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Effect of storage duration at ambient temperature on microbiological quality of chicken dendeng added with Black Soldier Fly maggot meal

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Abstract
The addition of BSF maggot meal as a sustainable protein source and food product development needs to be studied to determine its effect on the quality of chicken dendeng. Thus, this study aims to determine the effect of adding BSF maggot meal at 5% (w/w) to chicken dendeng and different vacuum storage durations (0, 10, 20, 30 days) at ambient temperature on the bacterial and fungi contamination, as well as the moisture content. The results showed that both storage time and the addition of BSF maggot meal significantly affected the number of bacterial and fungal contaminants without affecting the moisture. The effect of adding BSF maggot meal on the number of bacteria was observed on the 20 and 30 days of storage, where the number of bacteria in chicken dendeng added with BSF maggot meal was higher than the control. However, the number of fungi was not identified during 30 days of storage. Both bacterial and fungi counts remained below the maximum limit until the 30 day of storage. Therefore, the addition of chicken dendeng with 5% BSF maggot meal can be done without increasing the food safety risk based on bacterial and fungi counts.

Keywords: Bacteria, chicken dendeng, fungi, maggot meal, moisture content

Introduction

The International Feed Industry Federation (IFIF) states that the world population will reach 10 billion by 2050, this causes the consumption of animal protein to be needed more, but it is not directly proportional to the livestock population or food sources of protein because over time the population will decrease. Therefore, it is necessary to find additional or complementary food ingredients that can meet the need for animal protein optimally, one of which is by using food sources of protein from insects, such as maggots.

Most people use maggots to decompose organic waste and use them as animal feed. However, maggots also have advantages, namely they contain high nutrients, especially high protein content and are useful for human health if processed properly. The use of maggots processed into food ingredients is rarely developed by the community, so it is necessary to develop new innovations and develop food products in order to increase public awareness of the use of maggots, forms of food source diversification, and sustainability.

Utilization of maggots as a form of food diversification can be done by adding them to a food ingredient as a form of new innovation and protein addition. One of the food ingredients that can be processed with the addition of maggots is chicken meat which will then produce a processed chicken meat food product that is high in nutrients as a form of diversification of new and quality food products.

Chicken meat is an animal food that is widely consumed by the general public. The consumption of chicken meat by the Indonesian people is 7.46 kg/capita/year (BPN RI, 2023) [7]. In addition, the type of broiler chicken meat is more widely chosen by the public and reaches an average per capita consumption figure of 11.41 kg/capita/year in 2022 – 2026 (Directorate General of Food Crops Ministry of Agriculture, 2022) [14]. Good chicken meat has characteristics including bright yellowish white meat color, yellowish white chicken skin color, and has a non-sticky texture. One of the processed food products made from chicken meat is chicken dendeng.

Dendeng is a traditional Indonesian food from the Minangkabau region, West Sumatra. According to Badan Standardisasi Nasional (2020) [11], it is stated that the classification of beef dendeng based on the manufacturing process is divided into three, including the first, dendeng from raw meat with a dry texture, namely dendeng made through a drying process without going through a cooking process. The second is dendeng from cooked meat with a wet texture, namely dendeng produced through a partial drying process, accompanied by cooking, and made without drying, only through cooking until it reaches a certain level of dryness. The third is dry cooked beef dendeng, which is meat that is processed through a cooking and drying process. This process can be done with or without drying until the meat is completely dry.

Making this dendeng requires spices, including brown sugar (25%), white sugar (15%), galangal (2%), coriander (5%), garlic (15%), salt (5%), pepper (0.5%), and tapioca meal (15%). Making chicken dendeng consists of four stages, namely the preparation of tools and materials, grinding and mixing spices, drying stage, and frying stage. In order to fulfill the protein content and new innovations in the processing of chicken dendeng, maggots can be added which are processed into meal. We need to know that there are many sources of protein that can be used, one of which is fish meal. However, the use of fish meal is considered less economical and efficient compared to utilizing insects such as maggot meal which is considered more economical and of high quality. Previous research stated that maggot meal should be used as a substitute for fish meal with a maximum percentage of 25%, so as not to cause negative effects on energy and protein digestibility (Rumondor *et al*., 2015) [31].

The type of maggot used comes from the Black Soldier Fly (BSF) maggot larvae. BSF maggots have an elliptical shape with a yellowish and black color on the head and will change to a brownish color when molting. The color will change to brownish or dark when approaching hatching. These BSF maggots are rich in protein and amino acids (Lestari *et al*., 2018) [23]. Based on Cahyani *et al*., (2020) [12], the percentage of protein in maggots is 49.67%, carbohydrates 0.18%, and fat 21.17%.

Chicken dendeng added with BSF maggot meal is one form of modification or diversity of new food products that can attract consumer interest and produce processed food that is of higher quality and quality. Things that need to be considered are that in addition to looking at the physical properties and nutrient content, microbiological quality also needs to be considered. Chicken dendeng products due to the good nutrient content and the influence of storage time can be a good medium for the growth of microorganisms, so that there is a high possibility that there will be a decrease in quality, especially when stored at room temperature even though they are packaged in a vacuum form.

Microbiological testing of chicken dendeng added with BSF maggot meal is very important to estimate the shelf life and consideration of consumer food safety. One of the requirements for good food ingredients is reviewed based on the content of microorganisms, if the total number of microorganisms is still within the maximum threshold of microbial contamination, then it can still be said to be safe. In previous studies, it was proven that during storage, there was an increase in the Total Plate Count (TPC) value in packaged products. This is caused by the growth and development of coliform bacteria such as *Escherichia*, *Enterobacter*, and *Clostridium botulinum* (which are anaerobic). The total bacteria packaged with vacuum packaging are less than non-vacuum packaging (Delviani *et al*., 2021) [13]. This is because the oxygen content is very low which can reduce bacterial growth. The maximum limit value of ALT bacteria in dendeng is $1x10^5$ colonies/g.

In addition to the bacterial test, a fungal microbe and moisture test was also carried out. This test is a parameter carried out to determine the number of fungal isolates and the percentage of moisture in a food product. The growth of the number of fungi can reduce the quality of food products and if the growth of these fungal microbes exceeds the specified standard limit, namely $1x10^2$ colonies/g. As for the optimum moisture percentage in a food ingredient, it is 10% - 42%, so the quality of a food product can be said to be damaged or has decreased (Badan Standardisasi Nasional, 2020) [11].

Packaging methods for food products also need to be watched out for because they can affect the development of microbial activity, one of which is the vacuum packaging method in the form of packaging with reduced air, so that it can reduce the rate of respiration and metabolism to extend the shelf life and shelf life of food products (Razie & Widawati, 2018) [29].

This study aims to explore the effect of storage time at room temperature in vacuum packaging and the concentration of BSF maggot meal addition on the microbiological quality of chicken dendeng in the form of the amount of bacterial and fungal contamination, as well as the percentage of moisture.

Materials and methods

Maggot Meal

The type of maggot used to make this meal was the BSF maggot which was fed with leftover fruits and vegetables from agricultural products that were kept clean, so that it was suitable for processing into food for humans. The stages of making maggot meal consisted of six stages (Supartini *et al*., 2024) [37]. The first stage was maggot sorting, which was separating prepupa maggots from pupa. The second stage was maggot blanching. BSF maggot blanching was done by preparing tools and materials, then 15 kg of BSF maggots harvested at the age of 25 days before the larvae enter the prepupa phase are separated from the cassava. Clean BSF maggots were boiled for the BSF maggot blanching process at a temperature of ± 100°C for 1 minute and drained.

The third stage was the drying process using natural drying by drying in indirect sunlight and airing on a plastic tarpaulin for about 2 days to obtain sun-dried BSF maggots. The fourth stage was the milling stage in the form of grinding dry maggots with a blender. The manufacture of BSF maggot meal was done by drying in an oven at a temperature of 50 ° C for 24 hours, then weighing to determine the meal yield. BSF maggots were left at room temperature for approximately 20 minutes to reduce the temperature and were ground using a blender until BSF maggot meal was obtained with a yield of 51.17%. The fifth stage was the packaging stage into zipper plastic bag and labeling the packaging. The sixth stage is storing maggot meal in the freezer to maintain it was quality so that it can be processed and tested as the next stage. The nutrient content in this BSF maggot meal is 3.3% moisture; 9.35% ash content; 34.45% crude protein content; 8.65% crude fiber; 22.83% crude fat, 24.72% nitrogen-free extract 96.98% total digestible nutrient, and 5,368 Kcal/kg gross energy.

Chicken dendeng

Chicken dendeng manufacture consisted of four stages, namely the preparation stage of tools and ingredients, grinding and mixing spices, the drying stage, and the frying stage (Kemalawaty *et al*., 2019) [21]. Making chicken dendeng with the addition of BSF maggot meal was done by preparing the tools and ingredients, then the chicken breast was prepared approximately 300 g, then complementary spices such as garlic and brown sugar were sliced small to facilitate the process of making dendeng dough. The spices are sauteed until fragrant, then the chicken breast was mashed using a food processor together with spices and 15% tapioca meal to make dendeng dough.

The dendeng dough was weighed to determine the total weight, then divided into 6 pans based on the treatments and repetitions carried out. The 1st to 3rd pans were filled with chicken dendeng dough with treatment without the addition of BSF maggot meal as a control treatment (P0) and the 4th to 6th pans were filled with chicken dendeng dough with the addition of 5% BSF maggot meal as treatment one (P1), then the dough was flattened with a thickness of approximately 4 mm, then each pan was labeled according to the treatment and repetition. The pan containing the dendeng dough was oven-baked at a temperature of 80 ° C for 30 minutes for the first oven, then the dendeng dough from the first oven was removed and turned over for the second oven at a temperature of 80 ° C for 15 minutes. The dendeng dough from the oven was removed and weighed to

determine the yield, then chicken dendeng was obtained with the addition of BSF maggot meal. Sample storage was carried out at room temperature 28 - 30°C in vacuum packaging for 30 days for microbiological and moisture testing.

Moisture Test

According to Badan Standardisasi Nasional (2015) [9] explained that the gravimetric method with a non-vacuum oven is to condition the oven at a temperature of 105°C and wait until the temperature was stable, put the empty cup into the oven for at least 2 hours, move the empty cup into a desiccator for 30 minutes until it was at room temperature again and weigh the weight of the empty cup (A), weigh the sample of approximately 2 g into the cup and weigh it as the weight (B), put the cup containing the sample into the oven at a temperature of 105°C for 16-24 hours, then move the cup using tweezers into a desiccator for approximately 30 minutes and weigh it as the weight (C), do a minimum duplicate test.

The formula for calculating moisture was as follows:

$$\text{Moisture (\%)} = \frac{B-C}{B-A} \times 100$$

Description:
A = weight of empty cup expressed in grams
B = weight of cup + sample before drying
C = weight of cup + sample after drying

Bacterial contamination test

The initial stage in testing the microbiological quality of bacteria is the sampling carried out 4 times with a sample mass of approximately 5 g. Sampling was carried out based on the storage period at room temperature, namely sampling on days 0, 10, 20, and 30 of storage in vacuum packaging. The next step was the sterilization process of the equipment that will be used in the study during the bacterial ALT testing process, which begins with washing the equipment to be sterilized until clean and drying. All equipment was wrapped in paper, then put into an autoclave to be sterilized for 15 minutes at a temperature of 121°C with a pressure of 1 atm. The autoclave was turned off after sterilization is complete, then left for a few minutes until the autoclave temperature drops and all equipment that has been sterilized was removed for immediate use (Maulidina *et al*., 2023) [26].

The media used in microbiological testing on bacteria was Nutrient Agar (NA). The stages of it was manufacture are NA powder was weighed as much as 28 g then dissolved with 1 liter of distilled water. The media was heated and stirred over low heat until homogeneous, the NA and PDA media solutions that have been homogeneous were removed and drained until not too hot. Sterilization was carried out using an autoclave at a temperature of 121°C with a pressure of 1 atm for 15 minutes. If not used immediately, the media can be stored in the refrigerator and can be reheated if it was to be used.

The total bacterial count stage uses the ALT method with a dilution of up to 10^{-5}. The first stage was the preparation of test tubes and test tube racks, each sequentially labeled 10^{-1} to 10^{-5} as a dilution code. Each tube contains 9 ml of physiological NaCl, then the sample was weighed as much as 10 g and ground, then dissolved in an Erlenmeyer flask by adding 90 ml of NaCl solution, then homogenized to obtain a dilution of 10^{-1}. A sample of 1 ml was taken from test tube 1 using a sterile 1000 µl micropipette, then inserted into test tube 2 and homogenized using a magnetic stirrer, to obtain a dilution of 10^{-2}. From the dilution of 10^{-2}, another 1 ml was taken and inserted into test tube 3 containing 9 ml of physiological NaCl, to obtain a dilution of 10^{-3}. Made up to a dilution of 10^{-5} in the same way, then the NA media solution was immediately poured as much as 15 - 20 ml at a temperature of ± 40°C into a petri dish. Samples from test tubes 3, 4, and 5 (dilutions $10^{-3}, 10^{-4}$, 10^{-5} as much as 0.1 ml were taken using different sterile pipettes, then put into a petri dish and stirred in a number 8 pattern (Sundari, 2019) [36]. In the cup that has been poured with the sample, leave it for a while and incubate it for 24 - 48 hours at a temperature of 37°C, then count the colonies that grow using a colony counter with the following calculation formula:

$$N = \frac{\Sigma C}{[(1 \times n_1) + (0{,}1 \times n_2)] \times (d)}$$

(Badan Standardisasi Nasional, 2015a) [10]
Description:

N : Number of product colonies, expressed in colonies per ml or colonies per gram

ΣC : Number of colonies on all plates counted

n_1 : Number of plates in the first dilution counted

n_2 : Number of plates in the second dilution counted

D : First dilution counted

Fungal contamination test

The stages of calculating the amount of fungal contamination were more or less the same as the stages in the bacterial ALT test. The initial stage in testing the microbiological quality of fungi was sampling which is carried out 4 times with a sample mass of approximately 5 g. Sampling is carried out based on the storage period at room temperature, namely sampling on days 0, 10, 20, and 30 of storage in vacuum packaging.

Next was the sterilization process of the equipment that will be used in the research during the ALT bacterial and fungal isolation testing process, which begins with washing the equipment to be sterilized until clean and drying. All equipment was wrapped in paper, then put into an autoclave to be sterilized for 15 minutes at a temperature of 121°C with a pressure of 1 atm. The autoclave was turned off after sterilization is complete, then let stand for a few minutes until the autoclave temperature drops and all equipment that has been sterilized was removed for immediate use.

The media used in microbiological testing on fungi was Potato Dextrose Agar (PDA). The stages of it was manufacture were PDA powder was weighed as much as 39 g, then dissolved with 1 liter of distilled water. The media was heated and stirred over low heat until homogeneous, the PDA media solution that has been homogeneous is removed and drained until it is not too hot. Sterilization was carried out using an autoclave at a temperature of 121 ° C with a pressure of 1 atm for 15 minutes. In the PDA media, the media solution that has been drained, then added 2 ml of cefadroxil monohydrate antibiotic solution into a 1000 ml schott duran bottle to inhibit bacterial growth and prevent

microbial contamination in the surrounding area. If not used immediately, the media can be stored in the refrigerator and can be reheated if it was to be used.

Total fungal count with dilution up to 10^{-4} was done by preparing test tubes and test tube racks sequentially, then labeled 10^{-1} to 10^{-4} as the dilution code. Each tube contained 9 ml of physiological NaCl, then the sample was weighed as much as 10 g and ground to then be dissolved in an Erlenmeyer flask by adding 90 ml of NaCl solution and homogenized, so that a dilution of 10^{-1} was obtained. A sample of 1 ml was taken from test tube 1 using a sterile 1000 µl micropipette, then put into test tube 2 and shaken until homogeneous, so that a dilution of 10^{-2} was obtained. From the dilution of 10^{-2}, another 1 ml was taken and put into test tube 3 containing 9 ml of physiological NaCl, so that a dilution of 10^{-3} was obtained. Repeated until dilution10^{-4}, then PDA media solution is immediately poured as much as 15 - 20 ml with a temperature of ± 40°C into a petri dish. Samples from test tubes 2, 3, and 4 (dilution $10^{-2}, 10^{-3}$, 10^{-4}) as much as 1 ml were taken using different sterile pipettes, then put into a petri dish and stirred with a number 8 pattern. The dish that has been poured with the sample was left for a while, then incubated for 4 days at room temperature or room ± 27°C. After the incubation process, then count the number of fungal colonies on the dish using a colony counter and enter into the calculation of the same formula as ALT in bacteria.

Statistical analysis

This study was conducted with an experimental approach using a completely randomized nested design using two factors, namely the storage time factor (0, 10, 20, 30 days) which was nested in the main factor, namely the BSF maggot meal concentration factor (0% and 5%). Repetition was carried out 3 times to obtain representative data. Analysis of variance with a nested design was carried out to determine the effect of the two factors, then continued with the Tukey test at a significant level of 5%.

Results and discussion

Moisture

Moisture is one of the important factors in determining the quality of a food ingredient, such as processed livestock food ingredients. The moisture in the ingredients can also affect the shelf life. One of the processed livestock food ingredients that is affected by the moisture of the ingredients on its quality is chicken dendeng. The process of making dendeng involves a drying stage with an oven which aims to reduce the percentage of moisture in the dendeng as part of the preservation process and extend the shelf life of the ingredients. Making dendeng is chosen as a meat processing process so that it is not easily damaged. However, this dendeng making process does not completely remove the moisture of the ingredients, so the quality of the product will continue to decrease along with the length of storage (Kim *et al*., 2021) [22]. In general, beef dendeng is categorized as a processed food ingredient from livestock which is a food product with a medium moisture, namely around 10% - 50% (Josopandojo *et al*., 2019) [20].

Raw insect types such as BSF maggots have a fairly high moisture if they do not go through further processing and high moisture is found in insects after the boiling stage because the boiling stage can absorb more water during the processing process. However, to overcome the high moisture, a drying process is carried out because it can reduce the moisture of the material significantly. The heating and drying process with a long time and high temperature is thought to cause high water evaporation in the material (Wijaya *et al*., 2019) [40].

Foodstuffs with low moisture have a longer shelf life compared to foods with high moisture (Fikriyah & Nasution, 2022) [15]. In addition, determining the moisture in a food ingredient is very important to ensure proper handling measures both in processing and in distribution because improper handling or incorrect method of determining moisture will result in food damage and endanger health. The thermogravimetric method is one of the quantitative methods for determining the moisture in a material by drying the material and weighing it until its weight is constant (Nuryanti, 2018) [28].

Chicken dendeng is one of the processed livestock products that is classified as high in nutrients, so the addition of food additives that are rich in protein such as BSF maggot meal causes dendeng products to contain high nutrients, especially protein content of up to 40 - 50% (Bosch *et al*., 2014) [6]. Based on this, the effect of storage time and concentration of BSF maggot meal addition on the percentage of moisture of chicken dendeng can be seen in Table 1.

Table 1: The Effect of Storage Time and Concentration of BSF Maggot Meal on Moisture (%) in Chicken Dendeng

Concentration	Storage Period (Days)			
	0	10	20	30
0%	42,05 ± 5,62	44,21 ± 2,22	44,05 ± 4,59	44,83 ± 6,16
5%	40,57 ± 2,54	43,48 ± 2,46	42,28 ± 2,38	44,12 ± 4,67

Note: No significant difference (P > 0.05)

Based on Table 1 regarding the moisture of chicken dendeng added with BSF maggot meal with a percentage of 0% and 5% on days 0, 10, 20, and 30, it shows a change from 42.05% to 44.83% in the treatment without the use of maggot meal (0%) based on the storage period of days 0 to 30, and from 40.57% to 44.12% with the addition of 5% BSF maggot meal based on the storage period of days 0 to 30. Based on Table 1, it is concluded that there is no significant difference in moisture with the addition of 0% and 5% maggot meal in the storage period of days 0, 10, 20, and 30. The moisture on days 10 to 30 is in the range of 42.28% - 44.83%, but based on Badan Standardisasi Nasional (2020) [11], stated that the optimum moistue in packaged cooked dendeng is 10% - 42%. In the research Marsela & Budi (2022) [24], It is stated that dendeng as a processed product from semi-moist meat texture, also added with complementary ingredients such as salt, sugar and other spices can contain a moisture percentage of 12% to 40% when stored at room temperature.

The percentage of moisture in chicken dendeng added with BSF maggot meal with a storage period of 30 days is still not considered optimal, so to obtain a good percentage of moisture, a storage method of less than a week is needed with the addition of BSF maggot meal. This is because the percentage of moisture of dendeng with the treatment of adding BSF maggot meal is lower than dendeng without the addition of BSF maggot meal which can better maintain the quality of chicken dendeng products.

In the research Usfinit *et al*., (2023) [38] which proves that the moisture in processed chicken meat with the addition of insects can reach 34.46% - 55.09% and the highest moisture is found in the use of 100% chicken meat without the use of insect meal, so that in this case the addition of insects to a processed food ingredient, such as processing it into meal can reduce the moisture of the ingredients in it and can minimize damage to the ingredients due to high moisture. The addition of insects processed through the mealing process, in addition to increasing the nutrients contained in processed food ingredients, can also extend the shelf life of the ingredients because the moisture in the ingredients can be lower, making it easier to package the product, and can increase sales distribution to consumers *(*Asthami *et al*., 2016) [4].

Factors that affect the amount of moisture in a food ingredient are temperature and humidity. Lower room temperature can cause an increase in the absorption of moisture in the material, while the relative humidity in the surrounding environment with a high humidity level will cause an increase in the percentage of moisture in chicken dendeng (Masum *et al*., 2020) [25]. In an effort to maintain the quality of dendeng, it is necessary to regulate humidity as an ingredient used to balance the moisture of the material and used to increase the freshness and tenderness of the dendeng (Han *et al*., 2023) [17]. The percentage of moisture in dendeng is also influenced by the processing method because the dendeng processing method used, such as the oven method and the addition of spices, in addition to considering organoleptic quality, also influences the percentage of moisture in the ingredients, the color of the dendeng, the shelf life of the product, and fat oxidation (Alamuoye *et al*., 2024) [3].

The determination of the large and small moisture of dendeng is also influenced by the spices added in the manufacturing process, one of which is the addition of sugar as a sweetener. The addition of granulated sugar or brown sugar in the dendeng manufacturing process can bind and minimize the moisture in dendeng that is too high. Granulated sugar and brown sugar as spices added to chicken dendeng added with BSF maggot meal contain 89% - 97% sucrose, so that with the high sucrose percentage content it can bind the high moisture in chicken dendeng, but granulated sugar has a greater water binding capacity compared to brown sugar because it contains 94% sucrose (Nugraha *et al*., 2021) [27]. In this case, it can be concluded that to minimize the high percentage of moisture in chicken dendeng, sugar can be added because it contains sucrose, but it is still necessary to pay attention to the limit on the percentage of sugar used, which is around 25% to maintain the health of consumers (Jeklin, 2016) [19].

Seasonings added in the making of dendeng and affect the water moisture, in addition to sugar, are salt, phosphate, glycerin, and trehalose. Salt added to dendeng, in addition to providing a salty taste, is also used as a preservative. The glycerin compound in dendeng has the ability to bind high water through hydrogen bonds in the ingredients. In addition, the glycerin compound can also be an additive that is useful for extending the shelf life of the product. The phosphate content in chicken meat as a raw material for dendeng is useful for increasing water binding capacity, improving texture, and extending the shelf life of processed meat products. The trehalose content in chicken dendeng has a function in increasing hydration properties and reducing water migration in the ingredients (Han *et al*., 2023) [17].

Moisture in food also affects microbial activity because food that contains high moisture will mostly be damaged due to high microbial activity. However, in chicken dendeng that has gone through a drying process using the oven method, it is expected to minimize damage due to microbial activity because the moisture of the dendeng is lower and can slow down the growth of rotting microbes, and can extend the shelf life of the dendeng. Ground chicken dendeng has a higher percentage of moisture compared to the moisture of sliced chicken dendeng. This is because in ground dendeng, all the spices will be perfectly absorbed in the chicken dendeng that is made and cause the high weight of the ingredients in the dendeng (Salsabila *et al*., 2023) [23].

Bacteria

Chicken meat is one type of meat that is widely consumed by the public because in addition to being cheaper, it also has a high nutrient content. In addition, chicken meat is also widely chosen by the public because it is easy to process into quality food ingredients and has a long shelf life, for example, processing chicken meat into dendeng products. Chicken dendeng products have been widely circulated in the community, so that new innovations have been made by adding BSF maggot meal which is rich in animal protein and not many people have utilized this potential. However, chicken dendeng which is added with BSF maggot meal because it contains high nutrients, will result in a decrease in quality due to microbial activity, such as pathogenic bacteria. In addition, improper product handling will also damage the quality of the product and contain many pathogenic bacteria that can endanger human health (Wei *et al*., 2024) [39]. The increase in the total number of bacteria in processed chicken meat can be influenced by environmental conditions, namely temperature, pH, humidity, and oxygen availability. Based on this, the effect of storage time and concentration of BSF maggot meal addition on the number of chicken dendeng bacteria can be seen in Table 2.

Table 2: The Effect of Storage Time and Concentration of BSF Maggot Meal on the Number of Bacteria (..×10^5cfu/g) on Chicken Meat Dendeng

Concentration	Storage Period (Days)			
	0	10	20	30
0%	1,28 ± 0,92^a	2 ± 0,82^a	2 ± 0,61^a	2,03 ± 0,51^a
5%	1,43 ± 0,82^a	3,33 ± 0,61^b	3,5 ± 0,10^b	3,43 ± 0,12^b

Note: Numbers followed by different letter notations indicate a significant difference (P < 0.05)

Table 2 shows the bacterial ALT in chicken dendeng samples added with BSF maggot meal on days 0, 10, 20, and 30, there were changes, namely from 1,28 x 10^5 cfu/g become 2,03 x 10^5 cfu/g in treatments without the use of maggot meal based on storage time from day 0 to day 30, as well as from 1,43 x 10^5 cfu/g become 3,5 x 10^5 cfu/g on the addition of 5% BSF maggot meal based on storage time from day 0 to day 30.

Table 2 can be concluded that there is a significant difference in the number of bacteria with the addition of 0% and 5% maggot meal for storage periods of 0, 10, 20, and 30 days. The difference with a high correlation is the number of bacteria on days 20 and 30. The number of bacteria from the

test results is in the range 1,28 × 10^5 cfu/g – 3,5 × 10^5 cfu/g, where the number is still within the range $10^4 - 10^6$ cfu/g, so that it meets the quality requirements for microbiological contamination in packaged cooked ground beef dendeng based on Badan Standardisasi Nasional (2020) [11]. Table 2 shows that the number of bacteria with the addition of 0% and 5% BSF maggot meal can increase along with the length of storage time at room temperature in vacuum packaging.

The number of bacteria with the addition of 0% maggot meal was lower compared to 5%. The concentration of 5% maggot meal, especially on the 20th day of storage, showed the highest number of bacteria, but experienced a slight decrease on the 30th day with an average showing 3,5 × 10^5 cfu/g become 3,43 × 10^5 cfu/g. The number of bacteria with a concentration of 0% BSF maggot meal on day 0 of storage showed the lowest number. Based on this, it can be concluded that the longer the storage time of dendeng and the greater the percentage of BSF maggot meal addition to chicken dendeng, the more the number of bacteria will increase.

Chicken dendeng processed through a drying process with the aim of extending the shelf life and as a product preservation can minimize the number of pathogenic bacteria that appear in a product. In the study (Sorapukdee *et al*., 2016) [35] it is stated that the total number of bacteria in processed preserved chicken meat products can reach 2.79 log cfu/g. The right product drying method can eliminate most pathogenic microbes, so that microbiological safety can be maintained properly, but the length of product storage time, especially if stored at room temperature, will not guarantee the quality of processed livestock products.

In the research Shaltout *et al*., (2018) [33] It is stated that the total number of microbes in processed chicken meat products can reach an average of $4{,}24 \times 10^6$ cfu/g until $7{,}12 \times 10^6$ cfu/g. The large total number of bacteria in processed chicken meat can be caused by its susceptibility to decay and not infrequently there is also the spread of diseases transmitted to food products. The stages of slaughtering and processing chicken meat to make processed products also have the potential to experience contamination which can increase the number of bacteria in processed chicken meat food ingredients. The appearance of bacteria in food ingredients, especially in chicken meat, can cause the meat to smell bad and cause mucus because the longer the duration of product handling, the more contaminating bacteria will appear in the food ingredients.

Chicken meat is a good medium for microbial growth because it contains high nutrients, such as carbohydrates, proteins, and minerals. The total number of chicken meat bacteria processed into dendeng can reach $25{,}4 \times 10^6$cfu/g and has a shelf life of up to 20 hours at room temperature. However, to extend the shelf life of the ingredients, the smoking method can be used on chicken meat (Ina *et al*., 2022) [18].

The packaging form of a product can also affect the number of bacteria in it. Packaging forms such as vacuum packaging can minimize damage and the emergence of pathogenic microbes in animal-derived food ingredients. Vacuum packaging has several advantages, including being easy to operate, protecting the product from microorganisms, oxidation, and contamination that can cause damage (Wei *et al*., 2024) [39].

In the manufacture of chicken dendeng with added BSF maggot meal, in addition to chicken meat, bacteria in other food ingredients also need to be considered, such as other protein source foods, namely insects. Maggots can be processed as food ingredients, such as meal in the maggot phase, so it is also necessary to pay attention to the level of food safety and microbiological quality by knowing and determining the types of bacteria contained in it. In maggots themselves there are several types of bacteria such as lactic acid bacteria and cellulolytic bacteria, such as *Bacillus sp.*, *Proteus morganii*, and *Rumenococus sp*. BSF maggots do not have antimicrobial activity on gram-positive bacteria such as *Bacillus subtilis*, *Streptococcus mutans*, and *Sarcina lutea*, but show inhibition zones on gram-negative bacteria (*Klebsiella pneumoniae*, *Neisseria gonorrhoeae*, *and Shigella sonnei*) (Auza, 2022) [5].

pH affects the growth of pathogenic bacteria, namely at an optimal pH of 7.2 to 7.6. The next factor is humidity, where microbes can grow in wet media and humid air. The humidity value for microbes is generally 0.90 to 0.999. Another important factor is the availability of oxygen and is grouped into aerobic (grows when there is oxygen), anaerobic (grows when there is no oxygen), facultative anaerobic (grows with or without oxygen), and microaerophilic (grows when there is oxygen, but in small amounts) (Rini & Rohmah, 2020) [30].

The growth of pathogenic bacteria in high numbers in processed food ingredients from livestock can cause harmful effects to human health, so proper handling is needed. The use of proper packaging by paying attention to cleanliness and storing products in the refrigerator can minimize high microbial growth and maintain the quality of processed products. In addition, the use of argon gas or carbon monoxide has been widely used in the preservation process of processed chicken meat foods (Silva *et al*., 2018) [34].

Fungi

Processed livestock products such as chicken meat contain high nutrients and are used as a good growth medium for various types of microbes. One of the microbes often found in processed chicken meat is fungus. Fungi are eukaryotic microorganisms that live as parasites that grow on other microorganisms. The high moisture of chicken dendeng can also cause damage to food due to the activity of pathogenic microbes such as fungi. The appearance of fungal microbes in chicken dendeng can also be caused by the length of storage. Based on this, the effect of storage time and the concentration of BSF maggot meal addition on the amount of fungus in chicken dendeng can be seen in Table 3.

Table 3: The Effect of Storage Time and Concentration of BSF Maggot Meal on the Amount of Fungal Contamination in Chicken Dendeng

Concentration	Storage Time (Days)			
	0	10	20	30
0%	n.d.	n.d.	n.d.	n.d.
5%	n.d.	n.d.	n.d.	n.d.

Note: n.d indicates no fungi detected

Table 3 shows that no fungal contamination was detected in chicken dendeng during 30 days of storage. This indicates that chicken dendeng is safe for consumption because the amount of fungus is below the maximum limit of microbial contamination in food and it is acceptable that the food

processing process has met good processed food production methods, namely $1 \times 10^2 cfu/g$ - $2 \times 10^2 cfu/g$ (Badan Standardisasi Nasional, 2009) [8].

The type and count of fungi contained in a food ingredient can be known through a testing process. The purpose of testing the amount of fungal contamination is to determine whether or not there is fungal contamination in a food ingredient or it can also be interpreted as determining the number of fungal colonies in a food ingredient because the growth of this fungus can reduce the quality of a food ingredient. (Delviani *et al*., 2021) [13]. The number of fungi in processed chicken dendeng products on day 0 of storage has not been seen, but as the storage period increases, it will cause an increase in the number of pathogenic fungal microbes that are harmful to human health.

The high level of contamination from humans, dirty environment, and improper storage temperature can cause high mold growth. Based on this, sanitation is an important factor to keep processed products from being contaminated by pathogenic microbes that are harmful to human health (Hasanah *et al*., 2024) [2].

In the research Al Hasanah *et al*., (2024) [2] It was stated that the results of calculating the amount of fungal contamination in processed chicken meat products showed a figure of $1{,}17 \times 10^3 cfu/g$ until $1{,}62 \times 10^2 cfu/g$. The type of fungus found in processed chicken meat is *Aspergillus Niger*. This type of fungus has characteristics, namely having threads or hyphae that are white or yellow in color. The presence of these fungal microbes can also be caused by improper product handling and lack of sanitation in the product processing process and equipment used.

Packaging a processed livestock product in the form of vacuum packaging is in principle carried out by removing gas and water vapor from the product, while in non-vacuum packaging it is carried out without removing gas and water vapor from the product, so that storing the product in vacuum packaging can reduce the amount of microbial contamination, such as fungi (Adawiyah *et al*., 2016) [1]. The addition of spices used in the process of making chicken dendeng such as coriander and galangal can inhibit the growth of pathogenic microbes such as fungi (Hadrin *et al*., 2021) [16].

In this study, it was found that the microbiological quality of chicken dendeng added with Black Soldier Fly (BSF) maggot meal will decrease along with the increasing storage time at room temperature. This decrease can be seen from the increase in the number of bacteria along with the storage time. In addition to the storage time factor, the moisture of dendeng also plays an important role in its microbiological quality. Interestingly, chicken dendeng containing 5% maggot meal showed a higher number of bacteria compared to dendeng without maggot meal, but the number of fungi in the dendeng was not identified. This finding opens up insight into the role of maggot meal in changing the microbiological profile of chicken dendeng, which can have implications for the development of safer and more durable processed meat products.

This research has advantages, namely its innovative approach in combining BSF maggot meal which is used as an additional ingredient in chicken dendeng during storage in vacuum packaging. The use of BSF maggots also supports sustainability and the use of environmentally friendly local resources. In addition, this study explains the factors that can affect microbiological quality, such as moisture and storage time, which can be applied in the development of safer and more durable processed meat products.

In addition to the advantages, this study also has disadvantages, in the form of limitations in testing the duration of storage, which was only tested at a certain time without considering long-term storage or extreme storage conditions. In addition, although the effect of maggot meal concentration was found, this study did not explore further concentration variations that might provide more optimal results. Another limitation is that it only measures the number of bacteria and fungi as microbiological indicators, without examining other types of bacteria, such as *Enterobacteriaceae*, *Staphylococcus aureus*, and *Salmonella* which can pose a risk to food safety. In the future, this study can be expanded by testing various concentrations of BSF maggot meal to find the most effective dose in producing quality BSF maggot meal-based dendeng products that are accepted by consumers. In addition, tests under more diverse storage conditions, such as low temperature or high humidity, can provide a more complete picture of product durability.

Conclusion

The addition of 5% (w/w) BSF maggot meal to chicken dendeng has the potential to be used for sustainable protein sources. Storage in vacuum packaging can be a solution to maintain quality and extend the shelf life of dendeng, even though the dendeng is stored at room temperature. Sensory evaluation will be very important to determine consumer acceptance.

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