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PHYSICOCHEMICAL ANALYSIS OF GELATIN EXTRACTED FROM MECHANICALLY DEBONED CHICKEN MEAT (MDCM) RESIDUE

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Abstract: *Purpose:* Mechanically Deboned Chicken Meat Residue (MDCMR) is a waste product from chicken processing. Gelatin is water soluble protein mostly present in animals.
Methodology: Gelatin extracted from Mechanically Deboned Chicken Meat Residue by combination alkaline-acid extraction process. Highest yield of gelatin extracted (%w/w) at temperature 80°C (16.03%) compare with gelatin extracted at 60°C (5.96%) and 70°C (14.19%).
Findings: Proximate analysis of MDCMR showed the protein, moisture, lipid and ash content were 17.77±0.10%, 62.26±0.74%, 9.06±1.99% and 10.10±0.17% respectively. Protein content for the gelatin extracted at temperature 60°C, 70°C and 80°C were 26.61±0.82%, 28.04±1.07% and 33.00±0.35% respectively. Moisture, lipid and ash content for three type of gelatin extracted at temperature 60°C, 70°C and 80°C had significant different ($p<0.05$). Water activity of gelatins extracted does not have significant difference ($P>0.05$). Color determination and gel strength of gelatin were show the significant different ($p<0.05$).
Value: Thus, gel strength of gelatin extracted inversely proportional to the extraction temperature.

Keyword: *Mechanically Deboned Chicken Meat (MDCM) Residue; Gelatin; Gel Strength; Proximate Analysis; Physicho-Chemical Analysis*

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INTRODUCTION

Mechanically deboned chicken meat (MDCM) was produced by forcing chicken and some edible chicken meat under a high pressure through a device such as sieve. This process would produce mechanically deboned chicken meat and carcass (Carolina et. al. 2004). These mechanically deboned chicken meats were widely used in many industries especially in food industry, pharmaceutical and cosmetics while the carcass is not utilizing at all until present. Mechanically deboned chicken meat was widely used in food industry since 1960 (K.S Hwang 2005).

This study is mainly to extract gelatin from mechanically deboned chicken meat (MDCM) residue and to analyze the physiochemical properties. In general, there are a few types of agriculture such as chicken poultry, cow poultry, pig poultry and so on. Meanwhile, the chicken based poultry can be considered as one of the best income produced poultry since it can provide eggs and meat compare to the other poultries that normally supply meat alone at a time. Chicken poultry gets good support from the public in Malaysia. Thus, high rate of chicken production is needed to fulfill the increasing demand for chicken in market. Chicken meat can be commercialized in the form of fresh meat and also in the form of mechanically deboned chicken meat. Although Brazil is the third ranking chicken meat-producing country in the world with a total production of 6.5 million tons in 2001 (APA, 2002), but Brazilian legislation allows a maximum of 20% of total fresh meat to be substituted by MDCM in processed meats, such as meat emulsion, paste meat and chicken nuggets (Brasil, 1981).

This study is to extract gelatin from MDCM residue and analyze the physicochemical properties of the extracted gelatin. Gelatin is one of the popular skin care product. The

increased awareness among the people around the world towards health and beauty had given an opportunity to explore a new raw material to extract gelatin. Global demand for gelatin is kept on increasing. Currently, most of the commercial gelatin was extracted from the mammalian source such as skin and bones of cow, yak's bone and fish scale. Bae, (2008) uses fish skin such as *Siganus fuscescens*, *Kyphosus bigibbus*, *Myliobatis tobijei*, *Dasyatis akajei* and *Dasyatis laevigata* to extract gelatin.

The raw material from fish is failed to pull the people's attraction due to the allergic factor. Fish and shellfish are among the 8 types of food that account for more than 90% of allergic reactions (Nieuwenhuizen, 2006). Chicken meat is the most popular and cheapest source of meat because there are no dietary prohibitions or religious restrictions against chicken consumption (Ministry of Agriculture and Agro-based Industry). The usage of Gelatin extracted from cow arising many anxieties due to *Bovine Spongiform Encephalopathy* (BSE) and halal issues (Rahman et al. 2007).

Partial hydrolysis of collagen will produce gelatin while collagen is a protein mainly found in connective tissues of mammalians such as in cornea, tendon, ligament and skin (Semal,1992). Gelatin is a main derivative of collagen (Gilsenan et al. 2000). Besides that, gelatins derived from acid-treated and alkali-treated precursors are known as type A and type B, respectively (Eysturskard et. al., 2009). Tropocollagen is the basic structural unit of collagen (Gelse, 2003) which has three polypeptide chains (Zubaidah, 1995). These three chains coiled to form superhelical structure (Zubaidah, 1995). However, the industrial extraction process of collagen involves its denaturation to produce gelatin with low molecular weight and high water absorption capacity (Franco, 2007). In this study, extraction of gelatin will be performed following Alfaro et. al.(2010)'s method with proper modifications.

Physiochemical properties such as gel strength determination, colour determination and percentage of extracted gelatin will be calculated. Proximate analysis will be carried out to determine protein content, moisture content, fat content and ash content.

Gelatin has approximately 19 amino acid and contain high amount of certain amino acid such as proline, hydroxiproline and glycine (Arnesen.J.A. et.al., 2007). The content and the sequence of amino acid of gelatin depend on the raw material which is used to extract it. The content of hidroxiproline can be used to measure the percentage of the extracted gelatin (Nalinanon et.al., 2008).

MATERIALS AND METHODS

Materials

Carcasses of chicken or MDCM residue were obtained from Dindings Poultry Processing Sdn Bhd,Perak. The carcasses were grinded using meat grinder and were stored at 18 ^{0}C until used.

Methods

Extraction of Gelatin from MDCM residue

The frozen MDCM residue were defrozed at 4°C a day before extraction. The MDCM residue were washed with running water at room temperature to remove impurities. The MDCM residue were defatted in water at 35 ^{0}C under constant shaking, and afterwards washed with running water at room temperature (approximately 25 ^{0}C). After that, the MDCM residue were demineralized in a solution of 3% HCl for 24 h at 10 ^{0}C, and washed with running water at room temperature to remove the acid in excess, until the pH reaches above 4.

Alkaline pre-treatment was carried out in 4 g/100 g NaOH solutions (1:5 w/v) for a period of 72 h at room temperature. The MDCM residue was then washed with running water to remove alkali in excess. The extractions were carried out in distilled water at pH 4 that was maintained under constant shaking for 120 min at room temperatures. The pH was adjusted by adding of H3PO4, maintaining a proportion (2.5 : 1) for the solution and MDCM residue, respectively. After the extraction, the material was centrifuged (20,000g, 30 min), and the supernatant obtained was filtered in a Buchner funnel with filter paper Whatman NO. 4. Afterwards, the filtrate was concentrated using rotary evaporator and freeze dried in freeze dryer. Finally, the freeze dried gelatin pieces were packed and stored at 4°C of 60 ^{0}C, 70 ^{0}C and 80 ^{0}C, respectively.

Proximate Analysis

Ash, moisture, lipid and protein content were determined according to AOAC, 1990 method respectively AOAC 923.03 , AOAC 984.25, AOAC 960.39 and AOAC 991.20.

Determination of gelatin yield

The yield of extracted gelatin were calculated using the formula below :

$$\text{Yield} = \frac{\text{Dry weight of gelatin } (\text{g})}{\text{Wet weight of MDCM residue } (\text{g})} \text{X } 100$$

Determination of Gel Strength

6.67 % of gelatin solution was prepared at 60 ^{0}C following the *British Standard (BS 757:1975)* method and kept under constant mechanical shaking for 30 min, and immediately

transferred into standard Bloom jars of 150mL (Schott, Mainz, Germany). The characteristic dimensions of the flat-bottom jar were 85mm of total height and 65mm of shoulder height at diameters of 66mm outside, 59mm inside, and 41mm inside at the neck. The samples were refrigerated at 7 ^{0}C for 18 h. After cool maturation, thegel strength, expressed in Bloom value, was determined with a *Texture Analyzer* (TA.XT2, Stable Microsystems LTD, UK) The plunger was forced to penetrate 4mm into the sample at 8-10 ^{0}C to determine the maximum force (in g).

Determination of colour

Color was evaluated with a colorimeter(CR 300, Minolta Co., Japan) by using 6.67% (w/v) gelatin gels. Gels were prepared by dissolving dry gelatin in distilled water at 60 ^{0}C, which was kept under constant mechanical shaking for 30 min, and followed by 18 h of maturation at 7 ^{0}C.

Experimental Design and Statistical Analyses

An experimental design of CRD *(Complete Randomized Design)* was used. The analyses were done in duplicates and all the data were analysed using *one-way ANOVA. Duncan Multiple Range* test was used to determine the significance interval at confidence level of 95% (p=0.05).

RESULTS AND DISCUSSION

Proximate composition of raw material

In this study, the average moisture, lipid, protein and ash content of raw material (shown in table 4.1) were analysed using AOAC 1990. The ash content of MDCM residue is very high compare to MDCM and FCBM due to the composition

Table 4.1: Proximate Analysis of MDCM Residue Compare to MDCM and FCBM

	Proximate Content (% w/w ± Standard Deviation)				
	Moisture	Lipid	Protein	Ash	Reference
MDCM Residue	62.26±0.74	9.06±1.99	17.77±0.10	10.10±0.17	
MDCM	61.66±0.59	24.37±0.47	11.0±0.90	0.70±0.07	Negrao et al. (2005)
FCBM	72.34±0.37	2.04±0.29	24.0±0.27	1.12±0.02	Negrao et al. (2005)

MDCM = Mechanically Deboned Chicken Meat ; FCBM = Fresh Chicken Breast Meat

of bones such as marrow, cartilage, sodium ions and calcium phosphate (Field, 1999). The moisture content of MDCM residue is higher than MDCM also due to bone marrow which is high in moisture (Field, 1999).

Determination of yield

The yield of gelatin at different extraction temperature was clearly shown in table 4.2. The yield of gelatin from MDCM residue is approximately 12 % with combination of acid and alkaline extraction. The final product is almost similar with the studies (Characterization of Alkali-extracted Protein Prepared from Deboned Turkey Residue) done by Fonkwe and Singh (1996). This study indicates that yield of gelatin is directly proportional to extraction temperature as it was reported by Alfaro et al. (2010). The main component of organic fraction of bones is collagen (FAO 1962). Approximately 30% of bone is organic fraction, over 90% of that organic fraction is collagen (Field, 1999). Thus, bones can be treated as an alternative to skin in extracting gelatin.

	Extraction Temperature (^{0}C)		
	60°C	70°C	80°C
A=Dry weight of gelatin after freeze dryer (g)	59.62	70.95	80.15
B=Dry weight of gelatin/wet weight of MDCM residue (%w/w)	5.96	14.19	16.03
Average of B (%)		12.08	
C= Dry weight of gelatin/wet weight of Extracted protein (%w/w)	5.96	5.46	7.63
Average of C (%)		6.35	
D= Yield of gelatin at different temperature per total dry weight of gelatin (%)	28.29	33.67	38.04

Table 4.2: Summary of Extracted Gelatin from MDCM Residue

Proximate composition of gelatin

Moisture content

The moisture content of extracted gelatin at 60°C, 70°C and 80°C were 10.84%, 6.56% and 12.70% respectively. The all three types of gelatin show significant difference $p<0.001$. Gelatin is the final products of freeze drying method at -45°C, 0.1atm for 24 h. Therefore, gelatin is a final product which is easily absorbs moisture from surrounding. The extracted gelatin at 70°C shows high moisture compare to gelatin extracted at 60°C and 80°C. The moisture content of gelatin extracted at 60°C (10.84±0.87%) is almost similar to the commercial gelatin, Halagel (10.1%).

Lipid content

The extraction temperature affects the lipid content of

extracted gelatin ($p<0.05$). Gelatin extracted at 80°C is the highest, 0.22±0.18% followed by gelatin extracted at 70°C (0.18±0.09%) and gelatin 60°C (0.01±0.02). The bone marrow contains lipid (Field 2000). The high temperature will lead to the extrusion of lipid from bone marrow.

Protein content

The protein content in extracted gelatin at 60°C, 70°C and 80°C show significant difference ($p<0.001$). The protein content of gelatin 60°C, 70°C and 80°C respectively 27.61±0.82%, 28.04±1.07% and 33.00±0.35%. Duncan analysis indicates that the extracted gelatin at 60°C and 70°C are insignificant while extracted gelatin at 80°C is significant. In this study the time period for extraction was made constant while the temperature used for extraction were manipulated. Thus, the protein level increases when the temperature increases. According to Fonkwe & Singh (1997), the increasing temperature and duration during extraction will cause the protein content to increase. The high temperature will cause the decomposition of collagen and subsequently lead to production of collagen protein (Fonkwe & Singh 1997).

Ash Content

Ash content of 60°C, 70°C and 80°C gelatin are 48.29±2.50 %, 52.48±0.45 % and 39.82±3.75 % respectively. These three types of gelatin show significant difference at $p<0.001$. The high content of ash is due to the raw material which contains bones. According to Muyonga et al. (2004), ash content of bone extracted gelatin is higher about 3-10% compare to gelatin that extracted from other raw materials such as fish skin and meat. The high content of ash is due to improper washing method during extraction. Ion exchange method should be used to remove excessive minerals (Muyonga et al. 2004).

	Proximate Composition (% w/w ± Standard Deviation)			
	Moisture	Lipid	Protein	Ash
Gelatin 60°C	10.84^{b}±0.87	0.01^{b}±0.02	27.61^{c}±0.82	48.29^{b}±2.50
Gelatin 70°C	6.56^{b}±0.43	0.18^{a}±0.09	28.04^{b}±1.07	52.48^{a}±0.45
Gelatin 80°C	12.70^{a}±0.94	0.22^{a}±0.18	33.00^{a}±0.35	39.82^{c}±3.75

$^{a-c}$ Different letters in the same column indicate an insignificant difference ($P < 0.05$).

Table 4.3: Proximate Analysis of Gelatin Extracted from MDCM Residue

The high ash content is due to high amount of minerals and calcium in bones. According to Alfaro et al. (2010), the ash content of gelatin extracted from fish bones of King Weak contains high ash that is 3.8g/100g. The inorganic components of bone consist of 32.6% calcium, 15.2% phosphorus and other trace amount minerals (FAO 1962).

Physiochemical Analysis of Gelatin

Gel strength Gelatin Extracted from MDCM Residue

According to Diagram 4.1, gelatin 60°C, 70°C and 80°C indicates significant difference($p<0.05$). The gel strength of gelatin is due to molecular weight of gelatin (Segtnan et al. 2003). Bone collagen needs extreme extraction conditions such as temperature, time period of extraction and so on to produce gelatin with short molecular chains. Thus, low molecular weight of gelatin exhibits low gel strength (Muyonga et al. 2000). The gel strength decreases with increasing extraction temperature. Imino acid (β and γ fractions) needs higher temperature to fully degrade and this functional property of above stated fractions could produce highly stable gelatin gel (Liu et al 2009).

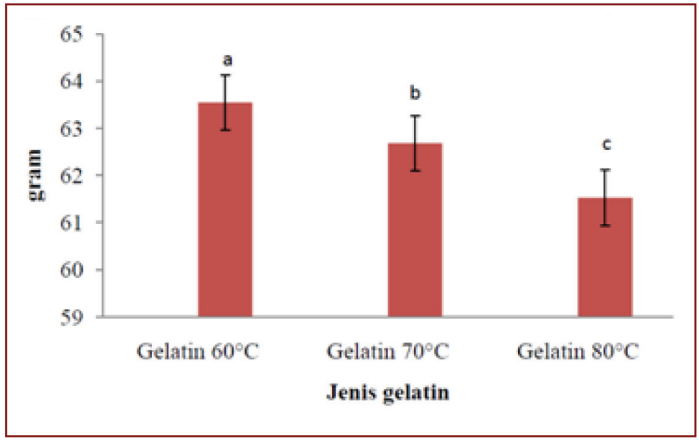

Diagram 4.1:
Gel Strength of Extracted Gelatin from MDCM Residue

Colour Gelatin Extracted from MDCM Residue

Colour of gelatin powder analysed. All the three types of gelatin show significant difference of L*, a* and b* value ($p<0.001$). The three parameters in the model represent the lightness of the color (L*,L*=0 yields black and L*=100 indicates white), its position between magenta and green (a*, negative values indicate green while positive values indicate magenta) and its position between yellow and blue (b*, negative values indicate blue and positive values indicate yellow). The intensity of white colour of gelatin powder decreases with increasing extraction temperature while intensity of yellow colour of gelatin powder increases with increasing extraction temperature.

	L*	a*	b*
Gelatin 60°C	$81.48^{a}\pm1.08$	$-5.18^{a}\pm0.15$	$8.27^{a}\pm0.84$
Gelatin 70°C	$71.45^{b}\pm0.65$	$0.13^{b}\pm0.34$	$9.21^{b}\pm0.43$
Gelatin 80°C	$63.83^{c}\pm0.83$	$1.32^{c}\pm0.18$	$12.75^{c}\pm0.66$

$^{a-c}$ Different letters in the same column indicate an insignificant difference ($P < 0.05$).

Table 4.5:
Colour Analysis of Gelatin Extracted from MDCM Residue

Water activity Gelatin Extracted from MDCM Residue

Water activity of gelatin 60°C, 70°C and 80°C was summarized in table below. One way ANOVA statistical analysis and Duncan shows that there is no significant difference in water activity of gelatin 60°C, 70°C and 80°C ($p>0.05$).

CONCLUSION

The protein content of extracted gelatin 60°C, 70°C and 80°C shows a distinct difference ($p<0.05$). Extracted gelatin at 80°C (33.00%) contains the highest protein content and followed by gelatin gelatin 70°C (28.04%) and 60°C (26.61%). The other proximate values such as moisture, lipid and ash content of extracted gelatin at 60°C, 70°C and 80°C shows distinct difference too($p<0.05$). Colour analysis of gelatin powder and gelatin gels shows significant difference ($p>0.05$). the different extraction temperature gives significant effect in final product($P<0.05$). The final product at 60°C, 70°C and 80°C respectively 28.29%, 33.67% and 38.04%. The percentage of yield is directly proportional to the extraction temperature. The extraction temperature of 80°C resulted in huge amount of yield production compare to other extraction temperature. The increasing extraction temperature resulted in distinct decrease ($p<0.05$) in gel strength of extracted gelatin. The gel strength of gelatin at 60°C, 70°C and 80°C respectively 63.55g. 62.68g and 61.53g.

	Water Activity (% w/w ± Standard Deviation)
Gelatin 60°C	$0.26^{a}\pm0.05$
Gelatin 70°C	$0.32^{a}\pm0.02$
Gelatin 80°C	$0.25^{a}\pm0.07$

[a] Same letters in the same column indicate an insignificant difference ($P < 0.05$).

Table 4.6: Water Activity of Gelatin Extracted from MDCM Residue

POTENTIAL USE OF THE RESEARCH OUTCOME

This research can be used as an initial step in utilizing the mechanically deboned chicken meat (MDCM) residue. Currently, the MDCM residue is only being used as an animal feed in zoos. Thus, this research actually is exploring a new mode of research where the end product could be commercialized in future. By this research, there will be chances of creating some new gelatin based industries around the world as chicken meat is a common food of all types of people around the world.

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BIOGRAPHY

Prof. Dr. Abdul Salam Babji is currently working as a professor in Universiti Kebangsaan Malaysia, Bangi who is an expertise is in Meat Science and Meat Technology. One of the Major area of R&D is meat and poultry meat product development with emphasis on healthful meat products looking into replacing synthetic food additives in meat products with phytochemicals-extracts of herbs and spices are tested for effectiveness as antioxidants and antimicrobial and extension of quality and shelf life of the products.

Ms Komate is currently pursuing studies (Msc) in food science in Universiti Kebangsaan Malaysia, Bangi. One of the related field is food biochemistry which involves works based on meat proteins.

Ms Voon Qi Yin is a graduate (Bsc.) of Universiti Kebangsaan Malaysia, Bangi. Her field of expertise is in meat products.

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