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Characteristics of halal gelatin from red snapper (*Lutjanus malabaricus*) bone and its potency as beta-carotene coating material

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ABSTRACT

Gelatin is a material produced from the partial hydrolysis of collagen sourced from the skin and bones of farm animals such as cows and pigs. Gelatin has been used for coatings because it has high permeability and dissolves in warm conditions, so the matrix cross-links are strong. The red snapper fillet processing industry produces 11.2-15% of waste, such as bone which has not been utilized optimally. The objective of this study was to determine the characterization of red snapper bone gelatin as a source of halal gelatin and measure its ability as a coating material for β-carotene pigment microencapsulation. Results showed the characteristics of red snapper bone gelatin with a yield of 10.71%, water content of 9.63%, protein content of 34.06%, ash content of 7.62%, gelatin fat content of 0.28%, and color intensity (L: 62.6). ; a+: 13.3 and b+: 30). The obtained halal gelatin was applied as a coating material for β-carotene pigment microencapsulation through the foam-mat method. It resulted in encapsulation with a yield of 16.75%, water content 9.25%, total carotenoid content 145.49 mg/g, surface carotenoid content 2.04%, solubility 78%, encapsulation efficiency 98.22%, color intensity (L: 50; a+: 29.9 and b+: 14.6), the particle size of 1004.04 µm and irregular shape.

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INTRODUCTION

Based on data, the Muslim population in Indonesia continues to increase to 87% of the total population of 229.62 million people Pew Research Center Religion and Public Life, (2015), which is in line with the need for halal products are pretty significant (Fatmawati, 2011). Therefore, various developments in all sectors have implemented halal aspects as applied to the food industry in gelatin. Gelatin is a substance produced from the partial hydrolysis of collagen sourced from the skin and bones of livestock such as cattle and pigs (Duconseille et al., 2015). Currently, Indonesia is still importing gelatin from several countries, such as Australia, and America, several countries in Asia, such as China and Japan, and several countries in Europe, such as Germany and France (Gumilar and Pratama, 2018).

Based on Statistics Indonesia data, in 2019, Indonesia imported 4,808 tons of gelatin, which continues to increase yearly. In line with the increasing demand for gelatin, processing gelatin made from fish bones can be a solution (Rodiah et al., 2018). However, the fish processing industry, especially red snapper fillets, contributes up to 50% of solid waste. According to Ifa (2018), only about 40-50% of the parts are processed into snapper fillets. As a result, the rest of the snapper parts, such as bones, scales, gills, skin, offal, and head, become waste that has not been utilized optimally. Consequently, the proportion of fish that cannot be eaten reaches 35%, skin 4%, and bones 11.2-15% (Saputra et al., 2015).

Many studies on the extraction of fish bone gelatine have been carried out, such as snakehead fish (Wulandari et al., 2013); katombo fish (Nurhaeni et al., 2018); Angola fish (Putri, 2013) and barramundi (Dian et al., 2012). Although gelatin extraction from tuna fish bones has been carried out in previous studies, the best gelatin results were obtained with a 3% HCL concentration (Panjaitan, 2016). According to Wahyuningsih (2019), The optimum condition of the extraction procedure was accepted by pre-treatment using 5% CH_3COOH with an extraction temperature of 60 °C which produces 58.19% swelling of fish scales and gelatin yield is 8.76% with a moisture quality of 6.68%, pH of 6.225, viscosity of 15.54 cP, and a melting point of 60 °C. The Extraction of red snapper bone gelatin has been studied previously. According to Jeya et al. (2012), the average yield of fish gelatin extracted from the bones of red snapper (*Lutjanus malabaricus*) is 9.14/100 g. The protein contents of the bone gelatin ranged from 78.5 to 82.36 g/100 g. The novelty of this research is that it is applied as a coating material for beta-carotene pigment microencapsulation through the foam-mat method. Safitri (2014) stated that gelatin from mackerel fish bones could be used as an essential oil coating with microencapsulation efficiency and total oil content of 43.06% and 2.71%, respectively. So this research is needed to determine the characterization of red snapper bone gelatin as a source of halal gelatin and measure its ability as a coating material for β-carotene pigment microencapsulation.

RESEARCH METHODS

Material

The primary material needed is red snapper bone obtained from PT. Inti Luhur Fuja Abadi (Pasuruan), Chantenay type Carrot with a length of 10-15 cm, orange in color. Other ingredients are distilled water, 4% HCL, n-Hexane pa, Petroleum Benzene pa, Maltodextrin (MD), carboxymethylcellulose (CMC), egg white, and Na2SO4 obtained from the Food Analysis Laboratory, University of Muhammadiyah Malang.

Equipment

The equipment needed in this research is Blender (Nagoya), Water Bath (Memmert), Analytical Balance (OHAUS PA224), Rotary Evaporator (IKA RV 10), Spectrophotometer UV-VIS (BEL Photonic), Color Reader (Konica Minolta CR-10), Centrifuge, Tube Centrifuge, Vortex, Cabinet Dryer, Desiccator, Buchner Funnel, Vacuum Pump, Sieve 80 mesh, Whatman Filter Paper.

Research Design

This study used a quantitative descriptive analysis method presented within a table. The purpose of measuring the data is to describe the characteristics of red snapper bone gelatin as a source of halal gelatin and its potential as a coating. The research method was carried out in two stages, extraction of gelatin from red snapper bones and extraction of beta-carotene pigment from carrots, followed by microencapsulation of β-carotene pigment. Five grams of red snapper bone gelatin and 15 grams of maltodextrin (1:3) mixed and would be applied to the β-carotene

pigment extract with three replications for each test.

Red Snapper Bone Gelatin Extraction

Fresh snapper bones are boiled in the water at 80°C for 30 minutes while stirred to remove fat from the bones. After boiling, it was washed using running water and reduced the size of the bones by 2 cm. They were dried in the sun for 6 hours. Furthermore, red snapper bones were demineralized by soaking in a 4% HCl solution for 48 hours, then washed with running water until the pH was neutral. The bone ossein (the bone that has been softened by soaking) was extracted using a water bath at a temperature of 80°C for 6 hours and then filtered using a vacuum pump. The gelatin solution obtained from the extract was concentrated at 80°C with an evaporator until all the solvents evaporated. The gelatin extract was poured into a baking sheet and dried in an oven for 48 hours (50-55°C). Subsequently, it was crushed using a blender to obtain gelatin powder (Istiqlaal Modification, 2018). Further testing was carried out for moisture content analysis (AOAC, 2015), ash content (AOAC, 2005), raw fat content by using the Soxhlet method (AOAC, 2005), raw protein by content using the Kjeldahl method (AOAC, 2005).

Carotene Extraction (Yogaswara Modification, 2017)

Carrots that had been sorted were then soaked in water and washed. Carrots were peeled and thinly sliced them. It was then dried using a cabinet dryer for 24 hours at a temperature of 50°C. After that, the dried carrots were rounded using a blender, sieved with a 40 mesh sieve to obtain the carrot powder. Then carrot powder was soaked using n-hexane (1:5). After that, the marinade of carrot powder was filtered using Whatman No.1 filter paper and a Buchner funnel to produce macerate and residue. Then the macerate was concentrated using a 50°C rotary evaporator with a pressure of 100 bar, and liquid carrot extract was obtained, which would be used in the microencapsulation process.

Carotene Microencapsulation (Modification of Pinto et al., 2018)

Carrot extract and foaming agent using egg white (1:5) were prepared. The egg whites were beaten until foamy, and then added beta carotene pigment extract was evaporated and homogenized for 3 minutes. Furthermore, gelatin (5 grams) and maltodextrin (15 grams) were dissolved in 100 ml of distilled water, then homogenized for 5 minutes, and poured on a stainless steel baking sheet with a thickness of about 2 mm. After that, it scraped from the pan and mashed using a mixer. Then, The results of microencapsulation of beta carotene pigment with red snapper bone gelatin coating will be compared with the results of microencapsulation of beta carotene pigment with a commercial gelatin coating

Analysis of Carotene Microencapsulation Water content analysis (AOAC, 2005)

The microencapsulated encapsulated powder weighed 2 g in a porcelain dish that had been dried, and the initial weight was known. The cup was then dried in an oven for 4 hours at a temperature of 100°C. The porcelain dish was cooled in a desiccator for 15 minutes, then weighed. If the weight obtained is not constant, then every 15 minutes, the drying will be carried out again as in the previous step. Then cooled and weighed to obtain a constant weight. The moisture content test using the oven method was then determined by comparing the mass of powder obtained after microencapsulation with the mass of solids before microencapsulation.

Yield (Hasrini et al., 2017)

Yield is the ratio between the number of ingredients after being microencapsulated with the ones before being multiplied by 100%.

$$\text{Yield (\%)} = \frac{Microcapsule\ weight\ (g)}{Total\ weight\ of\ material\ (g)} \text{ x } 100\%$$

Total Carotenoid Analysis (Haas et al., 2019)

Samples were prepared as much as 0.1 grams, dissolved with n-hexane pro-analyze in a 25 ml measuring flask to the limit of tera, then shaken until homogeneous, then measured using a spectrophotometer with a wavelength of 470 nm.

$$\text{Total Carotenoid (mg/g)} = \frac{A\ x\ V(mL)\ x\ 10^3}{A_{1cm}^{1\%}\ x\ P\ (g)}$$

A= Absorbance; V= Total volume extract (mL); P= Sample weight (g); $A_{1cm}^{1\%} = 2560$ (Extinction coefficient of carotene in n-hexane).

Surface Carotenoid Analysis (Haas et al., 2019)

The encapsulated powder was weighed as much as 50 mg and put into a 125 mL Erlenmeyer. Furthermore, 2.5 mL of distilled water was added and extracted with 5 mL of petroleum benzene.

After that, it was stirred for 15 seconds at 100 rpm and then centrifuged for 1 minute at 1000 rpm. The absorbance of the sample was measured using a spectrophotometer at a wavelength of 450 nm.

$$\text{Surface Carotenoid (mg/g)} = \frac{A \; x \; 10^2}{A^{1\%}_{1 \; cm} \; x \; P \; (g)}$$

A = Absorbance; P = Sample weight (g); $A^{1\%}_{1cm}$= 2303 (Extinction coefficient carotene in petroleum benzene).

Solubility (AOAC, 1984)

The sample was prepared as much as 1 gram (a), then dissolved in 20 ml of distilled water and filtered using Whatman filter paper no 1. Before use, the filter paper was dried in an oven at 105oC for 30 minutes and weighed (b). After filtering, the filter paper was dried in an oven at 105oC for 3 hours. Then, the filter paper is placed in a desiccator and weighed until a constant weight is reached (c).

$$\text{S}=100\% \left(\frac{(c-b)}{([\frac{100-MC}{100}])}\right) \text{ x } 100\%$$

S= Solubility (%); MC= Moisture Content (%).

Encapsulation Efficiency Testing (Wulandari et al., 2019)

Encapsulation efficiency in measuring the level of efficiency in the encapsulation process. The value of encapsulation efficiency can be determined using the following formula:

$$\text{EE}\%=\frac{(TC-SC)}{TC} \text{x } 100\%$$

TC = Total Carotenoid (mg/g); SC = Surface Carotenoid (mg/g)

Rehydration Ratio (Kumalasari et al., 2015)

The 10 grams sample was prepared, and 15 ml of distilled water was poured into an Erlenmeyer, then placed in a water bath (80°C, 10 minutes). Then cooled at room temperature and filtered using a vacuum pump. The rehydrated filtrate was then weighed. The rehydration ratio is determined using the following formula:

$$\text{Rehydration Ratio} = \frac{Weight \; after \; rehydration \; (g)}{Weight \; before \; rehydration \; (g)}$$

Bulk Density (Kumalasari, 2015)

A bulk density test was carried out using a 10 ml measuring cup and weighed before adding the sample. Then the microencapsulated powder was added to the tera limit and weighed. The weight of the 10 ml microencapsulation was determined from the difference between the weight of the 10 ml measuring cup filled with the microencapsulated to the tera limit and the weight of the empty 10 ml measuring cup. The bulk density was determined from the ratio between the weight microencapsulated and the volume of the measuring cup (10 ml). Bulk density (g/ml) was determined using the following formula:

$$\text{Bulk Density} = \frac{Microcapsule \; Weight(g)}{Measuring \; cup \; volume \; (ml)}$$

Color Intensity (Souripet, 2015)

The microencapsulated powder sample was flattened in clear plastic and flattened. Then put it on the color reader lens and press the button on the side of the color reader. The method used in the measurement is the absolute color system measurement L*, a*, b*.

Morphological Observations (Mardikasari et al., 2020)

Observations were made using an optical microscope. An optic Microscope was used to analyze the size of the microcapsules.

RESULTS AND DISCUSSION

Physicochemical Characteristics of Red Snapper Bone Gelatine

Visually, red snapper bone gelatin powder color tends to be darker than commercial gelatin derived from beef and pork bones because red snapper bone gelatin shows a dense structure and a browner color. In contrast, commercial gelatin has a less dense structure and a bright white color (Figure 1). Masirah (2018) stated that chemical and biochemical reactions and drying methods influence gelatine color. Standard fish gelatin powder tends to have a more transparent color than the extraction results, which are cloudy (Nasution and Harahap, 2018). Turbidity and darker color in gelatin powder is caused by contamination of inorganic compounds, proteinases, and mucosa that are not lost from inorganic compounds (Djagny et al., 2001 in Nasution and Harahap, 2018). According to the Gelatin Manufacturers Institute of America (2012), color does not affect the properties of gelatin or reduce its usefulness. The results of the chemical analysis of gelatin were compared with the Indonesian National Standard (SNI) 06-3735-

1995 and another standard, namely the Gelatin Manufacturers Institute of America (GMIA).

Figure 1 Red snapper bone gelatin (left) and commercial gelatin (right)

Gelatin Colour Intensity

The results of measuring the color intensity of red snapper bone gelatin and commercial gelatin using a color reader are shown in (Table 1).

Table 1 Colour Intensity Results

Parameters	Red Snapper Bone Gelatin	Commercial
L*	62.6	80
a*	13.3	4.9
b*	30	21.3

The value of L* indicates that commercial gelatin is greater than the brightness level of red snapper bone gelatin. Masirah (2018) states that fishbone gelatin has an L* value of 59.60, while commercial gelatin is 72.15. However, the study results tend to be lower than the research (Hapsari et al., 2018). For example, tuna bone gelatin with a 15% citric acid immersion concentration has an L* value of 73.45. Generally, gelatin has a whitish color with a degree of whiteness close to 100%. High-quality gelatin is usually colorless to expand its application in products. Using acid in immersion can cause interactions with protein molecules in the material, affecting the brightness level. The high acid concentration during demineralization can cause the gelatin color to darken (Hapsari et al., 2018). The dark color of gelatin is also caused by inorganic compounds, proteinases, and mucosa that are not lost from inorganic compounds (Djagny et al., 2001 in Nasution and Harahap, 2018). The a* value of red snapper bone gelatin was 13.3 higher than commercial gelatin. Red snapper bone gelatin has a higher level of redness when compared to tilapia bone gelatin, which is -2.22. The b* value of red snapper bone gelatin is 30, indicating the yellowness level. The b* value in this study tends to be higher than the research (Hapsari et al., 2018); tilapia bone gelatin has a b* value of 8.30. The measurement of the intensity of the red and yellow colors on snapper bone gelatin was higher than commercial gelatin and tilapia bone gelatin. Prihardhani and Yunianta (2016) argued that the materials used, the extraction stages, acid concentrations, and the drying technique affect the color produced. Commercial gelatin has a better color because it undergoes a chemical clarification process and filtration of impurities from the gelatin solution (Lin et al., 2015). However, the color of gelatin does not affect its properties of gelatin.

Yield

Red snapper bone gelatin yields 10.71% with 4% HCL immersion. Previous research by Saleh (2011) showed that red snapper bone gelatin with the acid method obtained yield values between 3.94% - 10.02%. The yield of red snapper bone gelatin is 9.14% (Jeya et al., 2012). The difference in yield value is due to the hydrolysis of H+ ions from the triple helix chain collagen into single collagen (Samosir et al., 2018). Hydrolyzed collagen causes degradation. Higher acid concentrations trigger degradation, and collagen will be hydrolyzed (Panjaitan, 2016). The presence of degradation causes collagen to become soluble and wasted during washing (Mulyani et al., 2013). The collagen hydrolysis process also causes the low yield to be not optimal (Aisyah et al., 2014).

In addition, the yield is influenced by the concentration of acid used during extraction. Research by Permata et al. (2016) carried out the extraction of catfish bone gelatin using HCL solvent and variations in the concentration of 2%, 4%, 6%, and 8%. The highest yield was obtained with a concentration of 4% with a soaking time of 5 hours obtained by 10,90%. The higher concentration of HCL can produce yields up to an optimum point and then decrease because collagen is converted to H+ concentration in an acid solution, making it easy to become gelatin. If the concentration of H+ ions is too much, it will cause the process of too much fishbone collagen destruction so that the gelatin is not converted into gelatin as a whole (Bhernama, 2020). The yield value of gelatin varies depending on the proximate composition, the number of dissolved components in the bone, the high collagen content, the species,

and the extraction method used (Nasution and Harahap, 2018).

The result of testing the water content of red snapper bone gelatin is 9.63%. The water content of this study is higher than the results of other studies by 6.26% (Jeya et al., 2012) and 8.06% (Hadi, 2005 in Yudhistira, 2019). The water content in red snapper bone gelatin followed the quality standard of SNI 06-3735-1995, which was a maximum of 16%, and SIGMA, which was 11.45%, so the water content in this study met the standard. The value of the water content is influenced by the immersion time; the longer the immersion, the more acid will diffuse into the fishbone tissue so that the collagen structure opens and produces weakly bound gelatin, and the binding capacity of water with gelatin is not strong. Weak water-holding capacity causes water to evaporate quickly on drying gelatin so that the moisture content of dry gelatin tends to be lower (Rares et al., 2017). The difference in the water content value is also suspected that a long drying time will cause the water content to decrease. The water content in gelatin does not affect the microencapsulation process.

The ash content test obtained from red snapper bone gelatin was 7.62%. This ash content value exceeds the ash content value according to the Gelatin Manufacturers Institute of America (GMIA), exceeding 2%, and SNI 06-3735-1995, which is a maximum of 3.25%. However, in the study of *(*Jeya et al. (2012), the gelatine ash content of snapper bones was 10.32% and 59.21%, according to Yudhistira et al. (2019). The high ash content is thought to be due to the use of too low a solvent concentration. The high concentration of acid solvent will cause high dissolved calcium in the solvent so that the amount of calcium in ossein decreases and the ash content decreases because the calcium extracted in it is reduced. The decrease in the ash content of gelatin is in line with the increasing concentration of the acid solvent used (Huda et al., 2013). The maximum limit recommended by SNI for edible gelatin is not explicitly given for skin or bone gelatin. Fishbone gelatin generally has higher ash and fat content due to higher mineral content (Jeya et al., 2012).

Testing the protein content of red snapper bone gelatin obtained 34.06% lower than with commercial gelatin at 85.99% and standard laboratory gelatin at 87.26% (Pertiwi et al., 2018). Meanwhile, SNI 06-3735-1995 does not state protein content as a parameter of gelatin quality. The low protein content is thought to be due to very high temperatures during extraction, causing the protein to be denatured. Islami et al. (2018) also reported that the increasing extraction temperature will cause the protein to undergo hydrolysis into simpler compounds other than protein. The low protein content is possible due to the low concentration of acid used as a solvent. The high acid concentration will increase the number of acid molecules and the molecular density. Acid molecules that interact and collide with calcium phosphate molecules in bones are getting more extensive and more effective in binding calcium minerals so that collagen is freed and converted into gelatine (Trilaksani et al., 2012).

The fat content of snapper bone gelatin was obtained at 0.28%, which is lower than the results of Yudhistira's research (2019) that the fat content of snapper bone gelatin is 4.12% and 6.2%, according to Jeya et al. (2012). However, it is not much different from commercial gelatine, 0.23%, and laboratory standard gelatine, 0.25% (Gunawan et al., 2017). The treatment causes a difference in the value of fat content during the gelatin-making process. Decreasing fat content in raw materials can be done by paying close attention to each process of making gelatine (Trilaksani et al., 2012). The fat content value obtained in this study followed the SNI standard, which did not exceed 5%; it was suspected that the fat came out maximally during the degreasing process. The fat content will be released when soaked with acid during the extraction process. Heating will break down fat and cause the fat to separate from the bones and float on the surface. The higher the extraction temperature used, the specific gravity of the fat will decrease and float on the surface (Pertiwi et al., 2018). The fat content will affect gelatine storage; high-fat content will allow quality changes during storage. Fat content is also a determinant of gelatin quality, although it is not the main parameter (Khirzin et al., 2019).

Application to Carotene Microencapsulated

Red snapper bone gelatine was applied as a coating agent in microencapsulated carrot-carotene pigment extract. Microencapsulation characteristics indicate the ability of red snapper bone gelatin as a coating material. The microencapsulation characteristics are presented in (Table 3).

Table *2* Comparison proximate composition of red snapper bone gelatin and commercials gelatin (%b/b)

Parameters	Red snapper bone gelatine (%)	Bovine gelatine (%)*	Porcine gelatine (%)*	SNI 06-3735-1995
Moisture Content	9.63±1.99	8.5 ± 0.20	8.4 ± 0.20	Max. 16
Ash	7.62±1.77	0.97 ± 0.072	1.02 ± 0.04	Max 3.25
Protein	34.06±3.89	91.2 ± 0.15	91.3 ± 0.14	-
Fat	0.28±0.04	0.41 ± 0.032	0.78 ± 0.05	<5

*Source: Ninan et al. (2012)

Table *3* Characteristics of microencapsulation of β-carotene pigments from carrot (%b/b)

Parameters	Values
Yield (%)	16.75±0.21
Moisture (%)	9.25±1.29
Total Carotenoid (mg/g)	145.49±43.26
Surface Carotenoid (mg/g)	2.04±0.9
Solubility (%)	78±4.00
Encapsulation Efficiency (%)	98.22±0.60
Rehydration Ratio (%)	198.97±63.87
Bulk Density(g/ml)	0.4539±0.22
Color Intensity	
L*	50.0± 6.4
a*	29.9± 1.9
b*	14.6 ± 0

The results of the yield calculation in the microencapsulation of 16.75% are different from the Sarungallo et al. (2016) study through the microencapsulation of red fruit oil with the best formulation obtained an average yield of 29-30%. Fridayana's research (2018) showed that microencapsulation with gelatine and maltodextrin coating materials on lettuce extract functional dyes had the highest yield of 11.22%. The yield value is influenced by the amount of maltodextrin used, which will be more able to interact with the encapsulated fraction.

The results of testing the moisture content of the β-carotene pigment microencapsulation obtained 9.25%. However, Sari's research (2013) stated that the water content test on the microencapsulated Gotu kola extract obtained the lowest water content of 5.70% due to the added gelatine triggering the total solids of the dried material so that the water content that undergoes evaporation is little. According to Gustavo (1999), water has a hydroxyl group, and gelatin forms hydrogen bonds that bind water molecules, so the more gelatin is added, the faster the evaporation of water causes the water content of the material to lower.

The application of a combination of red snapper bone gelatine and maltodextrin on the microencapsulated β-carotene pigment had a total carotenoid content of 145.49 mg/g. Antares research (2017) on microencapsulation of pandan dye extract has a total carotenoid content of 970 mg/100g. The total carotenoids in the microencapsulation of pandan fruit extract had a

total carotenoid of 19.17% with gelatine and maltodextrin coating materials (Aryayustama et al., 2018). Loss of carotene can be prevented by using maltodextrin and gelatin. Microencapsulation is influenced by the coating material used. Gusdinar et al. (2011) stated that Neurospora intermedia N-1 was used to extract carotenoids with gelatine and maltodextrin using spray drying; the results showed that the encapsulated powder was more stable than the non-encapsulated powder.

Examination of the surface carotenoids of the microencapsulated -carotene pigment was obtained at 2.04 mg/g. Yogaswara's research (2017) showed that the surface carotenoid yields ranged from 468-715 mg/g. The resulting surface carotene shows the amount of carotene outside the capsule and is not coated during the microencapsulation process. The lower amount of ncoated carotene indicates the optimal encapsulation process (Muchtadi et al., 2015).

The lower surface carotenoid values were caused by fishbone gelatin which can help the formation of emulsions during the microencapsulation process. Emulsion stability is an essential indicator in the microencapsulation process. Gelatin not only acts as an emulsion that can minimize particle size but can also unite oil components in water so that the fat content in the ingredients can be evenly protected

The solubility test of β-carotene pigment microencapsulation was obtained at 78%. Yogaswara's research (2017) showed that surface carotenoid yields ranged from 77-86%. Solubility testing is intended so the results can be applied as food additives. The solubility of the encapsulation is affected by the water content of the material. The high-water content in the material will make it difficult for the material to spread due to the absence of the formation of pores, so the material cannot absorb water optimally (Yogaswara, 2017).

The encapsulation efficiency value indicates the percentage of the core material that can protect by the coating material. The higher the value of encapsulation efficiency, the better the success rate of coating the core material by the coating material to minimize the degradation process of β-carotene pigment. Testing the efficiency of β-carotene pigment encapsulation was obtained at 98.22%. The results of the encapsulation efficiency obtained were higher than the study of Dłuzewska et al. (2020), which resulted in an encapsulation efficiency value of 50% with a combined coating of Gum Arabic and Maltodextrin and 67% with a whey protein coating. The high-efficiency value produced is due to the high stability of the emulsion coating material. The maltodextrin used is one of the polysaccharide groups that act in the matrix formation, while gelatin is a protein that acts as an emulsifier.

The rehydration ratio of microencapsulation-carotene pigment obtained 198.97%. Ng and Sulaiman (2018) resulted that the highest rehydration ratio in beetroot powder microcapsules is 6.96 to 8.15. The rehydration ratio is the ability to absorb water again after drying (Kumalasari et al., 2015). This difference in value is influenced by composition, particle surface, particle size, porosity, and powder structure. The higher the rehydration ratio, the higher its ability to rehydrate in water. However, the higher the rehydration ratio, the lower the bulk density because the rehydration process will increase the surface area.

The bulk density of microencapsulated-carotene pigment was 0.4539 g/ml. Previous research by Ng and Sulaiman (2018) resulted in the bulk density of beetroot powder with gelatin-coating material varying from 0.80 to 0.83 g/ml. The maltodextrin coating is 0.69 g/ml. The small particle size can cause the low bulk density to accommodate space, lower particle weight, and more air space. Shweta and Snoia, (2013), on microencapsulation of anthocyanins from Jamun fruit, state that the coating material affects the bulk density; the bulk density decreases when the concentration of gum arabic increases. Therefore, the powder produced with a maltodextrin coating material is less dense than the Arabic gum coating.

Measurement of color intensity obtained an L* value of 50.0, which indicates the brightness level of the -carotene pigment microencapsulation. This value is greater than the research by Ng Mei (2018), where the anthocyanin pigment encapsulation sample has an L* value ranging from 41.66 to 47.41. The high value of :* indicates the brighter the microencapsulation result due to the addition of maltodextrin, which tends to be whitish.

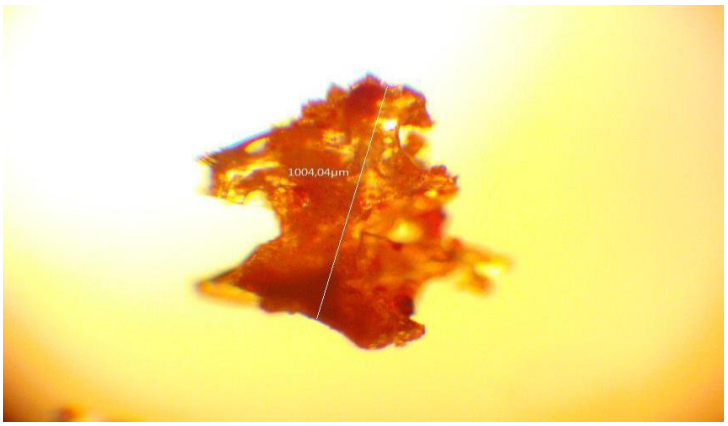

Figure 2 Optical microscope image of β-carotene microcapsule with a 50X magnification

The a* value or the level of redness in the microencapsulated-carotene pigment was obtained at 29.9. The results of this study are higher than Ng Mei's (2018) result, ranging from 6.66-12.65. The drying process influenced the increase in the redness value of the microencapsulation to produce a lighter red color. The low a* value allows the powder to change color to green due to decreased total carotene levels. The value of b*, or the level of yellowness in the microencapsulated -carotene pigment, was obtained in Fridayana's (2018) study explained sea lettuce extract encapsulation with a combination of gelatin and maltodextrin, which obtained an average yellowness level of 16.23. The added maltodextrin influences the low level of yellowness. The yellowness value decreased due to the addition of white maltodextrin (Purnomo et al., 2014).

Morphological Observations were made using an optical microscope with a magnification of 50 times, specified in (Figure 2).

Based on microscopic observations, the particle size observed was 1004.04 µm and irregular in shape. Therefore, the physical appearance of the microcapsules is produced following the size of the microcapsules in the range of 0.2-5,000 µm (Silva et al., 2014). Generally, the characteristic particle shape is spherical or spherical. However, the observed shape is irregular due to several factors, such as the preparation process, the formation of microcapsules, and drying, where the particles can merge with other particles so that they have a non-spherical particle shape after the drying process (Mardikasari et al. 2020). In addition, Shweta and Snoia (2013) revealed that the maltodextrin coating material produced non-spherical encapsulations due to its high hygroscopicity.

CONCLUSIONS

These results demonstrated that the red snapper bone gelatin produced has met the SNI standard with the characteristics of yield 10.71%, water content 9.63%, protein content 34.06%, ash content 7.62%, gelatin fat content 0.28%, and color intensity (L: 62.6; a+: 13.3 and b+: 30). In addition, snapper bone gelatin can coat -Carotene pigment and produces an encapsulate with a yield of 16.75%, water content 9.25%, total carotenoid content 145.49 mg/g, surface carotenoid content 2.04%, solubility 78%, encapsulation efficiency 98 .22%, color intensity (L: 50; a+: 29.9 and b+: 14.6) and particle size of 1004.04 µm and irregular in shape.

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REFERENCES

Aisyah, N., Huda, N., Azhar, M., and Fazilah, A. 2014. Poultry as an alternative source of gelatin. *Health and the Environment Journal*, *5*(1), 37–49.

Antares, A., Wartini, N. M., and Wrasiati, L. P. 2017. Karakteristik kapsul ekstrak pewarna buah pandan (pandanus tectorius) menggunakan penyalut maltodekstrin dan karaginan. *Jurnal Ilmiah Teknologi Pertanian*, *2*(2), 220–226.

Aryayustama, M. G., Wartini, N. M., and Suwariani, N. P. 2018. Stabilitas kadar karotenoid ekstrak buah pandan (pandanus

tectorius) pada suhu dan penyimpanan carotenoid stability of pandanus fruit extract (pandanus tectorius) on light and storage temperature. *Jurnal Rekayasa Dan Manajemen Agroindustri*, *6*(3), 218–224.

Bhernama, B. G. 2020. Ekstraksi gelatin dari tulang ikan kakap putih (lates calcarifer) dengan asam HCl. *Jurnal Sains Natural*, *10*(2), 43–54. https://doi.org/10.31938/jsn.v10i2.282

da Silva Dias, J. C. 2014. Nutritional and health benefits of carrots and their seed extracts. *Food and Nutrition Sciences*, *5*(22), 2147–2156. https://doi.org/10.4236/fns.2014.522227

Dian, P. P., Darmawan;, Erizal;, and Tjahyono. 2012. Isolasi dan sintesis gelatin sisik ikan kakap putih (lates calcarifer) berikatan silang dengan teknik induksi iradiasi gamma. *Indonesian Journal of Material Science*, *14*(1), 40–46.

Duconseille, A., Astruc, T., Quintana, N., Meersman, F., and Sante-Lhoutellier, V. 2015. Gelatin structure and composition linked to hard capsule dissolution: a review. *Food Hydrocolloids*, *43*, 360–376. https://doi.org/10.1016/j.foodhyd.2014.06.006

Fatmawati. 2011. Perlindugan hak atas kebebasan beragama dan beribadah dalam hukum indonesia. *Jurnal Konstitusi*, *8*(4), 490–520.

Fridayana, I. W. E., Wrasiati, L. P., and Ganda Putra, G. 2018. Karakteristik enkapsulat pewarna fungsional dari ekstrak selada laut (ulva lactuca l) pada perlakuan perbandingan gelatin dan maltodekstrin. *Jurnal Rekayasa Dan Manajemen Agroindustri*, *6*(4), 335–344. https://doi.org/10.24843/jrma.2018.v06.i04.p08

GMIA. 2012. *Gelatin Manufacturers Institute of America*. 1–25. http://www.gelatin-gmia.com/images/GMIA_Gelatin_Manual_2012.pdf

Gumilar, J., and Pratama, A. 2018. Produksi dan karakteristik gelatin halal berbahan dasar usus ayam. *Jurnal Teknologi Industri Pertanian*, *28*(1), 75–81. https://doi.org/10.24961/j.tek.ind.pert.2018.28.1.75

Gunawan, F., Suptijah, P., and Uju. 2017. Ekstraksi dan karakterisasi gelatin kulit ikan tenggiri (Scomberomorus commersonii) dari provinsi kepulauan bangka belitung. *Jphpi*, *20*(3), 568–581.

Gusdinar, T., Singgih, M., Priatni, S., Ae, S., and Suciati, T. 2011. Enkapsulasi dan stabilitas pigmen karotenoid dari neurospora intermedia n-1 (encapsulation and the stability of carotenoids from neurospora intermedia n-1). *Journal of People and Environment*, *18*(3), 206–211. https://doi.org/10.22146/jml.18443

Haas, K., Robben, P., Kiesslich, A., Volkert, M., and Jaeger, H. 2019. Stabilization of crystalline carotenoids in carrot concentrate powders : effects of drying technology. *Foods*, *8*, 1–16.

Hapsari, N., Rosida, D. F., Djajati, S., Aviskarahman, A., Dewati, R., and Sudaryati. 2018. Physical characteristics of fish bone gelatin extracted acid. *Advanced Science Letters*, *23*(12), 12272–12275. https://doi.org/10.1166/asl.2017.10619

Hasrini, R. F., Zakaria, F. R., Adawiyah, D. R., and Suparto, I. H. 2017. Mikroenkapsulasi minyak sawit mentah dengan penyalut maltodekstrin dan isolat protein kedelai. *Jurnal Teknologi Dan Industri Pangan*, *28*(1), 10–19. https://doi.org/10.6066/jtip.2017.28.1.10

Huda, W. N., Atmaka, W., and Nurhartadi, E. 2013. Kajian karakteristik fisik dan kimia gelatin ekstrak tulang kaki ayam (gallus gallus bankiva) dengan variasi lama perendaman dan konsentrasi asam. *Jurnal Teknosains Pangan*, *2*(3), 70–75.

Islami, A. D., Junianto, and Rostika, R. 2018. Karakteristik fisik dan kimia gelatin kulit kakap pada hasil ekstraksi suhu yang berbeda. *Jurnal Perikanan Kelautan*, *9*(2), 34–40.

Istiqlaal, S. 2018. Karakteristik gelatin tulang ikan tuna dengan perendaman cuka lontar dari nusa tenggara timur. *Jphpi*, *21*(3), 443–450.

Jeya Shakila, R., Jeevithan, E., Varatharajakumar, A., Jeyasekaran, G., and Sukumar, D. 2012. Comparison of the properties of multi-composite fish gelatin films with that of mammalian gelatin films. *Food Chemistry*, *135*(4), 2260–2267. https://doi.org/10.1016/j.foodchem.2012.07.069

Khirzin, M. H., Ton, S., and Fatkhurrohman, F. 2019. Ekstraksi dan karakterisasi gelatin

tulang itik menggunakan metode ekstraksi asam. *Jurnal Sain Peternakan Indonesia*, *14*(2), 119–127. https://doi.org/10.31186/jspi.id.14.2.119-127

Kumalasari, R., Setyoningrum, F., and Ekafitri, R. 2015. Karakteristik fisik dan sifat fungsional beras jagung instan akibat penambahan jenis serat dan lama pembekuan. *Pangan*, *24*(Maret), 37–48.

La Ifa, L. I., Artiningsih, A., Julniar, J., and Suhaldin, S. 2018. Pembuatan kitosan dari sisik ikan kakap merah. *Journal Of Chemical Process Engineering*, *3*(1), 43. https://doi.org/10.33536/jcpe.v3i1.194

Lin, C. C., Chiou, T. K., and Sung, W. C. 2015. Characteristics of gelatin from giant grouper (epinephelus lanceolatus) skin. *International Journal of Food Properties*, *18*(11), 2339–2348. https://doi.org/10.1080/10942912.2014.980947

Mardikasari, S. A., Suryani, S., Akib, N. I., Sahumena, M. H., Hastuti, S., and Putri, S. A. 2020. Mikroenkapsulasi asam mefenamat menggunakan polimer hidroksi propil metil selulosa dan natrium alginat dengan metode gelas ionik. *Majalah Farmasi Dan Farmakologi*, *23*(3), 71–74. https://doi.org/10.20956/mff.v23i3.9395

Masirah. 2018. Perbandingan karakteristik sifat fisikokimia gelatin tulang ikan bandeng dan gelatin sapi komersial. *Prosiding Seminar Nasional Kelautan Dan Perikanan*, *IV*, 285–292.

Muchtadi, T. R., Wulandari, N., Hunaefi, D., Andrianto, M. S., and Sukmawati, Y. 2015. Prospek industrialisasi produk hilir minyak kelapa sawit (industrialization prospect of palm oil downstream products). *Prosiding Seminar Hasil-Hasil PPM IPB 2015*, *I*, 159–180.

Mulyani, T., Sudaryati, and Rahmawati, S. F. 2013. Hidrolisis gelatin tulang ikan kakap. *Jurnal Teknologi Pangan*, *5*(2), 81–86.

Nasution, A. Y., and Harahap, Y. 2018. Karakterisasi gelatin hasil ekstraksi dari kulit ikan patin (pangasius hypophthalmus) dengan proses asam dan basa. *Pharmaceutical Sciences and Research*, *5*(3), 142–151. https://doi.org/10.7454/psr.v5i3.4029

Ng, M. L., and Sulaiman, R. 2018. Development of beetroot (beta vulgaris) powder using foam mat drying. *Lwt*, *88*, 80–86. https://doi.org/10.1016/j.lwt.2017.08.032

Nurhaeni, Rauf, R. S., and Hardi, J. 2018. Kajian ektraksi gelatin dari tulang ikan katombo (Selar crumenopthalmus) [the study of gelatin extraction from katombo fish bone (selar crumenopthalmus). *Kovalen*, *4*(2), 121–130.

Panjaitan, T. F. C. 2016. Optimasi ekstraksi gelatin dari tulang ikan tuna (Thunnus albacares). Jurnal WIYATA, *3*(1), 11–16.

Permata, Y., Widiastri, F., Sudaryanto, Y., and Anteng, A. 2016. Gelatin dari tulang ikan lele (Clarias batrachus): pembuatan dengan metode asam, karakterisasi dan aplikasinya sebagai thickener pada industri sirup. *Jurnal Ilmiah Widya Teknik*, *15*(2), 146–152.

Pertiwi, M., Atma, Y., Mustopa, A., and Maisarah, R. 2018. Karakteristik fisik dan kimia gelatin dari tulang ikan patin dengan pre-treatment asam sitrat. *Jurnal Aplikasi Teknologi Pangan*, *7*(2), 83–91. https://doi.org/10.17728/jatp.2470

Pew Research Center Religion and Public Life. 2015. The future of world religions: population growth projections, 2010-2050. http://www.pewforum.org/2015/04/02/religious-projections-2010-2050/

Pinto, M. R. M. R., Paula, D. de A., Alves, A. I., Rodrigues, M. Z., Vieira, É. N. R., Fontes, E. A. F., and Ramos, A. M. 2018. Encapsulation of carotenoid extracts from pequi (caryocar brasiliense camb) by emulsification (o/w) and foam-mat drying. *Powder Technology*, *339*, 939–946. https://doi.org/10.1016/j.powtec.2018.08.076

Prihardhani, D. I., and Yunianta. 2016. Ekstraksi gelatin kulit ikan lencam (Lethrinus sp) dan aplikasinya untuk produk permen jeli. Jurnal Pangan Dan Agroindustri, *4*(1), 356–366.

Purnomo, W., Khasanah, L. U., and Anandito, B. K. 2014. Pengaruh ratio kombinasi maltodekstrin, karagenan dan whey terhadap karakteristik mikroenkapsulan pewarna alami daun jati (Tectona grandis l. F.). Jurnal Aplikasi Teknologi Pangan, *3*(3), 121–129. http://journal.ift.or.id/files/33121129

Putri, R. W. 2013. Pengaruh lama perendaman dan konsentrasi asam klorida terhadap kualitas gelatin dari tulang ikan anggoli *(Pristipomoides multidens)*. Universitas Brawijaya.

Rares, R. C., Sompie, M., Mirah, A. D., and Kalele, J. A. D. 2017. Pengaruh waktu perendaman dalam larutan asam asetat (CH_3COOH) terhadap karakteristik fisik dan kimia gelatin ceker ayam. Zootec, *37*(2), 268. https://doi.org/10.35792/zot.37.2.2017.16063

Rodiah, S., Mariyamah, M., Ahsanunnisa, R., Erviana, D., Rahman, F., and Budaya, A. W. 2018. Pemanfaatan limbah tulang ikan tenggiri sebagai sumber gelatin halal melalui hidrolisis larutan asam dengan variasi rasio asam. ALKIMIA : Jurnal Ilmu Kimia Dan Terapan, *2*(1), 34–42. https://doi.org/10.19109/alkimia.v2i1.2260

Saleh, R. 2011. Ekstraksi gelatin dari limbah tulang ikan kakap merah (lutjanus sp) dengan metode asam. Teknosains, *5*(1), 33–42.

Samosir, A. S. K., Idiawati, N., and Destiarti, L. 2018. Ekstraksi gelatin dari kulit ikan toman (Channa micropelthes) dengan variasi konsentrasi asam asetat. Jurnal Kimia Khatulistiwa, *7*(3), 104–108.

Saputra, R., Widiastuti, I., and Supriadi, A. 2015. Karakteristik fisik dan kimia gelatin kulit ikan patin (Pangasius pangasius) dengan kombinasi berbagai asam dan suhu. Fishtech, *4*(1), 29–36. https://doi.org/10.36706/fishtech.v4i1.3496

Sari, S. M. E. P., Purwadi, and Thohari, I. 2013. The use of gelatin as pegagan extracted enkapsulan (Centella asiatica) on water content, ash content, solubility and rendemen. Universitas Brawijaya.

Sarungallo, Z. L., Murtiningrum, Santoso, B., Roreng, M. K., and Latumahina, R. M. M. 2016. Nutrient content of three clones of red fruit (Pandanus conoideus) during the maturity development. International Food Research Journal, *23*(3), 1217–1225.

Shweta, A., and Snoia, P. 2013. Pharamaceutical relevance of crosslinked chitosan in microparticulate drug delivery. International Research Journal of Pharmacy, *4*(2), 45–51.

Souripet, A. 2015. Komposisi , sifat fisik dan tingkat kesukaan nasi ungu. Agritekno, Jurnal Teknologi Pertanian, *4*(1), 25–32.

Trilaksani, W., Nurilmala, M., and Setiawati, I. H. 2012. Ekstraksi gelatin kulit ikan kakap merah (Lutjanus sp.) Dengan proses perlakuan asam. Jurnal Pengolahan Hasil Perikanan Indonesia, *15*(3), 240–251. https://doi.org/10.17844/jphpi.v15i3.21436

Ulumi, M. L. N. N., Wirandhani, D. S., Ardhani, R. F., Andhani, C. O., and Putri, D. N. 2021. Mikroenkapsulasi pigmen beta-karoten dengan metode foam mat drying menggunakan gelatin tulang ikan kakap merah sebagai bahan penyalut. J. Teknologi Industri Pertanian, *15*(4), 1183–1195. https://doi.org/10.21107/agrointek.v15i4.11689

Wulandari, A., Sunarti, T. C., Fahma, F., and Noor, E. 2019. Karakteristik mikrokapsul antosianin ubi jalar ungu dengan teknik spray drying. Jurnal Teknologi Industri Pertanian, 29(1), 34–44. https://doi.org/10.24961/j.tek.ind.pert.2019.29.1.34

Wulandari, Supriadi, A., and Purwanto, B. 2013. Pengaruh defatting dan suhu ekstraksi terhadap karakteristik fisik gelatin tulang ikan gabun. Jurnal Fishtech, *2*(1), 461.

Yogaswara, I. B., Wartini, N. M., and Wrasiati, L. P. 2017. Karakteristik enkapsulat ekstrak pewarna buah pandan pada perlakuan jenis enkapsulan. Jurnal Rekayasa Dan Manajemen Agroindustri, *5*(4), 31–40.

Yudhistira, B., Palupi, E., and Atmaka, W. 2019. The effect of acid concentration and duration of submersion toward the characteristics of gelatin of eel fish bone (Anguilla bicolor) produced through acid process. IOP Conference Series: Earth and Environmental Science, 246(1). https://doi.org/10.1088/1755-1315/246/1/012046