Effect of broiler age and extraction temperature on characteristic chicken feet skin gelatin[1]

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ABSTRACT: Gelatin was prepared from chicken feet skin of Broiler. Yield, moisture, ash content, pH value, fat content, protein content, viscosity and gel strength of the chicken feet skin were evaluated. A completely randomize factorial design was used, with two levels of broiler age (30 and 40 day) and tree levels of extraction temperature (45, 50 and 55ºC). Results of the research showed influence of interaction of both treatments Broiler age and extraction temperature was not significant ($P>0.05$) upon the yield, gelatin moisture, pH value, fat content, protein content and gel strength, while it was significant ($P<0.01$) to viscosity. The average of gelatin characteristic made of chicken feet skin from this study were yield 15,498%, moisture 10,930%; ash content 0,249%; pH value 3,422; fat content 0,139%; protein content 93,521; viscosity 6,896 poise and gel strength 119,085 g/cm^2. The results indicated that chicken feet skin gelatin can be used as a substituted for commercial gelatin for food industry application.

Key words: gelatin, chicken feet skin, Broiler, age, extraction temperature

INTRODUCTION

Gelatin is a protein substance that can dissolve in water does not naturally occur in nature, but derived from the destruction of collagen through the process of secondary structures with various degrees of hydrolysis (Phillips and Williams, 2000). Collagen is a fibrous protein found in many connective tissues in the body of animals, such as bone, cartilage, skin and tendons (Pearson and Dutson, 1992).

Physical and chemical properties of gelatin was significantly affected by raw materials, animal age, type of collagen and method of manufacture (Ledward, 1986), tissue type, species (Gomes-Guillen et al., 2009), collagen characteristics and treatment process (temperature , time, and pH) (Johnson-Banks, 1990; Kołodziejska et al., 2008). Muyonga et al., (2004) suggests that collagen derived from fish skin of Nile perch (*Lates niloticus*) with the age difference to produce the proteins that are almost identical (20-22%), the content and amino acid composition was not significantly different, whereas the fat and mineral content of adult Nile perch fish and was higher than that of young fish. Furthermore Dwi Wulandari (2006) argued that differences in the concentrations of acid and alkaline soaking process broiler feet skin with extraction temperature 45°C, showed no significant difference on yield, viscosity, fat content, ash content, pH, whereas the gel strength and protein content showed significant differences.

Gelatin is generally made from waste generated from the cutting and processing of livestock, such as skin and bone. Based on data in 2007, production of gelatin in the whole world about 326 000 tones, with details of 46.0% was derived from pig skin, cow leather 29.4%, 23.1% came from the bone and 1.5% from other sources (GME , 2008). On the basis of these data, the production of gelatin derived from pig skin is very high. This is a problem particularly in Indonesia, due to the gelatin on the market 100% of it is imported gelatin, while the majority of Indonesian people embraced Moslem which forbids a food that comes from pigs.

Therefore, it is necessary to find alternative sources that can replace the pig skin gelatin. One of the most abundant source is from poultry by-product, namely the shank of broiler chickens. In Indonesia, in general, broiler feet has been used as food (e.g. : soup, rambak) or created as an accessory (e.g.: wallet, belts). While in the area of South Sulawesi in particular, broiler feet are still regarded as waste, the utilization is still limited as food and feed.

Potential of broiler chicken feet as a source of gelatin can be seen from the increasing number of chicken population in Indonesia. Data from the Directorate General of Animal Husbandry (2008) total population of broiler chickens in Indonesia in 2008 is approximately 1.075.884.785 heads. In addition, qualitative skin fresh broiler chicken feet contains 22% crude protein, fat 5,50%, ash 3,5%, water 64% and 3% other substances (Sriyanto, 1986). According to Cheng et al., (2009), collagen content of broiler feet that is extracted using acetic acid ranging from 516.6 ± 28.9 mg/g. Further as stated by Vittayanont and Benjakul (2005), Lin and Liu (2006), the collagen of chicken feet, including collagen type I, contains many amino acids glutamate (Glu), aspartate (Asp), hyproxyproline (Hyp) and proline (Pro) and has stability to high temperature. Thus, collagen from chicken feet may be used as a material suitable for biomaterials. Dwi Wulandari (2006) stated that the average value of broiler chicken feet skin gelatin characteristic obtained with various concentrations of the curing material, are 12,31% yield, gel strength of 136 g/cm2, 7.51 poise viscosity, protein content 83.23 %, fat content 1.09%, 0,27% ash content, water content 6,75% and pH 4,5, there are 17 amino acids detected with glycine and hidroksiprolin quite high.

Based on the above description, the potential Broiler chicken feet skin should be studied as an alternative to gelatin pig skin and bones, as well as characteristics of the resulting gelatin.

MATERIALS AND METHODS

Gelatin production was conducted at the Laboratory of By-product Technology and Environment, Faculty of Animal Husbandry. Measurement of the characteristics of gelatin was done in the Laboratory Technology I, Faculty of Agricultural Technology and Laboratory of By-product Technology and Environment, Gadjah Mada University, Yogyakarta.

Material

Research materials used are skin feet of Hubbard broiler strain aged 30 and 40 days around 1500 pieces. This material was obtained in the form of pieces of chicken feet so the skin is still embedded in the bones. Weight ratio of chicken feet and foot skin of broiler chickens aged 30 and 40 days are presented in Table 1.

Table 1. Weight Comparison of Broiler Chicken Feet 30 and 40 day of age used in research

	Feet weak of the Broilers, g			
	30 day old		40 day old	
Replication	Skin	Complete feet	Skin	Complete feet
1	16,1	22,8	21,9	28,3
2	16,5	21,4	20,3	26,6
3	16,5	21,0	21,8	28,5
Total	49,1	65,2	64,0	83,4
Average	16,37	21,7	21,33	27,8

Methods

Sample Preparation of Chicken Feet

Broiler feet that have been separated from his body are washed and skinned by the method Purnomo (1992). Chicken feet with the scale still on it were washed clean. Cut finger nails. At the rear of the middle finger the skin was sliced from cob with a knife straight to the base of the longest finger. Weevil exfoliated skin sections up to ± 2 cm downwards and clamped with pliers. Sections of bone that has been exfoliated also clamped with pliers, and then each was held with one hand. Pulled to the opposite directions until the skin on fingertips peeling off. Meat that comes with the skin was removed with knife.

Gelatin Extraction

Making gelatin according to the method by extraction Dwi Wulandari (2006) through the curing process multilevel (alkaline, acid and acid) with slight modifications. Skin chicken feet after separated from the bone was washed, immersed in water at a temperature of 50°C for 30 minutes to remove the scales. Furthermore, washed, cut with a size of ± 1 cm2. Furthermore, as many as 400 g of each sample of skin that has been cut, soaked in 0.1% NaOH solution for 40 minutes, then washed with tap water (repeated up to three times), then soaked in 0.1% sulfuric acid solution for 40 minutes , washed with tap water (repeated up to three times). Furthermore, soaked in 0.4% citric acid solution for 40 minutes, washed with tap water (repeated up to three times). Comparison of chicken feet skin was soaking solution was 1 to 5, for each treatment. Subsequently the skin was soaked in distilled water and put into water bath with temperature extraction of 45°C, 50°C and 55°C for 24 hours to extract the gelatin. The next process is filtering gelatin solution using filter paper. Solution of gelatin obtained by each of Approximately 300 ml was container of 30.5 cm x 30.5 cm, then dried in an oven temperature of 60°C for 24 hours. Gelatin obtained then was crushed using a blender and stored for further analysis.

Study Design

Research using Completely Randomized Design (CRD) with factorial pattern, as the first fact of broiler chicken age (30 and 40 days) and second factor was is extraction temperature (45, 50 and 55°C), making six combination treatment and each treatment was replicated five (5) times.

Yield

The yield was calculated as dry weight gelatin/wet weight scaled skinsx100.

Proximate Composition

The moisture, crude protein, crude lipid and ash contents of the extracted gelatin derived from the fermented skate skin were determined in triplicate (AOAC, 1995). Crude protein of the gelatin was expressed as 5.4 x nitrogen content (Johnston-Banks, 1990). All values were calculated on a percent wet weight basis.

Viscosity

Gelatin solutions (10% (w/v)) were made by dissolving the dry powder in distilled water and heating at 60°C. Viscosity as a function of temperature was determined using a computerized Brookfield digital viscometer (Model DV-II, Brookfield Engineering, USA) equipped with a No. 1 spindle (Model RVT) at 60 rpm starting at 40±1°C (Kim, Byun, & Lee, 1994).

Gel Strength

Gel strength was determined according to the method described by Johnston-Banks (1990) on a gelatin gel of 6.67% concentration, formed by dissolving dried broiler feet skin gelatin in 50 ml distilled water. The solution was cooled at 10±1°C for 16 – 18 h. Measurements were conducted at 8±1°C using a Texture Analyzer (TA.XT2, Stable Microsystems LTD, UK) for a 4 mm depression at a rate of 0.5 mm/s using a probe 2 cm in diameter. The gelling and the melting point of gelatin solution was determined visually observing changes in appearance (fluidity) and sinking loaded using a magnetic stirrer bar (1 g) on the top surface of the gelatin sample, respectively.

Statistical Analysis

One-way analysis of variance (ANOVA) was conducted using SAS (SAS Institute Inc., Cary, NC, USA). Data were analyzed using the Tukey test to determine significant differences between means.

RESULTS AND DISCUSSION

Characteristics of feet skin gelatin with different treatment combination of broiler age and extraction temperatures are shown in Table 2.

Yield

The yield is a measure of the percentage of weight gained from the conversion of collagen in the skin. The higher yield being produced, the more efficiently and effectively the performed method. Table 2 showed that the average yield was produced by A2T3, followed by A1T3, A2T2, A1T2, A2T1 and A1T1. From the presented data, it can be seen the trend of increasing extraction temperature, the amount generated yield will be bigger. According Ockerman and Hansen (2000), high extraction temperature would increase yield.

Based on ANOVA, it showed that extraction temperature has a very significant effect on the percentage of gelatin being produced ($P < 0.01$). Kim et al (2008) stated that the yield of gelatin was continuously increased with increasing temperature and time of extraction. Furthermore, Williams (1997) stated that high temperatures help to break the hydrogen bonds and the gel are hydrolyzed. Number of hydrogen bonds broken and the gel will facilitate the dissolution of collagen in hot water, so as to maximize the acquisition of gelatin.

The results from using the HSD test showed that there was no significant difference ($P > 0.01$) between treatments. This was probably due to the temperature range being used in this study differed only 5ºC, so although there was an increasing yield for each treatment temperature, but the increment was very small. ANOVA results shows the treatment of broiler age and interaction between broiler age and extraction temperature had no significant effect ($P > 0.05$) on yield of broiler feet skin gelatin. The absence of age effect on yield resulting was probably due to the feet skin of broiler that used a very short life span, the only difference in 10 days. This is in contrast to the results obtained by Cole and McGill (1988) using calf skin with a treatment difference in age, the resulting yield increase with the age of cattle. This difference was probably caused by cow age range used was very wide, namely the age of 6, 18 and 60 months. In addition, the absence of age effect probably caused by that the resulting yield was almost equal to the yield of gelatin from skins of young broiler chickens foot. Swatland (1984) suggested that the protein content of collagen in the skin of animals was affected by age, increasing age of the animal would cause protein and fiber collagen growing stronger. Schrieber and Gareis (2007) stated that the collagen derived from younger animals was more easily soluble in hot water, these properties would be decreased with the increasing age.

Table 2. Effect of broiler age and temperature of extraction on characteristic chicken feet skin gelatin.

	Treatment					
Characteristic	**A1T1**	**A1T2**	**A1T3**	**A2T1**	**A2T2**	**A2T3**
Yield, %	15.281	16.030	16.422	15.531	16.242	16.493
Moisture, %	10.927	10.869	10.655	11.155	11.154	10.818
Ash content, %	0.253	0.207	0.191	0.393	0.304	0.330
pH	3.422	3.424	3.460	3.296	3.424	3.508
Fat content, %	0.179	0.098	0.095	0.198	0.125	0.196
Protein content, %	92.616	93.691	93.871	93.562	93.508	93.876
Viscosity, poise	6.904^{bc}	7.089^{ab}	6.293^{c}	7.723^{a}	6.512^{bc}	6.855^{bc}
Gel strength, g/cm^2	119.849	112.874	127.794	112.938	125.562	115.494

- interaction between the two treatments for all parameters showed no effect ($P > 0.05$), except for the viscosity parameter
- Different superscripts on the same line showed differences ($P < 0.01$)
- A1T1 (30 days of broiler age with extraction temperature of 45°C); A1T2 (30 days of broiler age with extraction temperature of 50°C); A1T3 (30 days of broiler age with extraction temperature of 55°C); A2T1 (40 days of broiler age with extraction temperature of 45°C), A2T2 (40 days of broiler age with extraction temperature of 50°C); A2T3 (40 days of broiler age with extraction temperature of 55°C)

Moisture

Result based on ANOVA, showing that the treatment combinations of Broiler age and extraction temperature and the interaction between the two treatments did not influence the moisture of gelatin (P> 0.05). The lack of effect of treatments on the moisture content of gelatin, due to similar temperature and time being used. Gelatin moisture values obtained (Table 2) which was between 10.655% - 11.155%, this value still meet quality standards set gelatin SNI (1995), maximally 16%.

Ash Content

Table 2 shows that the percentage of ash content of broiler chicken feet skin gelatin ranged between 0.191% - 0.393%. These values were in accordance with the standards required by SNI, maximally 3.25%. Table 2 also shows that the older the age of chickens, the percentage of ash generated was higher.

Based on ANOVA, it was shown that both treatments of broiler age and extra temperature hed significant (P <0.05) on the percentage of ash content of broiler feet skin gelatin. The effect of age on the ash content of gelatin is probably due to the occurrence of mineralization processes in cattle older. The statement by Muyonga et al (2004) also indicated that the ash content was also considerably higher for skins of Nile perch adult was probably because of increase mineralization on older age.

Value (pH)

Average pH value of gelatin obtained from all treatments ranging from 3.296 to 3.508 (Table 2). This pH value lower than the pH value of research results by Dwi Wulandari (2006) using the same immersion solution, ranging from 4.38 to 4.66. The existence of this difference is likely due to the soaking solution which was still trapped during the process of swelling, was not lost during the laundering and influence the final pH value of the product.

Results of ANOVA indicated that treatment of broiler age and the extraction temperature and the interaction between the treatment showed no significant effect (P>0.05) on the pH value of gelatin. This was caused by the same soaking process, i.e. using alkaline solution (NaOH), and acid solution (H2SO4 and citric acid). With the soaking solution of acid 2 (two) times, possibly had caused the pH of the final products had low values.

Fat Content

Average fat content of gelatin obtained ranged from 0095% - 0.198% (Table 2). The range is very good value, because it does not exceed 5% which is a maximum value required for the quality of gelatin according to SNI (1995). The low percentage of fat content in the resulting gelatin was probably due to the age of broiler that were still very young, so that the fat under the skin has not been formed (as stated by Muyonga et al., 2004), and extraction temperature used was also very low, so that the fat contained in the skin was not degraded . Mulyati and Sudaryati (2003) suggested that saturated fatty acids would be oxidized by the heat and break down into shorter carbon chain, making them easier dissolution. Winarno (1995) also state that fat molecules containing unsaturated fatty acid radicals would be oxidized during the heating and to farm shorter carbon chain.

Table 2, showed that the treatment of broiler age and extraction temperature treatment influenzed significantly (P <0.05) on the fat content of gelatin, but not their interaction (P> 0.01). This was in accordance with the statement by Muyonga et al., (2004), that the fat content of Nile perch adult was higher than the young, due to the accumulation of fat under the skin occurs with increasing age of the animal. Further added by Mulyati and Sudaryati (2003), that the fat content of gelatin was determined by the temperature and time of extraction, the longer the heating time the smaller the fat content, but the higher the temperature the higher the levels of fat extraction.

Protein Content

Gelatin as one type of protein that is produced through a process of conversion of hydrolysis of collagen, have very high protein content in them. Poppe (1992) stated that the standard protein content of commercial gelatin was about 85-90%.

Skin gelatin protein content of chicken feet in this study were between 92.661% - 93.876% (Table 2). The high content of protein in gelatin being produced, probably due to the raw materials used comes from chicken that are still young, so that the collagen was extracted perfectly.

ANOVA results indicated that treatment of broiler age and temperature of extraction and their interaction did not significantly influence ($P > 0.05$) the protein content of gelatin. The lack of effect of treatment is probably due to the treatment solution and time used the same marinade. According to Pearson and Dutson(1992) immersion had caused some cross-peptide bond been hydrolyzed. Imeson (1992) stated that a long immersion time had many more peptide bonds broken, there was a change in protein formation, more and more and more proteins are extracted.

Viscosity

Viscosity is the physical property of gelatin which is also very important. Leiner (2000) stated that the viscosity of gelatin had effect on gel properties, especially on the point of gel formation and melting points. High viscosity yield high rate of melting point and the formation of the gel was higher than the low viscosity of gelatin.

Viscosity values obtained from broiler chicken feet skin gelatin, was between 6.293 to 7.723 poise (Table 2). This was almost the same value obtained by Dwi Wulandari (2006), which was between 7.06 to 7.77 poise and is higher than the results of research Imeson (1992), which was between 1.5 to 7.5 poise. The high value of viscosity which was obtained by Stainsby (1977) correlated with the average molecular weight of gelatin, which was associated with long-chain amino acids. Schrieber and Gareis (2007) stated that the high viscosity of gelatin was related with the many components of high molecular weight.

Results ANOVA indicated that the treatment of broiler age had no significant effect ($P > 0.05$) on the value of viscosity of gelatin. While temperature of extraction treatment and the interaction between the treatment of broiler age and temperature of extraction caused significant effect ($P < 0.01$). Godmunson (2002) stated that the extraction temperature and time affected the viscosity, the higher the temperature, the lower the viscosity value. This was according to Imeson (1992), due to the high temperature water molecules had a greater energy to move, so that its viscosity was lower (more dilute solution)

Gel Strength

Average gel strength values obtained from chicken feet skin gelatin ranging from 112.874 to 127.794 Bloom. This value was still in accordance with the standards required by the gel strength GMIA (2006) which was ranging from 50-300 Bloom.

Results of ANOVA showed that the age treatment and the interaction between age and temperature of extraction had no significant effect ($P > 0.05$) on the strength of skin gelatin gel from broiler feet. This is likely related to the molecular weight distribution of gelatin which is almost the same. Gilsenan and Ross-Murphy (2000), stated that the molecular weight distribution associated with the large number of α chains. Furthermore, Sims et al (1997) stated that the conditions forming a stable gel was the ability of free chains to form a lot of cross linking

CONCLUSIONS

Based on the results and discussion, we can conclude as follows: 1). Chicken feet skin gelatin can be used as a substituted for commercial gelatin in food industry application. 2). Treatment of broiler chicken age does not influence the characteristics of gelatin, especially the characteristics of yield, moisture content, pH value, protein content, viscosity, and gel strength, but shows the effect on the

characteristics of ash and fat content. 3). Treatment of extraction temperature has effect on the characteristic extraction yield, ash content, fat content, and viscosity, but did not influence the characteristics of the water content, pH value, protein content and gel strength of skin gelatin foot broiler.

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