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The effects of fried shallot (*Allium Ascalonium L.*) on the physical quality and acceptability of beef meatball

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Abstract
Shallots (*Allium ascalonicum L.*) are widely used culinary ingredients known to enhance the physical properties and sensory appeal of meat-based products in Indonesia. This study aimed to determine the effect of incorporating fried shallot into beef meatballs, focusing on their physical properties, specifically water holding capacity, cooking loss, and firmness, as well as sensory acceptability, including color, taste, aroma, chewiness, and overall acceptance. The research employed an experimental method using a Completely Randomized Design (CRD) with four treatments and five replications P0 (0%), P1 (2.5%), P2 (5%), and P3 (7.5%). An analysis of variance (ANOVA) was used to determine the effect of fried shallot addition on the physical characteristics of the beef meatballs, followed by the Duncan's multiple range test. Acceptability was evaluated using the Kruskal-Wallis test, and significant differences between treatments were further analyzed using the Mann-Whitney test. Results showed that the 5% fried shallots addition (P2) was the most ideal, producing the best physical qualities with a water holding capacity (WHC) value of 21.63%, cooking loss of 3.3%, and firmness of 99.87 mm/g/10 seconds. Sensory acceptability was rated at '2' on a numerical scale, indicating 'slightly like'.

Keywords: Shallots, fried shallots, beef meatball, physical properties, sensory acceptability

Introduction

Beef meatballs are a popular processed meat foodin Indonesia, , typically made by grinding beef and mixing it with various spices, binders, and fillers, then forming the mixture into balls and boiling them (Halid *et al*., 2023) [1]. According to the Indonesian National Standard (SNI)3818: 2014, meatballs are defined as processed meat products made from animal meat mixed with starch and spices, with or without other food ingredients, and/or permitted food additives, shaped into balls and cooked. According to SNI classification, there are two categories of meatballs: those with a minimum of 50% meat content and combination meatballs containing at least 20% meat.

The addition of fried shallots to beef meatballs is intended to improve various factors, especially flavor and tenderness. SNI outlines several quality criteria for meatballs that can be improved, including a standard aroma and taste profile typical of meat (SNI, 2014) [2]. Fried shallots contribute distinctive aromatic and flavor qualities that can complement and elevate these characteristics. In culinary practice, fried shallots are also used as garnishes, suggesting their potential to improve both the taste and overall acceptability of meatballs (Yofananda *et al*., 2020) [3].

Various additives are added to various foods to enhance their nutritional and sensory qualities, one of which is carbohydrates. Carbohydrates are essential macronutrients that serve as the primary energy source for humans. They are abundantlyfound in grains, tubers, fruits, and vegetables. Beyond their role in energy provision, carbohydrates can form texture, viscosity, and food stability. These multifaceted functions makecarbohydrates critical in food formulation and processing (Siregar NS, 2014) [4].

In addition to dietary fiber, fat is also one of the components that has various benefits in food. Fat is an important component in increasing the physical integrity of food products. It is a hydrophobic compound that occurs in various forms in both plant and animal sources. In plant-based foods, fat, commonly known as vegetable fat, is found in legumes or coconuts. Fat itself has the ability to improve the taste and texture of a food product which has the potential to increase acceptability (Ariani *et al*., 2024) [5].

Fried shallots have a significant amount of fats (approximately 35%) and carbohydrates (approximately 42%), which support their dual functionality in food enhancement. Traditionally used as garnishes, fried shallots widely appreciated for their ability toenhance the aroma, flavor, and texture of dishes. In addition, shallots can also provide a distinctive texture sensation, making food more enjoyable and appealing (Yofananda *et al*., 2020) [3].

Excessive use of shallots in a food product can cause various side effects. One such issue is the high sulfur content in shallots, which, when consumed in large quantities, can lead to unpleasant breath and an overpowering onion flavor that masks the balance of other ingredients (Yofananda *et al*., 2020) [3].

Limiting the use of additives in food needs to be considered to get good results. One study found that adding garlic to meatballs as much as 5% of the meat produced meatballs with a strong onion flavor and the best antimicrobial properties (Mahros *et al*., 2021) [6]. Another study demonstrated that the addition of onion extract at concentrations between 5% and 10% to meatballs obtain ideal food quality and good shelf life. These findings support the effectiveness of shallot addition in the 5%–7.5% range for achieving balanced flavor and improved product characteristics. (Elhassaneen *et al*., 2023) [7].

Materials and Methods

This research was conducted at the Livestock Product Processing Technology Laboratory, Faculty of Animal Science, Padjadjaran University. The process used materials including 4 kg of frozen shank part of beef sourced from

Cihapit market In Bandung, West Java; 200 gram of tapioca flour; 1 kg of shallots sourced from Sumenep, East Java; 3% garlic by the weight of the meatball dough; Palm oil; 3 litre of water; 1,5% salt by the weight of the meatball dough; 1% pepper by the weight of the meatball dough; 1% beef-flavored MSG by the weight of the meatball dough, and 10% of ice cube by the weight of the meatball dough.

The equipment used included a meat grinder, mixer, scales with an accuracy of 0,01 gr, digital scales, penetrometer, thermometer, Whatman No. 41 filter paper, knife, cutting board, stove, pan, iron basin, oven, ceramic cup, oven, desiccator, plastic clips, oil strainer, ruler, stopwatch, calculator, heat resistant plastic, label paper, laptop, paper and pen, questionnaire sheets, plates, glass cup, and tissues. The research was conducted experimentally with a Completely Randomized Design (CRD) with four treatments of added concentrations of fried shallot (0%, 2,5%, 5%, 7,5%) and five repetitions, resulting in 20 experimental units. The data on physical quality were processed statistically through Analysis of Variance (ANOVA) manually. If a significant difference was found, it was followed by by the Duncan's Multiple Range Test at a significance level of P≤0,05, also conducted manually. Meanwhile, the acceptability test processed through Krukal-Wallis test to find the significance between the independentand dependent variables at a significance level of P > 0,05. If significant, it was followed by the Mann Whitney test at a significance level of P ≤ 0,05 using IBM SPSS.

Procedure for making fried shallots

Before making the selection of fried shallots , fresh shallots were selected to ensure consistency of shallot quality, and the quantity of shallots used is adjusted to the research treatment. Next, the shallot was peeled and then thinly sliced. The sliced shallots weresoaked in salt solution (5%). After soaking, the shallots were drained and fried in palm oil until golden brown. The fried shallots are then drained to remove excess oil (Khasanah *et al*, 2019) [8].

Procedure for making beef meatballs

Beef shank was first weighed to a total of 4000 grams and divided into four portions for each treatment group, and further subdivided into five parts for each repetition. Various ingredients were weighed using a digital scale, including tapioca flour 5%, ice cubes 10%, salt 1.5%, pepper 1%, garlic 3%, flavoring 1% and fried shallots as much as 2.5%, 5% and 7.5% of the meat weight. All beef portions were ground using a meat grinder until the texture was smooth and then collected in a basin. All ingredients, including tapioca flour, garlic, salt, pepper, flavoring, ice cubes and fried shallots were mixed using a food processor until homogeneous. The resulting dough was shaped manually using a tablespoon to form meatball with a diameter of 2.5-3 cm. and the meatballs were boiled in water at a temperature of 50-60 ° C for 8 minutes. Boiling was then continued at a temperature of 100 ° C for 10 minutes until the meatballs floated. After boiling, the meatballs were drained and cooled at room temperature for 30 minutes. (Harmini *et al*, 2021) [9].

Water Holding Capacity

The water holding capacity test measures the ability of a food product to retain water during external treatment. This test was divided into two phases: free water content and total water content. The following are the stages of the free water content test using the pressing technique (Khomsi, 2024) [10]

1. Weigh 0.3 grams of the sample
2. Wrap the sample in Whatman No. 41 filter paper and place it between two glass plates.
3. Press the sample with a 35 kg load for 5 minutes
4. Measure the wet area on the filter paper and the total area of the filter paper using the formula for the area of a circle
5. Calculate the free water content using the following formula.

$$mg\ H_2O = \frac{Area\ (cm^2)}{0.0948} - 8.0$$

Explanation:
mg H_2O = Free Water Content
Area = Area of Water
0.0948 = Constanta
8.0 = Constanta

Meanwhile, the total water binding capacity test using the drying method can be continued with the following stages (Anggraini *et al*., 2020) [11]

1. The sample is first weighed and recorded at 5 grams
2. An empty cup it is dried in an oven for 30 minutes at 105 ° C, cooled and weighed.
3. The weighted sample is put into an cooled empty cup , then oven-dried at a 102 ° C for 3 hours (with an additional hour if needed) until a constant weight is achieved.
4. The cup is then cooled using a desiccator for 30 minutes.
5. The final weight of the sample is recorded.

$$Total\ Water\ Rate = \frac{(x+y)-z}{x} \times 100\%$$

Where:
x = Sample weight before oven
y = weight of filter paper
z = sample weight after oven

To calculate Water Holding Capacity (WHC), the formula used is:

$$WHC = Total\ Water\ Rate - \frac{mg\ H_2O}{300} \times 100\%$$

Cooking Loss

Cooking loss refers to the reduction in weight of the food product due to the cooking process. The following are the steps of the cooking loss test:

1. The weight of eacah meatball dough portion is measured per unit per experiment.
2. Next, the meatball are molded and cooked by first boiling them for 8 minutes at 50-60 ° C and continued with the second boiling at 100 ° C for 8 minutes
3. The meatballs are then drained and cooled for 15 minutes at room temperature.
4. The sample is reweighed and the cooking loss can be calculated using the following formula:

$$Cooking\ loss = \frac{B1 - B2}{B2} \times 100\%$$

Where:
B1 = Sample weight before cooking
B2 = Sample weight after cooking

Firmness

T Firmness was measured using an Intest penetrometer. The following steps were taken to measure meatball firmness:

1. Meatball samples are cut into cubes of 2 x 2 x 2 cm.
2. The meatball sample that has been cut can be placed under the penetrometer needle and make sure the scale is set to zero before the needle touches the sample.
3. Press the penetrometer lever for 10 seconds and the firmness is read from the penetrometer scale.
4. Meat firmness can be calculated using the formula

$$Firmness\ (\text{mm/g/10 second}) = \frac{Number\ of\ Measurement\ results}{10}$$

Acceptability Test

Acceptability was evaluated using the organoleptic method. This test involved 20 moderately trained panelists from the Faculty of Animal Science, Padjadjaran University. The panelists evaluated samples based on color, taste, aroma, and texture.

The following are the stages of the organoleptic test carried out:

1. Cooked meatball samples are placed on labeled plates according to their respective treatment.
2. Each panelist is provided with a glass of water to cleanse their palate between tastings.
3. Panelists taste each sample and evaluate themusing a questionnaire
4. The hedonic scale used in the questionnaire is converted into a numericalscale for analysis.

Table 1: Transformation from hedonic scale to numeric scale

Hedonic Scale	Numeric Scale
Absolutely do not like it	5
Do not like it	4
Slightly like it	3
Like it	2
Strongly like it	1

Results and Discussion

Table 2: Average physical quality and Duncan test of physical quality

Variable	Treatment			
	P0 (0%)	P1 (2,5%)	P2 (5%)	P3 (7,5%)
Water Holding Capacity (%)	31.07%^{b}	16.56%^{a}	21.63%^{a}	22.56%^{a}
Cooking Loss (%)	3.30%^{c}	3.55%^{ab}	5.35%^{bc}	5.75%^{c}
Firmness (mm/g/10 second)	90.00^{a}	82.40^{a}	99.87^{ab}	105.40^{b}

Note: Different superscript letters indicate a statistically significant difference ($P \leq 0.05$) based on Duncan's Multiple Range Test.

Water holding capacity

Based on table 2, it can be seen that the treatment with the addition of fried shallots (P1, P2 and P3) showed a lower water holding capacity value compared to without the addition of fried shallots. This is due to the increasing amount of fiber which can reduce the Water Holding Capacity. The increasing amount of fiber can reduce the ability of food emulsions. Fiber itself has the property of binding to food proteins which can function as emulsifiers, but this bond can reduce the protein contained in processed foods. Lack of protein in food causes the interfacial oil-water bond to be unstable (Sarka & Singh, 2016) [12]. The addition of fiber with high concentrations can cause fat droplets to be less evenly mixed with the dough so that the dough is less homogeneous. Fat that is inhibited from being dispersed in the dough can reduce the mobility of the emulsion properties of food on the surface (Dickinson, 2003) [13].

The nature of carbohydrates that absorb water is one of the factors why the binding power of beef meatballs with the addition of shallots has good fluid retention. Good water retention can reduce cooking losses and maintain food nutrition (Suryani, 2006) [14]. However, during cooking, water-soluble fibers tend to degrade, unlike their insoluble counterpart (Pérez *et al*., 2009) [15]. The relatively high fat content in fried shallots can indirectly affect the water binding capacity. Fat can indirectly increase the protein content in meat, so that with high protein it can increase the water binding capacity of food (McClements, 2016) [16].

Cooking loss

Based on table 2, the cooking loss observed in treatments P1 (2.5%) and P2 (5%) showed smaller values compared to P0. Meanwhile, P3 did not provide a significant difference with P0 in the cooking loss aspect. This trend may be because the high carbohydrate content in fried shallots causes minimal cooking loss in beef meatballs. This is reflected in the increase in fried shallot content along with the decrease in cooking losses from beef meatballs, but its use needs to be limited. In treatment P3 (7.5%), cooking losses increased. This increase may be explained by the high oil content of fried shallots. When added excessively, the oil can lead to greater fluid separation during cooking, thereby elevating the cooking loss in beef meatballs(Ana Florencia de Alzaa, 2010) [17].

The cooking loss capability is correlated with Water Holding Capacity. Higher WHC often results in lower cooking loss. However, in this study, cooking loss and water holding capacity have the same value. One factor is the emulsion which is inhibited by the fiber content of shallots. The high insoluble fiber content in fried shallots causes the food dough to be unstable. Destabilization is caused by the clumping of fat droplets in the dough. Particles contained in crude fiber which can be found in cellulose or lignin can also disrupt the homogeneity of the food dough (Joyce, 2017) [18].

Another relevant factor is the fiber capacity of onions. Along with the addition of fried shallots to beef meatballs, the fiber content of the food increases, but fiber has a water content limit. The content of fried shallots which is dominated by water-insoluble fiber can accommodate 3-10 grams of water/g of fiber (Chau & Huang, 2003) [19].

Firmness

Based on table 2, the firmness of beef meatballs shows the tenderness value in treatment P3 (7.5%) with a result of 105.4 mm/g/10 seconds which is higher than P1 (2.5%) and P2 (5%) and P0 (0%). The increase in tenderness is caused

by the increase in carbohydrate levels contained in fried shallots. Many carbohydrate components are contained in starch and fiber in food (Walsh *et al*., 2010) [20]. Soluble fiber is often found in fried shallots, such as pectin. Soluble fiber itself can easily increase the juiciness of a food due to the softer texture of the food. Soluble fiber is also a hydrocolloid which is commonly used in the food industry as an emulsifier (Elleuch *et al*., 2011) [21].

The interaction of carbohydrates and proteins can also affect the food texture. The sugar content within carbohydrates can weaken the gluten network, while starch can strengthen the food structure with the right cooking temperature (J.A. Delcour, 2010) [22]. The interaction of carbohydrates and proteins occurs in the process of mixing fried shallots, wheat flour and beef during mixing. Mixing in a food processor forms the texture of the meatball dough and the coagulation of the meatballs which forms an intramolecular bond between the carbohydrate group and the protein group.

The oil content in fried shallots plays a role in the tenderness of the end product in food. The role of lubrication in cooking oil can affect the interaction of molecules in the dough by reducing friction in the food, resulting in a softer food texture (Stauffer, 2007) [23]. Moreover, oil can inhibit the gelatinization of starch which can be found in the manufacture of meatball dough and form a layer of gluten tissue in food which can form a softer texture (Conforti, 2006) [24].

Table 3: Average acceptability test and Duncan test of acceptability

Variable	Treatment			
	P0 (0%)	P1 (2,5%)	P2 (5%)	P3 (7,5%)
Color	2.2 [a]	2 [a]	1.95 [a]	1.9 [a]
Aroma	2.15 [a]	2.05 [a]	2 [a]	2.2 [a]
Taste	2.35 [a]	1.85 [a]	1.8 [a]	1.75 [a]
Firmness	2.25 [a]	2.3 [a]	1.8 [a]	1.95 [a]
Overall Acceptance	2.3 [a]	1.9 [a]	1.9 [a]	1.8 [a]

Note: Different lowercase letters in the end of indicate a significant difference.

Color

Based on Table 3, there was no significant difference in color preference between the various treatments, either from P0 or between the fried shallot addition treatments. The average panelist scores ranged from 37.8 to 42.3, and continued with the Kruskal Wallis calculation. The numerical scale in the data shows an increase in color preference in panelists with the addition of fried shallots, indicating that it can increase the color preference of panelists. The test was continued with the Kruskal Wallis test to determine whether there was a significant difference between treatments in the data. The Kruskal Wallis calculation was greater than 0.05 which can be interpreted as a rejected hypothesis and there was no significant difference between the data.

Although the statistical analysis does not show a significant difference, a visual trend can be observed in the slight increase in panelist preference with the addition of fried shallots. Shallots have a purplish red color pigment called quercetin and anthcyanin which are easily soluble in water and can provide color to food if used in sufficient quantities. During the frying process, the shallots undergo the Maillard reaction, an interaction between reducing sugars and amino acids, which results in a golden-brown coloration(Adna Ridhani & Aini, 2021) [25]. Adding fried shallots can give a brownish color to beef meatballs, but a large amount is needed to get a significant color difference.

Aroma

As shown in Table 3, the average ranking results of the tenderness aspect of beef meatballs given fried shallots ranged from 39.38 to 42.56. The data was then processed into the Kruskal Wallis test to determine whether there was a significant difference between the treatments. Kruskal Wallis test indicated that there was no significant difference between the treatments.

Raw shallot has a distinctive aroma due to the content of various volatile compounds such as sulfur and cysteine, which evaporate easily when exposed to heat. The frying period can cause volatile compounds to decrease through evaporation and heating degradation, causing the distinctive aroma of raw shallots to decrease. In addition to cooking, processes such as soaking onions can also reduce volatile compounds (Fellows, 2017) [26]. The influence of other spices that affect the aroma such as garlic and pepper and meat in the meatball dough can cover the distinctive aroma of shallots and dominate the aroma of beef meatballs**.**

Taste

The average ranking results of the taste aspect of beef meatballs ranged from 32.5 to 43.45, with an average hedonic score categorized as "slightly like". These ranking data were further analyzed using the Kruskal Wallis calculations to determine the magnitude of the difference in value between the various treatments tested. Data points that share the samelowercase letter at the data that does not have a significant difference.

There are many factors that affect the taste of a food preparation, one of which is the lack of ingredients used in the preparation of beef meatballs. According to Soeparno (2015), the effect of spices on beef food preparations requires a relatively high quantityto provide a significant effect [27]. In this study, the addition of 7.5% fried shallots did result in a higher sensory score compared to samples without fried shallots; however, the difference was not statistically significant.

Factors other than spices can also be due to the taste of meat that is too strong in beef meatballs. Beef has a dominant taste if used in large quantities (Ledward, 2017) [28]. In this case, the flavor of the fried shallots may have been masked by the strong beef taste, especially since the amount used was relatively low, and other supporting ingredients were minimal. This may have resulted in no significant difference between the treatment groups and the control.

Firmness

Table 3 shows the firmness values in the form of the average ranking and the panelists' numerical scale in the meatball acceptability test. The average rankings ranged from34.43 to 48.15 with an average hedonic scale of "rather like" in all aspects. The data was further processed with the Kruskal Wallis test to determine whether there was a significant difference in value between the data. The data shows the results of the Kruskal Wallis test with an asymp. sig. value of more than 0.05, which means that there was no significant difference in the data between the treatments.

Meatballs that have a dense and chewy texture are caused by the interaction of beef myofibril muscles and binders that are usually played by starch such as wheat flour (Tornberg,

2005) [29]. In this study, fried shallots that have minimal starch content and also a crunchy texture cannot provide a significant effect because the mixing step with the beef dough causes homogenization of the beef meatballs.

Several factors can affect the texture of beef meatballs, including the composition of the meatballs, the manufacturing process and the heating duration. The effect of the cooking process is caused by the absorption of water with hydrogen bonds between starch molecules so that it is replaced by starch bonds and water molecules. This bond replacement affects the swelling and dissolution of filler molecules, in this experiment in the form of fried shallots and wheat flour, which form the texture of chewy meatballs (G. & SS, 2014) [30].

Overall Acceptance

Table 3 shows the overall acceptance data for all beef meatball treatments in the experiment. The overall acceptance scores are ranked between 31.63 and 43.55 with an average hedonic scale of "rather like". The data was further analyzed using the Kruskal Wallis test to determine whether there is a significant difference between the data. The data shows that there is no significant difference with an asymp. sig. value of more than 0.05. The acceptability test of adding fried shallots to beef meatballs shows that the panelists' preferences have broadly the same preferences. Of all the aspects tested in the organoleptic test, the panelists gave the same value, in the form of a numeric scale of 2 (rather like).

Conclusion

The addition of fried shallots to beef meatballs affects their physical quality (water holding capacity, reduced cooking weight, softness) but does not significantly affect their organoleptic acceptability (color, taste, aroma, chewiness and overall acceptance). Among the tested formulations, Treatment 2, which incorporated 5% fried shallots, give the best result with 21,63% Water holding capacity, 3,3% reduced cooking weight, 99,87 mm/g/10 second on softness and overall score of 2 of slightly like on acceptability test. These findings suggest that the 5% fried shallot formulation provides the optimal balance between improved physical quality and acceptable sensory characteristics, making it a recommended addition level in beef meatball preparation.

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