed a yield of 0.92–2.31%, moisture content of 0.13–3.6%, ash content of 13.43–29.81%, viscosity of 2.96–10.05 mPa·s, melting point of 30.12–31.85 °C, gel point of 16.07–18.82 °C, and gel strength of 52.52–77.95 g Bloom. In this study, conversion of collagen to gelatin resulted peak yield at 24 h with acceptable gel performance. However, all products exhibited ash contents far above the SNI limit ($\approx 3\%$), evidencing incomplete removal and/or carry-over/re-precipitation of bone-derived minerals; thus the current chicken-head gelatin remains non-compliant and requires process optimization.

Accordingly, its application potential is limited until demineralization is strengthened, e.g. by demineralization prior to extraction, improving solid–liquid ratios and washing, and adding rigorous clarification (fine filtration/centrifugation) and deionization to reliably reduce ash and achieve specification.

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