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Analysis of carcass weight and proximate composition as guinea pig [*Cavia porcellus* (Linnaeus, 1758)] meat quality indicator

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Abstract. Guinea pig (GP) meat [*Cavia porcellus* (Linnaeus, 1758)] can serve as an alternative food due to its high protein content. GP is the staple food in Peru, thus tropical regions (Indonesia) can cultivate it. GP can be purchased at animal markets for an acceptable cost. Carcass weight and proximate analysis are required to evaluate GP meat characteristics. To examine the impact of frozen storage on meat quality, this study aimed to compare GP meat quality with chicken and catfish. The frozen meat was from commercial markets. The methodology comprised meat selection, carcass weight, proximate evaluation, and data analysis. The hind leg, thigh, and tail sections of GP, chicken, and catfish, respectively, were used for proximate evaluation and evaluated using the Titrimetric method, the Weibull method, the Oven Drying method, ash calculation, the By Difference method, and meat tenderness test. Regarding carcass weight, GP has the lowest weight. However, it has the finest proximate analysis results, compared to catfish and chicken, with a protein value of 17.42%. GP meat has potential to be gained as a high-protein food source at a reasonable cost. As opposed to chicken and catfish, more portions of GP can be consumed as meat.

1 Introduction

Countries in Southeast Asia and the Asia-Pacific region have a human population where almost half of them experience the triple burden of malnutrition, as indicated by undernutrition, overweight, and micronutrient deficiencies. Indonesia is one example of a country experiencing these problems, with 1 in 3 children suffering from stunting and 1 in 10 children suffering from wasting [1]. In 2022, the prevalence of stunting in Indonesia was 21.6%, which decreased from the previous year, which reached 24.4% [2].

There are three main causes of stunted growth and development in children: inadequate consumption, breastfeeding errors, infections, and family factors and household practices [3]. Research showed a significant relationship between food consumption and the presence of stunting. A diverse diet that is high in protein from animal sources can increase growth [4]. The nutritional problems found in Indonesia and other developing countries are the low

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quality of food, especially the need for more diverse food types. Another research showed that there is a relationship between protein consumption and growth. Children who consume less protein will have low blood serum, resulting in a slowdown in protein and fat synthesis by the mTORC1 gene, inhibiting cell growth [5]. Thus, feeding a high-protein diet is needed to reduce the prevalence of stunting.

There is an association between stunting and low consumption of animal-sourced foods [6]. Animal protein is higher than vegetable protein because it contains a more complete amino acid composition. Meat, eggs, fish, and milk are common animal sources, but they are still quite expensive for low-income countries [6]. To overcome this, there is a need for alternative food sources of high protein at a more affordable price. Guinea pig [(Cavia porcellus (Linnaeus, 1758)], besides being a research animal, can also be an alternative food source because its meat contains high protein. In addition, Guinea pig meat is also low in fat, making it a potential food alternative to improve the public health profile. Another advantage is that in terms of breeding, guinea pigs have become the main food in Peru so that guinea pigs can be farmed in tropical areas, including Indonesia [7].

Meat quality can be determined through proximate analysis. The proximate analysis will show the macronutrient content of the food, including protein, fat, water, carbohydrates, and collagen. Carcass weight is also an important parameter because it affects the quality and profitability of meat. Increasing carcass weight has an impact on significantly improving meat flavor and freshness [8].

Another parameter that determines meat quality is the storage method. Storing meat in the frozen form will extend the shelf life. Freezing and thawing mainly affect the water fraction in meat, where water is located within and between meat muscle fibers [9]. When water freezes, nutrient concentrations (proteins, carbohydrates, lipids, vitamins, and minerals) will increase, affecting the homeostasis of the meat system. Environmental changes due to freezing and thawing around muscle fibers will result in changes in cell membrane characteristics, which will have an impact on meat quality [9]. Thus, it is necessary to analyze the proximate content that has undergone freezing and thawing to determine the quality of the meat. This study aimed to analyze the quality of guinea pig meat when compared with chicken and catfish meat. In addition, this research also studies the effects of freezing and thawing on meat when compared to fresh guinea pigs, chicken, and catfish meat. No research has discussed the quality of guinea pig meat compared to other commercial meat, such as catfish and chicken, before. Furthermore, the meat quality test with the parameter on carcass weight and proximate profile must be studied because it will be proposed as an alternative food. Thus, this research is crucial to be done.

2 Materials and methods

The research was conducted for two months (September - October 2023). Carcass weight measurement and meat pH testing were conducted at the Animal Physiology Laboratory and Animal House, Faculty of Biology UGM. Proximate analysis and meat texture test were conducted at Saraswanti Indo Genetech Laboratory. The proximate analysis and tenderness of meat are evaluated using the Titrimetric method (protein), the Weibull method (fat), the Oven Drying method (water content), ash calculation, and the By Difference method (carbohydrate). The conducted methods are based on the Standar Nasional Indonesia (SNI) No. 01-2891-1992, published in 1992, titled Cara Uji Makanan dan Minuman. This standard is a basic reference for testing the nutrient content of foodstuffs.

The materials needed are the guinea pig, chicken, catfish, NaCl, distilled water, PCA media, ethanol, HNO_3, $HClO_4$, H2SO4, formaldehyde solution, NaOH 0.2 N, phenolphthalein indicator, HCl 0.2 N, $Ba(OH)_2$ 10%, $BaCl_2$ 10%, potassium iodide solution, natrium thiosulfate solution, litmus paper, and NBF 10%.

The tools needed are a guinea pig cage, surgical equipment, tape meter, microtube, centrifuge, electrophoresis, UV Transilluminator, burette, Soxhlet extraction equipment, oven, autoclave, glassware including Erlenmeyer and measuring cup (Pyrex), bunsen, vacuum equipment, Petri dish 15 mm x 90 mm, porcelain cup, hot plate stirrer, micropipette, propipette, pipette tip, vortex, waterbath, incubator, weighing bottle with lid, exiccator, analytical balance, blender and sterilizable jar, dilution bottle, UV lamp, and test tube.

2.1 Ethnical clearance

All procedures regarding handling of experimental animals, maintenance, and data collection methods are carried out based on Ethical Clearance. Submission of Ethical Clearance to the Ethical Commission for Animal Experiments of LPPT UGM. Ethical Clearance was required as animals are involved and as a guarantee that there is no harmful treatment of animals in this research.

2.2 Animal selection guinea pig, chicken, and catfish

The animals used in this study were guinea pigs, chickens, and catfish. Guinea pigs [*Cavia porcellus* (Linnaeus, 1758)] were adult American strains or >6 months old, female sex, and weighed 400-500g. Chicken [*Gallus gallus* domesticus (Linnaeus, 1758)] in the form of ready-to-cut meat (30-35 days old) from female sex individuals, and weighing 1.5-2.0 kg. Catfish [*Clarias batrachus* (Linnaeus, 1758)] in the form of meat ready for consumption (age 2.5-3.5 months), derived from male/female sex individuals, and weighing >125 g. Each animal amounted to 3 individuals.

Meat samples used were fresh meat and frozen meat. Chicken and catfish meat were obtained from Yogyakarta fresh meat shop in fresh-to-process form, while guinea pigs were obtained alive from the Yogyakarta animal market (PASTY).

2.3 Caracas weight analysis

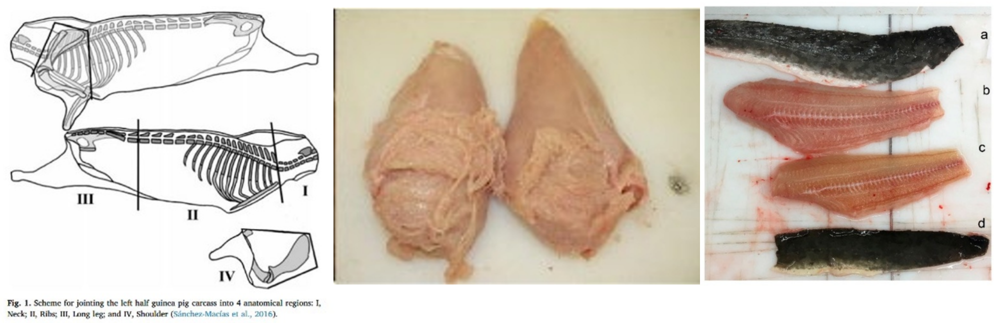
All the frozen meat was frozen in a fridge with a temperature of < -15°C. They were thawed until melting (approximately 3 hours after being put at room temperature). Guinea pigs that met the criteria for slaughtered meat (healthy and minimum body weight) were slaughtered according to the procedure for providing consumer meat by cutting three channels: trachea, esophagus, and neck veins (carotid arteria and jugularipers vein). The guinea pigs are then skinned, and the head, feet, and tail are removed. The contents of the organs are also removed. The weight of the remains became the carcass weight of the guinea pig. Chicken and catfish meat were obtained from fresh meat stores selling meat commercially.

Carcass weight calculations are divided into whole weight calculations : hot visceral carcass weight, cold visceral carcass weight, hot non-visceral carcass weight, and cold non-visceral carcass weight [10]. The description of the weight is:

- Whole weight = live weight
- Cold visceral carcass weight = meat with head, feet (chicken and guinea pig) or fins (catfish), and internal organs that are still frozen (just removed from the freezer).
- Hot visceral carcass weight = meat with head, feet (chicken and guinea pig) or fins (catfish), and internal organs that have undergone thawing treatment.
- Cold non-visceral carcass weight = meat without a head, feet (chicken and guinea pig) or fins (catfish), and internal organs that are still frozen (just removed from the freezer).

- Hot non-visceral carcass weight = meat without a head, feet (chicken and guinea pig) or fins (catfish), and internal organs that have undergone thawing treatment.
- Carcass ratio = (Hot non-visceral carcass weight / Whole weight) x 100% [10].

The illustration of guinea pig carcass, chicken carcass, and catfish carcass are presented in Figure 1.



a b c

Fig. 1. a. Guinea Pig Carcass [11], **b.** Chicken Carcass [12], **c.** Catfish Carcass [13]

2.4 Proximate content analysis

Proximate analysis was conducted to analyze the meat's protein, fat, carbohydrate, water, and ash content. The test sample was fresh meat from guinea pigs. Protein content was determined by the Titrimetric method based on SNI 01-2891 - 1992. A 2 g sample was added with 1 mL of PP solution and 10 mL of 10% BaCl2 solution, then titrated with $Na(OH)_2$ solution until red. The sample was added back with 5 mL $Ba(OH)_2$. The solution was allowed to stand for 15 minutes while homogenized and filtered. A solution of 80 mL was taken, and the ammonia content was distilled with a vacuum device and put into HCl. The CO_2 content in the sample was drained until the CO_2 disappeared, then neutralized with NaOH to form a light blue color on litmus paper and added with 0.2 N HCl. The sample was free of ammonia.

The ammonia-free sample is then added with 20 mL of formaldehyde solution and titrated with 0.2 N HCl solution until the color is the same as the dick solution. The solution was added back by the titrated sample until the color was less than the control solution. Calculation of protein with mg N_2 as a neutral amino acid in 80 mL of solution. The formula used is as Equation (1).

$$Amino\ acid = [(V1 - V2) \times 2.8 \times 1.25] / W \times 100\% \qquad (1)$$

Description: V1 is the volume of the base, V2 is the volume of acid, W is the weight of the sample, and 1.25 is the conversion value [14].

Total fat content was tested using the Weibull method (hydrolysis method) based on SNI 01-2891 - 1992. The sample was added with HCl, 20 mL of water, and some boiling stones, then heated, filtered, and washed with hot water. Samples were extracted with hexane for 2-3 hours at 80ºC. Weighing was carried out until a fixed weight was reached [14].

Total carbohydrates were analyzed by the By Difference method. Moisture content was tested based on SNI 01-2891 - 1992 method, point 5.1. This step is done by drying 1-2 g samples at 105°C for 3 hours. The sample is then cooled in an exicator. The weight of the sample is weighed until it reaches a constant weight. The calculation of moisture content can be done by the Equation (2).

$$W/W1 \times 100\% \tag{2}$$

Description: W is the weight of the sample before drying, and W1 is the difference in weight after drying [14].

Ash content analysis was based on the SNI 01-2891-1992 method point 6.1. Samples as much as 2-3 g were placed in a porcelain cup. The sample was fumigated through heating at 550°C until the fumigation was completed completely. The sample was cooled in an applicator and then weighed until it reached a fixed weight. The calculation of ash content can be done using the Equation (3).

$$(W1 - W2) / W \times 100\% \tag{3}$$

Description: W is the weight of the sample before frying, W1 is the weight of the sample + cup after frying, and W2 is the weight of the porcelain cup.

The meat texture test is based on the SNI 01-2891- 1992, point 1.2 [14].

2.5 Data analysis

The statistical analysis method used was one-way ANOVA (α=0.05) followed by post hoc test Duncan using IBM-SPSS.v.25 software to compare the quality of guinea pig, chicken, and catfish meat through carcass weight parameters. Before the statistical analysis, the Saphiro-Wilk test was used to analyze the normality of data distribution. A value of α=0.05 was considered a significant result or significant difference [15]. Proximate analysis of guinea pig, chicken, and catfish meat was stated based on the results of the test.

3 Results and discussion

3.1 Ethical clearance approval

This research has been approved by the Research Ethics Commission of the Faculty of Veterinary Medicine, Gadjah Mada University, with number 108/EC-FKH/Eks./2023.

3.2 Carcass weight calculation

Carcass weight calculation is done by weighing guinea pigs, chicken, and catfish carcasses without skin, internal organs, head, and feet (non-visceral). The Shapiro-Wilk test showed that all the data was normally distributed; thus, it was continued with one-way ANOVA. The carcass weight used is the means of hot non-visceral weight (weight of body without a head, feet (chicken and guinea pig) or fins (catfish), and internal organs that have undergone thawing treatment). The results of these calculations are shown in Table 1.

In this study, the data used to calculate carcass ratio is the weight of hot non-visceral carcass and whole weight. This is because the meat to be consumed through thawing treatment (hot) and without internal organs from consumed animals. Chicken has the largest carcass weight ratio, followed by catfish and, finally, guinea pig. Whole weight and carcass weight among guinea pigs, chickens, and catfish were significantly different from each other when calculated by one-way ANOVA (α=0.05). The carcass ratio weight and whole weight of guinea pigs were significantly different from chicken and catfish. Guinea pigs had the smallest carcass ratio weight because the skin of guinea pigs was removed during sample preparation, while carcass calculations on chicken and catfish meat included the skin. Guinea pig skin is thick and hard [16], so when it is removed, it will significantly reduce the carcass weight of guinea pigs.

Table 1. Hot Non-Visceral Carcass Weight Means of Guinea Pig, Chicken, and Catfish Meat

Sample	Whole Weight (g)	Non-Visceral Carcass Weight (g)	Carcass : Whole Weight Ratio (%)
Guinea Pig	607.67	245	40.44a
Chicken	1538	1071	69.64b
Catfish	156.33	98	62.80b

Significance value: α=0.05

There is a positive correlation between carcass weight and meat quality. The higher the carcass weight, the better the meat flavor and thicker [8]. With thicker meat, the portion of meat that can be consumed will be more.

3.3 Proximate analysis result

Proximate analysis of meat was conducted on the parameters of total energy, energy from fat, ash content, water content, carbohydrates, total fat content, and protein content. he results of these tests are shown in Table 2.

Table 2. Proximate Analysis Results of Guinea Pig, Chicken, and Catfish Meat

Parameter	Unit	Content		
		Guinea Pig	Chicken	Catfish
Total Energy	Kcal/100 g	202.25	282.62	116.43
Fat Energy	Kcal/100 g	113.85	187.02	48.15
Ash	%	0.86	0.69	0.94
Moisture	%	64.39	54.63	76.64
Carbohydrate	%	4.68	8.65	1.32
Total Fat	%	12.65	20.78	5.35
Protein	%	17.42	15.25	15.75

The protein content of guinea pigs is the highest compared to chicken and catfish. Protein levels can determine the quality of meat because protein is a molecule that forms muscle and bone in animal growth. Muscle microstructure is related to the proteins that comprise muscle cells (myofibrils). One of the muscle cell constituent proteins is myostatin. Myostatin is part of transforming growth factor-β (TGF-β), encoded by the myostatin gene. The function of the gene is to build muscle (myogenesis) and skeletal muscle growth. The high level of muscle-building protein makes the muscles have better quality so that the quality of the meat also increases, both in terms of taste, color, pH, moisture content, texture, and meat nutrient content [17]. The high protein content in guinea pig meat indicates that guinea pig meat can be a high-protein alternative food.

The fat content of guinea pigs is between chicken and catfish. Fat is a parameter of meat quality because fat is a sign of animal development and growth. Animal growth can be characterized by weight gain over time. Body composition can change with fat storage after bone and muscle growth slows down. As animals grow from infancy to adulthood, lipid levels in body tissues increase by 50-75% [18].

Freezing can cause protein denaturation due to an increase in intracellular ionic strength which is an effect of water movement into the extracellular environment. However, protein denaturation does not contribute significantly to the deterioration of meat quality as there is no significant difference in the protein content of fresh and frozen meat. Freezing can also cause lipid oxidation which can initiate secondary lipid oxidation when the meat is thawed so that it can change the color, new, and taste changes in the meat. The existence of lipid oxidation is due to chemical reactions that can occur during freezing conditions. Under these conditions, the frozen water fraction causes an increase in the concentration of solutes both inside and outside the cell (intracellular and extracellular) which provides the right environment for chemical reactions of lipid oxidation [9].

3.4 Organoleptic test (texture) of meat

The organoleptic test aims to observe each meat quality's texture. Based on the results of the organoleptic test conducted, the results are shown in Table 3.

Table 3. Results of Organoleptic Test of Guinea Pig, Chicken, and Catfish Meat Texture

Parameter	**Sample**		
Top	Guinea Pig	Chicken	Catfish
Texture	Tender	Tender	Tender

In this study, water-holding capacity (WHC) is thawing loss. The loss of water due to thawing loss is due to the destruction of muscle fibers and protein denaturation. The water content in meat can determine the quality of meat because water content affects the level of meat elasticity. In general, freezing can increase meat elasticity, but it can harm other meat texture components. The positive effect of freezing on meat elasticity has been observed in pork and lamb, where meat subjected to freezing has better quality than fresh meat. This increase in chewiness is largely due to the destruction of the myofibrillar structure of the meat by ice crystals [19]. In addition, higher water binding can be a sign of lower fat content, which leads to a higher level of juiciness. Tenderness and juiciness have a positive correlation with the flavor of meat, which drives people's liking [20].

When meat is frozen, water, which is one of the main components of meat, will turn into solid ice crystals, so the water will expand when frozen. These crystals can have sharp edges, which can damage cells. Water outside the cell membrane will freeze first, then absorb the water inside the cell. When thawing, the balance of water content is no longer the same as it was originally, so meat that undergoes thawing treatment will lose some of its flexibility. To reduce the possibility of meat spoilage, the meat must be subjected to rapid freezing so that the ice crystals formed will be smaller in size [21].

According to the results, guinea pigs can be a promising future food source. There is an increasing population, and so is the demand for food. On the other hand, the food supply is insufficient to meet the needs; moreover, climate change threatens food production [22]. Several regions already have limited land [22], so it is important to find other ways to maximize the land while still giving enough amount for the demand. Guinea pigs contain high-value nutrition which could be an alternative nutritious food, especially for regions facing a shortage of food availability. As guinea pigs native to Peru, they can live well in tropical regions [7] without facing weather problems. This animal has a small body size. Thus, it does not need much land to farm them. If guinea pigs are farmed and the meat is processed properly, regions facing nutritional problems will reach food security.

4 Conclusion

Based on the research that has been conducted, it can be concluded that guinea pig meat contains the highest protein content, which reaches 17.42%, compared to chicken and catfish meat, guinea pig meat could be a high-protein alternative food. In addition, guinea pig, chicken, and catfish meat still have a chewy and tender texture so freezing and thawing treatments do not significantly damage the meat structure. These results indicate that freezing can be done to maintain meat quality. The carcass weight of guinea pig meat is the smallest compared to chicken and catfish, so it is necessary to calculate the carcass of guinea pig meat with its skin.

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