



Formulation Development of a Peel-Off Mask using Red Tilapia Fish (*Oreochromis niloticus*) Scale Gelatin as a Gelling Agent

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ABSTRACT: Gelling agents are essential components in peel-off mask bases, with gelatin being a commonly used material. Red Nile tilapia (*Oreochromis niloticus*) scales, a by-product of the fishery, have potential as a halal gelatin source. This study aimed to compare the characteristics of gelatin derived from red Nile tilapia scales (NTSG) with commercial gelatin (CG) as a gelling agent in peel-off mask bases through their physical evaluation. Gelatin extraction and characterization were conducted, followed by the formulation of peel-off masks with gelatin concentrations of 6%, 8%, and 10%. NTSG characteristics met the Indonesian National Standard (ISN) and GMIA based on organoleptic properties, pH, ash content, moisture content, and gel strength. Gel physical characterisation revealed pH values of 5.7–5.9, a viscosity of 3500–6500 cP, a spreadability of 5–7 cm, an adhesion time of more than 4 seconds, and a drying time of 15–30 minutes. The results indicate that red Nile tilapia scales can produce gelatin suitable as a gelling agent on peel-off masks.

Keywords: peel-off mask; gelling agent; gelatin; Nile tilapia scales.

Introduction

Gelatin is a substance obtained from the partial hydrolysis of collagen derived from the skin, white connective tissue, and bones of animals. Currently, most commercially available gelatin is sourced from the hydrolysis of bovine bones, pig skin, and bovine skin [1]. Gelatin is a natural biopolymer that possesses unique physicochemical properties, including gel-forming ability, film-forming capacity, and thermoplastic characteristics, making it highly versatile in various applications [2]. Due to these properties, gelatin is widely utilized in several industries, especially pharmaceutical, food, and cosmetic sectors [2,3]. According to literature, the most common sources of gelatin are pig skin (46%), bovine skin (29.4%), mixed pig and bovine bones (23.1%), and other sources (1.5%) [4]. The development of alternative gelatin sources presents market opportunities for the industry. The gelatin market is projected to increase by 292.53 thousand metric tons with a growth rate of 9.12% from 2020 to 2025 [4].

Recent studies have shown growing interest in exploring marine sources, particularly fish, as alternative gelatin sources [4]. Gelatin is produced from the hydrolysis of collagen found in fish bones, skin, and scales, making fish processing waste, especially abundant Nile tilapia

scales, a potential raw material source that requires optimal utilization [5]. Besides its high availability, gelatin exhibits excellent functional properties, including stabilizing, gel-forming, binding, emulsifying, precipitating, and nutritional enrichment, as well as the ability to form thin, elastic, and transparent films with high digestibility [3,5]. Gelatin can be used as a gelling agent in peel-off mask formulations, forming a film that can be peeled directly from the skin after drying and spreading on the face, resulting in a thin, transparent film layer [6-8].

The present study aims to compare gelatin derived from Nile tilapia scales with commercial bovine gelatin as a gelling agent in peel-off masks. The evaluation includes various physical stability tests such as organoleptic assessment, homogeneity, pH, viscosity, spreadability, adhesion and drying time. This study aims to determine whether gelatin derived from Nile tilapia scales has comparable potential as commercial gelatin as a gel-forming agent.

Methods

Materials

The materials used in this study included red Nile tilapia

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scales obtained from Senen Fish Market, Central Jakarta. Other materials used were commercial gelatin (PT. ESSENL), polyvinyl alcohol (PVA) (PT. Anugrah Visi Cemerlang), nipagin (Ueno Fine Chemicals Industry), propylene glycol (PT. Anugrah Visi Cemerlang), and distilled water (Aquadest) (PT. Anugrah Visi Cemerlang).

Procedure

Preparation of Gelatin from Red Nile Tilapia Scales

Sample Identification

The tilapia scales were identified through the Freshwater Fish Identification Institute at the Faculty of Fisheries and Marine Sciences, Bogor Agricultural University.

Extraction

The collected scales were cleaned of impurities, washed, and soaked for 24 hours in water containing a surfactant. This procedure follows several techniques that have been done previously [5,9]. The scales were then refrigerated, drained, sun-dried, and air-dried until completely dry. A total of 200 g of dried red Nile tilapia scales was weighed into four separate containers. Each container was soaked in a lime juice solution with a scale-to-solution ratio of 1:3 (w/v) for 24 hours to produce ossein. The soaked scales were rinsed with running water until a neutral pH was obtained. The ossein was then placed into glass bottles and mixed with distilled water at a ratio of 1:2 (w/v). Extraction was carried out using an autoclave at 121°C for 90 minutes. The gelatin extract was filtered to separate it from the residue, and then dried in an oven. The dried gelatin sheet was cut and ground using a blender to produce gelatin powder, which was then weighed.

Gelatin Identification and Characterization

The obtained gelatin powder was further processed for characterization tests, including organoleptic evaluation (color and odor), yield, ash content, moisture content, heavy metal content (arsenic, copper, zinc, sulfite), pH, viscosity, and gel strength. Gelatin characterisation was carried out according to the standards set by GMIA [10].

Formulation of Peel-Off Masks Using Gelatin from Nile Tilapia Scales and Commercial Gelatin

Peel-off mask formulations were prepared in a total volume of 200 mL, as shown in Table 1. The peel-off mask formulation began by dissolving polyvinyl alcohol (PVA) in preheated distilled water at 80°C, followed by homogenization until a homogeneous mixture was achieved (M1). In a separate container, gelatin was dissolved in distilled water at a ratio of 1:4. To achieve a homogeneous mixture and constant stirring, the gelatin solution was heated on a hot plate at 48.9°C [11,12]. After the gelatin was fully dissolved, the swollen PVA solution (M1) was gradually added to the gelatin solution, with continuous stirring using a stirrer rod, until a homogeneous mixture was formed (M2). Nipagin was dissolved in propylene glycol due to poorly soluble in water, and stirred until homogeneous (M3). The M2 mixture was then added to M3 and stirred until it was homogeneous, and then allowed to cool. The cooled peel-off mask base was slowly transferred to a homogenizer, and the remaining water was added gradually while the mixture was homogenized until a uniform consistency was achieved.

Physical Evaluation

Evaluations included organoleptic properties (shape, color, odor), homogeneity, pH, spreadability, adhesion, viscosity, and drying time at room temperature.

Table 1. Formulation of peel-off mask gelatin base (n/replication=3).

Bahan	F1 (%)	F2 (%)	F3 (%)	F4 (%)	F5 (%)	F6 (%)
Nile Tilapia Scale Gelatin (NTSG)	6	8	10	-	-	-
Commercial Gelatin/ Bovine (CG)	-	-	-	6	8	10
PVA	10	10	10	10	10	10
Nipagin	0.1	0.1	0.1	0.1	0.1	0.1
Propilen Glikol	10	10	10	10	10	10
Aquadest (add)	200	200	200	200	200	200

Table 2. Characterisation of gelatin (n=3).

Gelatin	Colour	pH	Ash content (%)	Moisture content (%)	Viscosity (cPs)	Gel strength (Bloom)
NTSG	Yellow	5.49±0.009	1.605±0.015	10.39±0,007	15.61±0.012	159±0.001
CG	Yellow	5.61±0.004	1.125±0.003	10.38±0,007	16.20±0.008	165±0.028
ISN	Qualify	3.8-7.5	<3.25	Max. 16	Min 15	Min 75
GMIA	-	3.8 – 5.5	Max. 3	-	1.5-7.5	50-300

Organoleptic Test

Organoleptic evaluation was performed visually to assess the consistency, aroma, and color of the peel-off gel mask [12-14].

Homogeneity Test

Homogeneity was assessed by applying 0.1 g of the sample on a glass slide and observing its uniformity.

pH Measurement

The pH of the peel-off mask was measured using a calibrated pH meter. Calibration was done with a neutral buffer (pH 7) and an acidic buffer (pH 4). One gram of the sample was prepared, and the pH was recorded. The formulation's pH should be within the skin's physiological range of 4.5–6.5.

Spreadability Test

A 0.5 g sample was placed in the center of a graduated glass plate, covered with another glass plate, and left for 1 minute. The diameter of the spread sample was measured with a ruler [12]. A spreadability of 5–7 cm indicates good consistency and comfort during application.

Adhesion Test

A 0.25 g sample was placed on a glass slide, covered with another glass slide, and a 500 g weight was applied for 5 minutes. The two glass slides were then attached to a 65 g weight, and the time until separation was recorded.

Viscosity Test

Viscosity was measured using an Anton Paar viscometer. After determining the suitable spindle by trial and error, the sample was placed in a beaker, and viscosity was recorded at spindle RH5 and 50 rpm.

Drying Time Test

One gram of peel-off mask was applied on the back of the hand, and the drying time until film formation was measured using a stopwatch. An acceptable drying time ranges from 15 to 30 minutes [12,13].

Elongation and tensile strength tests

were conducted to determine the elasticity of the peel-off gel mask during use and to assess whether the mask cracks easily or remains flexible after application to the skin [15,16].

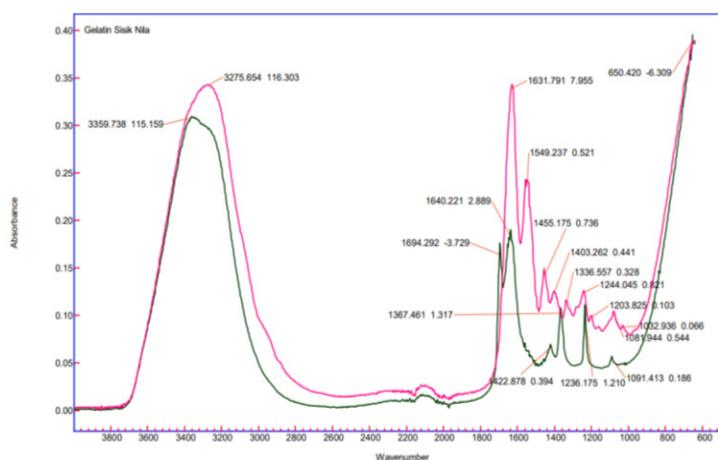


Figure 1. FTIR Identification Result of Gelatin (red curved line = tilapia scale gelatin, black curved line = commercial/beef gelatin).

Table 3. Comparison of physical evaluations of gelatin-based peel-off masks (NTSG and CG), n=3

Formula	Viscosity (cPs)	pH	Adhesion time (sec)	Spreadability (cm)	Drying Time (minute)
F1 (NTSG)	2101.67±6.94	5.93±0.01	4.07±0.16	7.1±0.16	18.52±0.35
F2 (NTSG)	3697.67±13.27	5.82±0.01	4.57±0.13	6.17±0.25	19.12±0.08
F3 (NTSG)	6322.33±47.21	5.76±0.01	6.06±0.15	5.03±0.21	20.84±0.85
F4 (CG)	1632±36.04	5.9±0.01	3.66±0.18	7.17±0.12	16.98±0.48
F5 (CG)	4094.67±100.15	5.89±0.01	3.94±0.20	6.0±0.14	19.18±0.06
F6 (CG)	5131±64.28	5.83±0.01	5.11±0.19	5.63±0.13	20.2±0.08

Statistic Analysis

Physical stability data, including pH, spreadability, adhesion, drying time, and viscosity from each formulation, were analysed for normality and homogeneity. A one-way ANOVA was conducted to determine significant differences among the data sets.

Result and Discussion

Gelatin Quality Evaluation

Gelatin standards have been established as quality requirements for comparing the gelatin obtained. This enables us to evaluate the quality and characteristics of fish scale gelatin in comparison to standard gelatin [9,10]. The gelatin extracted from Nile tilapia scales (NTSG) was characterized and compared with commercial gelatin (CG) based on standards from the Gelatin Manufacturers Institute of America (GMIA) and the Indonesian National Standard (INS). It can be seen on Table 2.

Both NTSG and CG exhibited a yellow color and an acceptable aroma, meeting the requirements of ISN 06-3735-1995. The visual characteristics of the two gelatins were comparable. These results align with previous research that supports the function of gelatin as a gelling agent [3,5,10].

The pH of NTSG was 5.49 ± 0.009 , within the GMIA standard range of 3.8–5.5, while CG had a slightly higher pH of 5.61 ± 0.004 . Both values are acceptable for cosmetic use, with minor differences attributed to neutralization efficiency during extraction [9].

Ash content for NTSG and CG was $1.605\% \pm 0.015$ and $1.125\% \pm 0.0003$, respectively, both below the INS maximum limit of 3.25%. This indicates good mineral purity, with slightly higher ash in GSI likely due to residual minerals from raw materials or processing [5,10].

Moisture content levels were similar for NTSG ($10.39\% \pm 0.007$) and CG ($10.38\% \pm 0.007$), well within the SNI limit of 16%. Proper drying ensured comparable stability and functional properties. This water content is important in the gel form because it affects the physical properties of the preparation and determines its stability [14-16].

The results of measuring the viscosity of NTSG yielded a value of 15.61 ± 0.012 cP, which is slightly lower than that of CG at 16.20 ± 0.008 cP. Both fall within the low to medium viscosity range, reflecting comparable molecular characteristics. Viscosity refers to the gel mask's ability to flow and spread over the skin layer. The higher the viscosity, the lower the spreadability will be, and the less effective the peel-off layer [16,18,21].

Both gelatins met safety standards with no detectable mercury or arsenic. Copper and zinc levels were low and well below SNI limits, confirming the absence of toxic metal contamination. The absence of heavy metal content is evidence of the safety of cosmetic raw materials, as per established regulations [8].

The results of determining the gel strength of gelatin were 159 ± 0.00115 Bloom for NTSG, and 165 ± 0.02815 Bloom for CG, both within the range of 50–300 Bloom,

Table 4. Elongation and tensile strength value of gelatin peel-off masks (n=3)

Formula	Tensile Strength (MPa.)	Elongation
Peel off mask base of NTSG	4.58 ± 0.55	323.27 ± 33.01
Peel off mask base of CG	3.59 ± 0.86	115.80 ± 65.91

indicating suitable gel-forming capacity. The gel strength values of both gelatins prove their ability as good gelling agents in peel-off masks [10,16,18]

Identifying the molecular structure of fish gelatin with commercial gelatin by FTIR, it appears that both have similar structures.. This indicates that the two gelatins are identical. FTIR spectra revealed similar functional groups (O-H, N-H, and C=O) for both NTSG and CG, with absorption peaks that closely matched, confirming comparable chemical structures. This is illustrated in [Figure 1](#).

This comprehensive evaluation demonstrates that gelatin derived from Nile tilapia scales meets established quality standards and exhibits physicochemical properties comparable to commercial bovine gelatin, supporting its potential as an alternative gelling agent in cosmetic formulations [3,12,13].

Results of Peel-Off Mask Formulation and Physical Evaluation

The peel-off masks were formulated using gelatin from Nile tilapia scales (NTSG) and commercial gelatin (CG) at concentrations of 6% (F1, F4), 8% (F2, F5), and 10% (F3, F6). Gelatin served as the gel-forming agent, known to accelerate drying time with increasing concentration. Polyvinyl alcohol (PVA) was added as a plasticizer to form a film layer that is easily removable after the preparation dries, which also affects the viscosity of the gel to increase it [13,15, 21]. The results of the physical evaluation for all formulas are presented in [Table 3](#).

Throughout storage at room temperature, no significant changes in color, odor, or consistency were observed. All formulations remained homogeneous under storage conditions for a month.

pH values ranged from 5.70 to 5.92, within the normal skin pH range (4.5–6.5), indicating suitability and safety for topical application. Statistical analysis showed significant differences among formulations.

Viscosity increased with gelatin concentration for both GSI and CG formulations, reflecting higher polymer fiber content and liquid retention [11]. All formulations showed significant differences in viscosity values across concentrations and storage conditions.

Spreadability decreased as gelatin concentration increased, consistent with increased viscosity. Spreadability shows an inverse relationship with viscosity; as the viscosity of the formulation increases, its ability to spread decreases [12,14,15]. Statistical tests confirmed significant differences among formulations.

Adhesion times ranged from approximately 3.7 to 5.5

seconds, meeting peel-off mask requirements. Both the type of gelatin and its concentration significantly influenced adhesion. Drying times for all formulations ranged from 16 to 24 minutes, within the acceptable range of 15–30 minutes. Significant differences among formulations were observed. The concentration of gelatin as a gelling agent also affects the adhesion time and spreadability of the gel mask preparation. The higher the gelatin concentration, the lower the spreadability, but the higher the adhesive strength [6,8,11].

In this study, a comparative analysis was conducted between peel-off masks based on NTSG (F1, F2, F3) and peel-off masks based on CG (F4, F5, F6) There were significant differences between the tilapia scale gelatin-based formula and bovine gelatin in viscosity, pH, adhesiveness, and spreadability, while drying time did not show any significant differences.

Gelatin has a function when it comes into direct contact with facial skin; it can immediately form an elastic film, making it easier to clean the mask after use [13,17,20]. This indicates that tilapia scale gelatin has potential as an alternative to bovine gelatin in peel-off mask formulations, with competitive physical characteristics. This summary demonstrates that peel-off masks formulated with gelatin from Nile tilapia scales have comparable or superior physical properties relative to commercial gelatin, supporting their potential as alternative gel-forming agents in cosmetic applications.

Tensile strength determines the strength of the film layer and is an important mechanical property of peel-off masks, representing the film's ability to resist deformation and mechanical damage [8,15,16,17]. The higher the tensile strength, the better the mask film performs during peeling and increases a film's resistance to mechanical damage [17]. [Table 3](#), showed that the tensile strength values obtained for the NTSG-based peel-off mask and the CG-based peel-off mask were 4.58 MPa and 3.59 MPa, respectively. The minimum tensile strength value according to the Japanese Industrial Standard (JIS) is 0.39 MPa; therefore, both tensile strength test results in this study met the JIS requirements. The tensile strength measurement results for peel-off masks using tilapia fish scale gelatin as a gelling agent gave slightly higher values compared to commercial gelatin gelling agents. This can be attributed to the NTSG's ability to form hydrogen bonds between chains, resulting in a denser film that can withstand greater tensile loads before breaking. This proves that tilapia fish scale gelatin-based masks have better strength, ensuring that the mask does not tear easily when removed from the skin.

Elongation testing is defined as the percentage

change in length of a material before it breaks, indicating the material's elasticity or ability to stretch [17,18]. Table 4 shows a very significant difference in elongation values, where the NTSG Peel-Off Mask has a much higher elongation ability (around 323%) compared to the Commercial Gelatin Peel-Off Mask (around 115%). High elongation indicates the flexibility and elasticity of the film. A highly elastic film will be easy to apply evenly on the skin surface, follow the contours of the face, and, most importantly, can be removed intact without leaving residue or tearing. The high elongation of the tilapia fish scale gelatin-based mask (323.27%) is a significant advantage, as it will provide a better and more comfortable user experience for consumers. Films that are too stiff (low elongation) tend to break or are difficult to remove [17,18].

Based on all the research above, the use of gelatin from tilapia fish scales has the potential to become a halal raw material source in the pharmaceutical industry, as it is derived from fish waste with very low haram potential [1-3,9]. It is important to increase the use of non-synthetic materials to expand raw material sources in the pharmaceutical industry.

Conclusion

Red Nile tilapia scales (*Oreochromis niloticus*) produce gelatin that functions as a gelling agent in peel-off mask bases, providing physical stability that meets pharmaceutical standards. A comparative analysis with commercial gelatin demonstrated that gelatin from Nile tilapia scales complies with the quality parameters specified in INS 06-3735-1995 and GMIA 2019. These parameters indicate that gelatin derived from red Nile tilapia scales is safe for use as a cosmetic raw material with potential halal certification.

Conflict of Interest

The authors have no conflicts of interest regarding this investigation.

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