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Comparison of microscopic meat quality parameters in guinea pig [*Cavia porcellus* (Linnaeus, 1758)], broiler chicken, and local catfish as protein source

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Abstract. The amount of animal protein consumed determines the health status of individuals. Unfortunately, the rising demand for meat has resulted in a land shortage and exorbitant pricing. In Andean countries, guinea pigs (GP) have been raised for centuries as an inexpensive animal protein source like broiler chicken (BC) and local catfish (LC) in Indonesia. This study aimed to compare the meat quality of GP, BC, and LC based on their color and histomorphometry analysis. Samples were taken from the hind leg (GP), thigh (BC), and tail of frozen meats. After being observed visually to compare their color, samples were processed for histological preparation following routine procedure, fixed in NBF 10%, and stained with Hematoxylin-Eosin and Mallory Acid Fuchsin. Muscle cell size and collagen fibers were calculated. Results demonstrated that GP meat appeared red although all three meats are categorized as white meat. GP meat has the largest muscle cell size (87.7±10.9μm), indicated high content of protein. GP meat also has the most collagen fibers, affecting palatability. It can be concluded that GP meat is prospective to be developed as an alternative protein source. Another benefit is that the price of GP is affordable and requires less space to breed.

1 Introduction

According to the FAO (Food and Agriculture Organization), food security is a state where all humans can access nutritious and safe food to meet their basic food needs and food preferences to achieve a healthy life. Along with food security, health issues are also increasingly discussed as the world's population increases. The increasing number of people on earth causes an increase in the need for all goods, including food. As a basic need that a human being must fulfill to survive, food is an aspect that has a role in the life of a country.

The high demand for food also affects the availability of livestock and farming land in the world. The most influential land use in this declining land availability is in animal products. Some livestock, especially large animals such as cattle, are rumored to be the type of livestock that takes up the most land. This is due to the large body size of cattle, and the

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feed needed is also taken from plants or farm products [1]. maintenance, beef is one of the most expensive animal meats and less affordable for low-income people. Therefore, there is a need for alternative animal products that are less land-intensive and cheaper but still have good structural and nutritional quality.

Two types of meat are often consumed in Indonesia, namely chicken meat and catfish meat, because they are easily found and have affordable prices. Chicken meat itself is a meat that is also much needed and consumed, which is estimated at 5.68 kg/capita. As farm animals, chickens produce not only meat but eggs for consumption, which are classified into two types: laying hens and broilers. Chickens have a protein content of 20% and 1.85% fat in their meat [2], while in their eggs, there is a protein content of 16-17% and a fairly high lipid content of 31-33% [3].

Based on the ability of catfish to survive in poor water conditions, catfish are widely cultivated for consumption. Like fish in general, which has an excellent protein content based on its amino acid composition, catfish is also a fish with many nutrients. As much as 20% protein content is found in this fish. Catfish also contains 13% fat contained in its meat. Catfish also contains macroelements and microelements of minerals, such as calcium, magnesium, sodium, potassium, iron, and zinc. The values contained in some mineral elements are quite high compared to some other consumed fish [4].

Guinea pigs [*Cavia pocellus* (Linnaeus, 1758)] are commonly kept as pets. In addition to being a pet, this animal has developed into an animal consumed in developing countries. Peru, South America, is one of the countries that pioneered the consumption of guinea pigs [5]. Almost all parts of guinea pigs can be utilized as a consumed animal so that no part is wasted. According to Nuwanyakpa's research[6], guinea pigs have a protein content of 21% in their meat. This protein content is higher than other animal products, such as chicken and beef. Guinea pig meat also has a low-fat content, which is 5%. Based on the age of consumption, guinea pigs are classified as animals that take a short time to be cultivated until they can be consumed compared to other animals. In addition, guinea pigs have diverse feed preferences and are easy to find. In terms of land used for cultivation, guinea pigs can be cultivated at home without the need to use a very large area [7]. This makes the cost of growing guinea pigs more affordable than that of other livestock. Guinea pig farming can also overcome field loss or livestock land crisis because it requires a small amount of land.

This study aims to look at the microscopic aspects of the three animals, guinea pigs, broiler chickens, and local catfish, as a consideration for guinea pigs as a potential alternative animal protein size. Due to the absence of in-depth research on guinea pigs, especially the histological part of their muscle/flesh, this study can provide the latest information about guinea pigs, especially in considering guinea pigs as an alternative food.

2 Materials and methods

2.1 Ethical clearance submission

Before preparing the sample, ethical clearance is submitted containing details of the treatment carried out on experimental animals. Ethical clearance is submitted to the ethics commission of LPPT UGM.

2.2 Sample preparation

The animals used in this study consisted of guinea pigs [*Cavia porcellus* (Linnaeus, 1758)], chickens [*Gallus gallus domesticus* (Linnaeus, 1758)], and catfish [*Clarias batachrus* (Linnaeus, 1758)] with a total of three each. The guinea pigs sampled were adult females weighing 400-500 grams, i.e., approximately six months old or more. Chickens were obtained as broilers weighing 1.5-2 kg. The catfish used were adult catfish ready for consumption weighing >250 grams. All three animals were obtained, frozen, and then thawed. Guinea pigs and chickens were skinned, and carcass weight was calculated, including whole weight, cold carcass, and hot carcass. Guinea pig and chicken meat samples were taken from the shank/lower thigh, while catfish were taken from the abdomen. The three meat samples were taken with a size of 1x1 cm and then stored in 10% NBF for 48 hours.

2.3 Preparation of histological slide

Samples of the three types of animals that have been soaked in 10% NBF for 48 hours are then washed. After washing, the samples were soaked with graded alcohol to remove the remaining fixation solution attached (dehydration), and then the samples were immersed in toluol solution overnight. The samples were immersed in paraffin solution and kept in the oven until the paraffin entered the sample perfectly (approximately 3 hours). Embedding is done by inserting the sample along with paraffin into the mold block and then waiting until it hardens and can be sectioned or cut with a microtome. Cutting with a microtome is done transversely so that the muscle bundle can be seen. The captured coupes are affixed to the preparation slide on a hotplate [8]. This preparation was submitted to the Anatomical Pathology department, FKKMK UGM.

2.4 Staining (Hematoxylin-Eosin and Mallory Acid Fuchsin)

Each sample made two types of preparations. Three slides were given Hematoxylin Eosin staining to calculate muscle bundle size, and three others were given Mallory Acid Fuchsin staining to see collagen content.

2.5 Data analysis

Data analysis was performed by observing the preparations using an OlympusCX33 microscope and *Optilab* application. In each preparation, the circumference of the muscle bundle was calculated with 50 repetitions. The observation results were analyzed using one-way ANOVA.

3 Result and discussion

The Ethical Clearance form consists of how the treatment of the animals is submitted. The form was accepted (Ethical Clearance number: 108/EC-FKH/Eks./20. The three animals used in this research, including guinea pig, catfish, and chicken, are two different types of meat. Based on observation, catfish and chicken meat are white because they have white (catfish) and pink (chicken) flesh, while guinea pig has reddish meat similar to beef. On microscopic observation, the muscle bundles of the three samples were observed. In all three samples, there were empty spaces that caused the muscle fascicles to not be dense between each other. In addition, some muscle bundles were damaged or degraded.

Sample preparation using frozen meat samples that are thawed causes damage to the muscle bundles. Freezing meat will tend to form ice crystals in every part of the cell. This is because the majority of cell formers in the body are liquids. The ice crystals contained in the cells when the meat is frozen will make the meat lose natural moisture and then become hard and dry (drip lost). The freezing and thawing process will affect protein contained in meat, where the protein content tends to decrease due to denaturation by extreme temperatures[9].

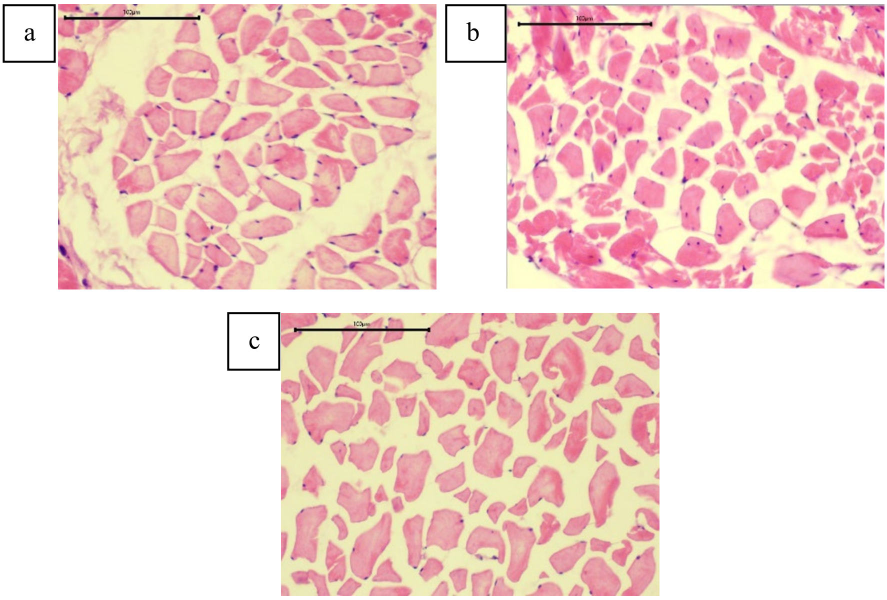

Fig. 1. Histology of **(a)** Guinea pig, **(b)** Broiler chicken, **(c)** Local catfish muscle bundle with Hematoxylin-Eosin staining (40x)

In the histological aspect, freezing and thawing will cause muscle fibers or bundles to shrink [10]. It can be seen in the appearance of muscle bundles that there are gaps between the bundles that are quite large. In addition, there were also cracks or damage to the muscle bundles in the sample. In this study, the phenomenon of the cracks by freezing and thawing cannot yet be compared with the original one. The effect of freezing and thawing on the muscle bundle can make the appearance of the muscle bundle looked better or worse in another aspect than the original one. However, in another way this study which uses the freezing sample of the meat could show how the freezing method of food preparation can affect the quality of the food.

Microscopic analysis was carried out on the other three samples, namely determining the bundle's size by calculating the bundle's circumference. Based on the results of calculations using Optilab with 50 repetitions, the following results were obtained:

Table 1. Average muscle bundle circumference

	Guinea pig	**Broiler Chicken**	**Catfish**
Bundle Circumference (µm)	87.7	72.9	66.1
Standar Deviation	10.9	25.1	12.9

The average size of muscle bundles shows that guinea pigs have the largest muscle bundles compared to the other two samples. Seen at 10x magnification, guinea pig muscle bundles have the largest size and are widely scattered. Chicken muscle bundles are large but not larger than guinea pig muscle bundles, while catfish muscle bundles have the smallest size, but the number is huge. The plasma membrane of the muscle bundle (sarcolemma) contains the nutrients contained in the meat. This causes a larger muscle bundle that can increase the content of nutrients in the meat [11].

Morphometric analysis of the muscle bundles of the three animals was also carried out with One-way ANOVA to see if there was a true difference in muscle size between the three samples.

Table 2. One-Way ANOVA data analysis

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	12175.8	2.0	6087.9	19.4	3.24E-08	3.1
Within Groups	46043.4	147.0	313.2			
Total	58219.1	149.0				

Based on the results of the One-way ANOVA analysis, it can be seen that the p-value was calculated as 3.2 x 10^{-8}. The p-value in the analysis is smaller than 0.05, indicating a significant difference among the three samples. In addition to staining using Hematoxylin and Eosin, staining using Mallory Acid Fuchsin was also performed with the aim of looking at the collagen content of each meat sample. Collagen in meat determines the quality of meat. Collagen is a protein found in the sheath of muscle bundles. In addition to protein quality, collagen also affects the tenderness or texture of meat [12]. Collagen in meat can be seen by staining using Malory. In this study, collagen can be observed, which is marked with a blue color around the muscle fascicles.

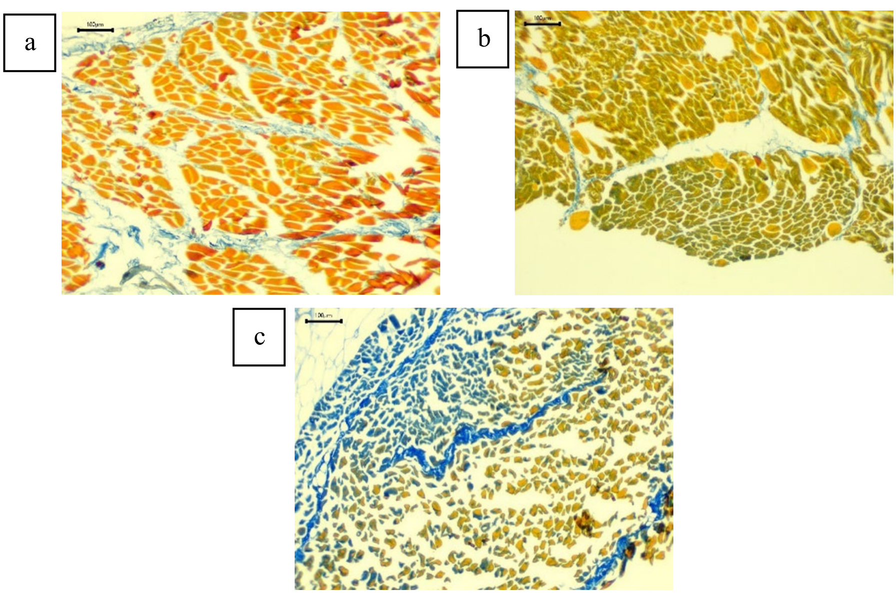

Fig. 2. Histology of (a) Guinea pig, (b)Broiler chicken, (c) Local catfish muscle bundle with Mallory Acid Fuchsin staining (10x)

Guinea pigs were found to have more collagen surrounding the muscle fascicles than the other two samples. The least collagen content was found in chicken. Collagen, one of the connective tissues in the muscle bundle, shows that the more collagen is contained, the more the meat will tend to be chewy [13].

4 Conclusion

Based on the research conducted, it was found that guinea pig meat has the best quality compared to chicken meat and catfish meat based on morphotometric analysis. This can be seen from the average size of the muscle bundle analyzed by calculating the circumference of the bundle. The meat quality can also be seen from the amount of collagen that envelops the muscle fascicles, which indicates the protein content in the meat. Thus, the potential of guinea pigs as a food alternative can be further considered. Additional research on nutritional or proximate content data is needed so that the quality of guinea pigs as an alternative to animal protein can be better proven. The study of the guinea pigs, such as the cultivation or breeding information, consists of the land used, the cost required, and the ease of cultivation data that can lead the guinea pig to be compared and considered as an alternative food source.

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