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Physicochemical characteristics of beef meatballs with the addition of edamame flour (*Glycine max* (L.) Merrill)

[Karakteristik fisikokimia bakso daging sapi dengan penambahan tepung edamame (Glycine max (L.) Merrill)]

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ABSTRACT

Meatballs are a popular processed meat product made from minced meat combined with various additional ingredients, commonly including flour. Tapioca flour is often used, although it has relatively low nutritional content. Edamame flour, by contrast, offers enhanced nutritional value. The study aimed to determine the optimal percentage of edamame flour addition to improve the physicochemical properties of beef meatballs. The experimental method involved processing back leg beef meatballs with varying levels of edamame flour. A Completely Randomized Design (CRD) was used, consisting of four treatments and five replications: T0 (control), T1 (3% edamame flour), T2 (6% edamame flour), and T3 (9% edamame flour). The results revealed highly significant differences (P<0.01) in protein content and water-holding capacity (WHC), significant differences (P<0.05) in water content and texture, and no significant differences (P>0.05) in pH and fat content. The addition of 9% edamame flour (T3) yielded the best outcomes: pH (6.58), WHC (54.72%), texture (4.54 N), protein (16.32%), water content (67.42%), and fat content (8.14%). These results indicate improvements in the nutritional and physicochemical quality of beef meatballs. Therefore, edamame flour can be recommended as a functional ingredient to enhance meatball quality. The 9% level appears optimal for increasing protein and moisture retention, contributing to better texture and overall product quality. Future research should investigate sensory properties and consumer acceptance to support the potential for commercial application.

Keywords: Edamame soybeans, fillers, functional food, meatball quality, restructured meat

ABSTRAK

Bakso merupakan produk olahan daging yang digemari masyarakat, terbuat dari daging cincang dengan campuran berbagai bahan tambahan. Tepung yang umum digunakan adalah tepung tapioka dengan kandungan gizi yang relatif rendah. Penambahan tepung edamame pada bakso perlu diperhatikan, karena tepung edamame memiliki kandungan gizi yang lebih seimbang dibandingkan tepung tapioka. Tujuan penelitian ini untuk mendapatkan persentase penambahan tepung edamame yang optimal terhadap sifat fisikokimia bakso sapi. Penelitian ini menggunakan metode eksperimen yaitu percobaan pengolahan bagian daging sapi paha belakang dengan penambahan tepung edamame. Penelitian ini menggunakan Rancangan Acak Lengkap (RAL) dengan empat taraf perlakuan penambahan tepung edamame, yaitu T0 (kontrol), T1 (3%), T2 (%), dan T3 (9%), yang diulang sebanyak 5 kali. Hasil penelitian menunjukkan bahwa terdapat perbedaan sangat nyata (P<0,01) pada kadar protein dan WHC, perbedaan nyata (P<0,05) pada kadar air dan tekstur, serta tidak memberikan perbedaan nyata (P>0,05) pada pH dan kadar lemak. Kesimpulan dari penelitian ini adalah bakso sapi dengan penambahan tepung edamame 9% (T3) merupakan persentase terbaik dengan nilai pH (6,58), WHC (54,72%), tekstur (4,54 N), protein (16,32%), kadar air (67,42%), dan kadar lemak (8,14%) yang dapat meningkatkan kualitas bakso sapi ditinjau dari sifat fisikokimia. Berdasarkan temuan ini, tepung edamame dapat direkomendasikan sebagai bahan fungsional untuk meningkatkan sifat gizi dan fisikokimia bakso sapi. Penggunaan tepung edamame 9% dalam produksi bakso dapat menjadi alternatif yang menjanjikan untuk meningkatkan kandungan protein dan retensi air, sehingga menghasilkan tekstur dan kualitas keseluruhan yang lebih baik. Penelitian lebih lanjut dapat mengeksplorasi atribut sensoris dan penerimaan konsumen untuk mendukung aplikasi komersialnya.

Kata kunci: Bahan pengisi, kedelai edamame, kualitas bakso, pangan fungsional, restrukturisasi daging

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Introduction

Meatballs are processed products made from ground meat, flour, and a mixture of additional ingredients then formed into balls that are very popular with many people (Suryadi & Hermanto, 2023). Beef is widely used as the primary ingredient in meatballs due to its high animal protein content, which makes it a nutritious food source. A 100-gram serving of fresh beef contains approximately 66.0% moisture, 201 calories, 18.80% protein, 14% fat, 1.2% ash, 11 milligrams of calcium, and 170 milligrams of phosphorus (Anindyajati et al., 2022). The process of making meatballs is the application of meat restructuring technology, namely the process of uniting pieces of ground meat with the addition of adhesive from irregular shapes into larger products with the addition of thickeners and fillers. The addition of fillers in the form of flour in making meatballs can increase the stability of the emulsion in meatballs and also add to the taste of the product. Flour with high carbohydrates such as tapioca flour, cassava starch flour, palm starch flour, or sago, are generally used as thickeners and fillers. The use of flour as a filler should be limited, as SNI 01-3818-1995 states that it should not exceed 50% of the meat's weight when processing meatballs (Lamadjido et al., 2019). The addition of edamame soybean flour (*Glycine max* (L.) Merrill) as a filler needs also to be considered. Edamame flour contains 30.40% carbohydrates, of the total carbohydrates, the amylopectin content in soybean flour ranges from 11.70-14.40% and while the amylose content range for 12-16%. Lower amylose levels compared to amylopectin content can influence the texture characteristics of product (Sonjaya et al., 2022).

Despite the extensive use of carbohydrate-based filler such as tapioca flour in meatball production, their primary function is limited to acting as binders and providing texture rather than improving the nutrional profile of the product. Conventional filler like tapioca and cassava starch contribute minimal protein and functional properties to meatballs, making them less ideal for enhancing their nutritional value. Previous studies have explored various alternative plant-based fillers, yet research on the use of edamame flour remains limited. The potential of edamame as a functional ingredient in meatballs has not been fully investigated, particularly in its ability to improve physicochemical properties such as protein content, texture, and water-holding capacity. Edamame flour contains 37% protein and 30% carbohydrates, making it a promising substitute for traditional fillers (Prayitno & Rahman, 2020). Unlike regular soybeans, edamame has larger seeds, higher phytic acid content, and a smoother texture, which makes it easier to cook (Ma'sum et al., 2020). Additionally, the amylopectin content in edamame flour (11.70%-13.40%) and its amylose content (12%-16%) play a crucial role in determining the final texture of the product (Sonjaya et al., 2022). Moreover, edamame contains essential amino acids, dietary fiber, vitamins C and B, and phytochemical components such as saponins (0.13-6.15%), isoflavones (0.10-3.0%), and sterols (0.22-0.45%), which provide antioxidant benefits (Triasih & Priyadi, 2021). The nutritional content of 100 grams of edamame flour consists of protein (31.50%), fat (1.4%), water (10.75%), carbohydrates (22.35%), fiber (28.66%), and ash content (5.36%) (Akbar & Wibowo, 2023). Given these advantages, incorporating edamame flour into meatball production could address the limitations of conventional fillers while enhancing the nutritional quality and functional properties of the product.

The nutritional content of edamame influences the quality of meatballs. A high amylopectin ratio enhances chewiness, while a high amylose ratio makes the meatballs more compact (Prayitno & Rahman, 2020). Fiber also affects Water Holding Capacity (WHC). Edamame flour provides a high fiber content, making the dough more compact, as meat naturally has low fiber. Edamame flour has a high protein value so it can increase WHC (Wijaya et al., 2019). Protein can increase WHC because it has hydrophilic properties and the ability to store water when exposed to the heating process. Edamame has a pH of 7, while the pH of beef is only around 5.4-5.8, which means that the pH of edamame is higher (Wiyono et al., 2020). The addition of edamame flour in meatballs can cause the pH of edamame to be higher than the isoelectric of beef protein, which will increase water holding capacity. Increasing pH increases the reactive groups of

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meat proteins, causing a lot of water to be bound, so that the water holding capacity will increase (Omar et al., 2024). Based on the description above, the purpose of this study was to obtain the optimal percentage of edamame flour addition to the physicochemical properties of beef meatballs. The addition of edamame flour is a good innovation to improve the physicochemical properties of meatballs.

Materials and methods

Materials and equipments

The material used in this study was the back leg of beef and edamame flour. Additional materials consisting of tapioca flour, table salt, pepper, fried shallots, garlic, sugar, albumen, Sodium Tri Polyphosphate (STPP), and ice cubes were purchased at the Tawangmangu traditional market, Lowokwaru, Malang City. The edamame soybeans used in this study were obtained from edamame suppliers in Lowokwaru, Malang City. They were then processed into edamame flour at the Technical Implementation Unit of the Batu Herbal Materia Medica Laboratory.

The tools used in this study included various equipment for making beef meatballs and testing their properties. The tools used for the production of beef meatballs were Kylo brand chopper, PX224 PIONEER digital scale, Maspion brand cutting boards, Findking brand knives, Turboplast brand basins, Doll brand spoons, Pamosroom brand drainers, Djawa brand pans, and Rinnai brand gas stoves. Equipment for protein content test analysis was a destruction flask, distillation flask, and Erlenmeyer flask. The equipment used for pH testing included digital scales, Eutech Cyberscan PH1500 brand pH meter and test tubes. WHC testing used glass plates, 35 kg loads, Whatman 42 filter paper, and transparent plastic. Texture testing used TX-700 texture analyzers, knives, cutting boards, and digital scales. The equipment used for water content testing was a petri dish, desiccator, oven, and Electronic Scale brand analytical scales. The equipment used for the fat content test is Pyrex brand Soxhlet, desiccator, oven, mortar, and Electronic Scale brand analytical scales.

Methods

The research method used is a laboratory experiment with a Completely Randomized Design (CRD). The number of treatments consists of 4 treatments which will be repeated 5 times with a total of 20 samples completed on the same day, then continued with the Duncan test if the results are significantly different. The treatment given is the addition of edamame flour to the beef meatball production process. The percentage of edamame flour used is 0%, 3%, 6% and 9% (w/w). The determination of the percentage of edamame flour added in this study is based on previous research (Prayitno & Rahman, 2020; Soraya, 2018).

The process of making edamame flour

Edamame soybeans are processed into edamame flour at the Technical Implementation Unit of the Batu Herbal Materia Medica Laboratory. Making edamame flour includes sorting soybeans, washing, peeling, roasting, and grinding them into flour. The stages of making modified edamame flour are preparing edamame soybeans, sorting, and peeling them from their skins. The edamame soybeans are washed until clean and then drained until dry. The edamame soybeans are baked in an oven at a temperature of 50- 60 °C for 6-7 hours. Then the dried edamame is ground into powder. The edamame powder is sieved again with an 80-mesh sieve until it becomes fine edamame flour (Chodijah et al., 2024; Millan et al., 2020). The edamame flour used was first tested for protein, water, and fat content as a reference. The content of edamame flour used in the study presented in Table 1.

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Table 1. Edamame flour content used in the study

Test Criteria	Results (%)
Protein	36.22 ± 0.02
Carbohydrate	30.61 ± 0.13
Fiber	3.27 ± 0.02
Water	7.48 ± 0.10
Fat	21.62 ± 0.12
pH	6.7 ± 0.10

Note: Data from the test results of edamame flour content used in the study

Process of making beef meatballs with the addition of edamame flour

According to Nurmasytha et al. (2023) the stages of making beef meatballs with the addition of modified edamame flour include: weighing 100 g of beef. Grind the beef using a chopper until half smooth with 10% ice cubes. Add 10% ice cubes, 4% egg white, 10% tapioca flour, 4% salt, 0.25% pepper powder, 3% fried garlic, 2.5% fried shallots, and 0.25% STPP and edamame flour T0 (Control), T1 (3%), T2 (6%), T3 (9%). All ingredients are ground until homogeneously mixed and a perfect emulsion is formed. The dough is formed using a spoon into balls. The meatballs are boiled and shaped at a temperature of 70˚C for 15 minutes so that the gelatinization process occurs until the meatballs float. After floating, the meatballs are removed and transferred to be boiled a second time. Boil at 100˚C for 10 minutes for the meatball cooking process. Drain and finish the meatballs.

pH

The meatball testing procedure is the first stage is to calibrate the pH meter with a pH 4 and 7 buffer solution. pH meter is calibrated every time it is used for measurement. A 5-gram sample is finely chopped and then dissolved in 45 ml of distilled water. The solution is homogenized so that it mixes evenly (Millan et al., 2020).

Water Holding Capacity (WHC)

The WHC test of meatballs can be measured using a carverpress. A sample of 0.3 grams is placed on filter paper and clamped with a carverpress, namely between two clamping plates with a force of 35 kg/cm^2 for 5 minutes. The filter paper used is Whatman paper no. 42. The pressed sample is drawn on graph paper by subtracting the area of the wet area from the area covered by the sample (AOAC, 2005).

Texture

Meatball texture testing is done using tensile strength. The tensile strength is turned on and waited for 5 minutes. The sample to be measured is placed right under the tool needle. The load is left and then the indicator scale is read after the tool stops. The value listed on the monitor is the hardness value expressed in Newton (N) units (Mopangga et al., 2021).

Protein content

Meatball protein content testing was carried out using the Kjeldahl method. The sample was ground and weighed as much as 0.5 g. The sample was put into a Kjeldahl flask and 10 ml of H_2SO_4 was added to the sample. Destroyed for 1 hour until a clear liquid was formed, then cooled. The sample was distilled using NaOH and PP indicator until alkaline. The distillate was collected into an Erlenmeyer flask containing 5 ml of boric acid solution and methyl red indicator. The distillate was titrated using 0.02 N HCl until a light purple color was formed (AOAC, 2005).

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Water content

Determination of water content in meatballs is done by drying using an oven. The procedure is that the sample is weighed as much as ± 5 g then put into a porcelain cup, then the cup containing the sample is dried in an oven at a temperature of 105 oC for 5 hours until a constant weight is obtained (AOAC, 2005).

Fat content

Meatball fat content testing was carried out using the Soxhlet method. Filter paper was prepared and then dried in an oven for 1 hour at a temperature of 100-105ºC. The filter paper was taken, put into a desiccator for 15 minutes, and then weighed. The sample was weighed as much as 2 g, placed in the middle of the filter paper, and then the filter paper was folded. The sample was then dried in an oven for 4 hours at a temperature of 100-105ºC. After the sample was oven-dried, the sample was put into a desiccator for 15 minutes and then weighed. The sample was put into a soxhlet apparatus and added with a fat solvent liquid of 2.5 - 3 times the extraction volume. This process lasted for 14 hours, after which the sample was removed from the apparatus and aired for 30 minutes. The sample was oven-dried for 1 hour at a temperature of 100-105ºC. The sample was taken, put into a desiccator for 15 minutes, and then weighed (AOAC, 2005).

Results and discussion

pH value

Beef meatballs added with edamame flour, the results of the analysis of variance and tests showed no significant difference (P>0.05) in the pH value. Edamame flour contains minerals such as potassium (K^+), sodium (Na^+), and calcium (Ca^{2+}) which are basic. Edamame flour added to the meatball dough causes positive ions to be released into the solution. These basic ions can neutralize hydrogen ions (H^+) which are acidic, thereby reducing the concentration of H^+ and causing an increase in pH. Increasing the pH of edamame flour will increase the reactive groups of meat proteins, causing a lot of water to be bound, so that the water holding capacity will increase (Omar et al., 2024). The pH test data can be seen in Table 2.

Table 2. Physical characteristic of beef meatballs added with edamame flour (*Glycine max* (L.) Merrill)

Treatment	pH	WHC (%)	Texture (N)
T0	6.38±0.30	50.66± 0.60^a	3.94±0.41^a
T1	6.42±0.24	51.18±0.35^a	4.00±0.10^a
T2	6.50±0.37	52.16±0.80^b	4.42±0.37^b
T3	6.58±0.08	54.72±0.65^c	4.54±0.42^b

Note: In the same column, superscripts $^{a, b, c}$ indicates a highly significant difference (P<0.01), Different superscripts $^{a, b}$ in the same column indicates a significant difference (P<0.05), and no notation indicates no difference (P>0.05).

Based on the data results in Table 2, it can be seen that the pH test results showed no significant difference, but there was an increase in the pH value of beef meatballs along with the percentage of edamame flour added. The pH value is a benchmark for inhibiting the emergence of biological contamination such as bacteria, fungi, and other microorganisms that can damage the texture, taste, and nutrition of food (Prayitno & Rahman, 2020). Beef contains a pH ranging from 5.4 to 5.8. The control treatment sample (T0) showed the lowest pH value 6.38±0.30, while beef meatballs with the addition of 9% edamame flour (T3) had a higher pH value 6.58±0.08. This is because edamame flour contains protein with amphoteric properties, which can neutralize lactic acid that is usually formed during meat processing (Triasih & Priyadi, 2021). The addition of edamame flour to beef meatballs is known to increase the pH value, which then affects the water holding capacity (WHC) of the product (Wiyono et al., 2020). Although there was an increase in the pH value, the effect was not statistically significant. The addition of edamame

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flour was able to stabilize the pH of beef meatballs, so that it could contribute to product quality without significantly affecting its base characteristics. Contrary to the statement in the introduction, it was stated that the addition of edamame would increase the pH value which would then affect the WHC value.

Water holding capacity (WHC)

The addition of edamame flour to beef meatballs gave a highly significant difference (P<0.01) to WHC. This is thought to be because edamame flour is rich in nutrients (Table 1). Protein will interact with water through hydrogen bonds, thereby increasing the ability of meatballs to hold water. The increase in the WHC value of beef meatballs with a higher percentage of edamame flour can be attributed to the protein and fiber content in edamame flour. Protein in edamame flour can form a gel network with meat protein, thereby increasing WHC (Soraya, 2018). The dietary fiber content in edamame flour also contributes to the increase in WHC. Fiber can hold water in its matrix, thereby increasing the capacity of meatball dough to maintain moisture (Nurmasytha et al., 2023). The WHC test data for beef meatballs with the addition of edamame flour can be seen in Table 2.

Based on the data in Table 2, the WHC value of beef meatballs increased as the percentage of edamame flour increased. The average value obtained in the WHC test in this study ranged from 50.66% to 54.72%. The control treatment sample (T0) showed the lowest WHC 50.66± 0.60 %, while beef meatballs with the addition of 9% edamame flour (T3) produced a higher WHC 54.72±0.65 %. WHC in food products, especially processed meat products such as meatballs, is an important indicator in determining the texture, chewiness, and stability. A material's ability to hold water is affected by its physical and chemical properties, as well as the interactions of proteins, fibers, and fats with water. This factor not only affects sensory quality but also the product's resistance to moisture loss during cooking or storage. High WHC in processed meat products can prevent cooking shrinkage and maintain sensory characteristics such as hardness and chewiness (Evanuarini et al., 2024). The combination of raw material formulations, such as edamame flour, and the control of processing methods, such as mixing and cooking, are key to producing meatballs with optimal WHC without exceeding the specified limits (Triyannanto et al., 2021).

Texture

The addition of edamame flour to beef meatballs can provide a significant difference (P<0.05) in the texture test. The increase in texture value in beef meatballs along with the increasing percentage of edamame flour addition can be associated with the role of edamame flour content which affects the Water Holding Capacity (WHC), fiber, protein, and water content in the meatball dough. This interaction affects the level of elasticity of the product which is more compact. Fera et al. (2015) stated that in the study that had been conducted, the texture value of beef meatballs with the addition of 15%, 25%, and 35% sago flour had an average value of 3.00, 3.07, and 3.15. This can occur because the texture of food products is influenced by the ability to bind water. The protein content in edamame flour helps increase the protein network that forms a gel in the dough, producing a more chewy and stable texture. The higher WHC due to the addition of edamame flour allows water to be trapped better in the protein matrix, so that the meatballs become juicier and do not dry out easily (Soraya, 2018). Dietary fiber from edamame flour also contributes to improving texture by increasing the density of the dough structure and providing good binding power to water and fat (Mopangga et al., 2021). In addition, the higher water content due to increased WHC helps create a softer and less hard texture. The test data on the texture of beef meatballs with the addition of edamame flour can be seen in Table 2.

Based on the data results in Table 2, it can be seen that there is a significant increase in texture value in beef meatballs addition with edamame flour. The average value obtained in the texture test in this study ranged from 3.94 - 4.54 N. The control treatment sample (T0) showed the lowest texture 3.94 ± 0.41 N, while beef meatballs with the addition of 9% edamame flour (T3) produced a higher texture 4.54 ± 0.42 N.

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The texture value of beef meatballs with the addition of edamame flour is relatively high because beef and edamame flour also have quite high protein content, so it affects the results of meatball products, the protein content of the meat used, and additional ingredients in making meatballs will affect the high and low texture of the meatballs. Protein coagulation, collagen gelatinization, water release and swelling, and starch gelatinization are factors that affect changes in texture. The addition of fillers aims to improve the elasticity of the final product and form a solid texture (Mopangga et al., 2021). The research that has been carried out is still higher than the research on meatballs with the addition of sago flour, which indicates that edamame flour has a better hard chewy texture.

Protein content

Beef meatballs with the addition of edamame flour have a highly significant effect (P<0.01) on protein content. This can be suspected because the balanced amino acid profile in edamame flour contains essential amino acids as its components so it has a higher protein content than tapioca flour, which is 36.22% which plays a role in increasing the protein content of meatballs. The protein content of a food product will be influenced by its composition, in beef meatballs the addition of edamame flour, the role of using meat, and egg white will also affect the increase in protein value. Protein content test data can be seen in Table 3.

Table 3. Chemical characteristics of beef meatballs added with edamame flour (*Glycine max* (L.) Merrill)

Treatment	Protein (%)	Water (%)	Fat (%)
T0	13.40± 0.76^{a}	70.58± 0.26^{a}	8.09±1.78
T1	14.68±0.18^{bc}	69.26±2.21^{ab}	8.09±1.20
T2	15.21±0.17^{bc}	68.76±1.44^{ab}	8.42±0.66
T3	16.32±0.95^{c}	67.42±0.12^{b}	8.14±0.13

Note: In the same column, superscripts $^{a, bc, c}$ indicate a highly significant difference (P<0.01), Different superscripts $^{a, ab, b}$ in the same column indicate a significant difference (P<0.05), and no notation indicates no difference (P>0.05).

Based on the data results in Table 3, it can be seen that there is an increase in the protein content value in beef meatballs in line with the amount of edamame flour added. The average value obtained in the protein content test in this study ranged from 13.40% to 16.32%. The highest average protein content result was 16.32 ± 0.95 % beef meatballs with 9% added edamame flour (T3), while the lowest value of 13.40 ± 0.76 % was obtained without the addition of edamame flour (T0). According to Hermana et al. (2023) regarding the substitution of the use of soy flour in beef meatballs, the average protein content was 16.15% -23.31%, these results are higher because the percentage of soy flour used is higher, namely 25%, 50%, 75%, and 100%, so the use of soy flour is much more than tapioca flour. Increasing protein levels will make meatball products better in quality because protein plays a role in the process of gluing the dough to form an emulsion because the function of protein is as an emulsifier so that meatballs are not easily destroyed when boiled (Mopangga et al., 2021).

Water content

Beef meatballs with the addition of edamame flour have a significant effect (P<0.05) on water content (Table 3). Maybe since a higher percentage of edamame flour results in a lower water content in the meatballs. The carbohydrate content of edamame flour, which is 30.40%, contains starch, causing the formation of starch bonds with meat protein, causing water not to be bound optimally by meat protein. This is following Prayitno & Rahman (2020) who stated that increasing the addition of edamame flour will be followed by a decrease in the water content of meatballs because the water content of edamame flour is lower than tapioca flour. Edamame flour has a lower water content because it is denser and rich in protein and fiber, so it absorbs less water than tapioca flour, which generally has a higher starch content and greater water absorption properties (Triasih & Priyadi, 2021).

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Based on the data in Table 3, it can be seen that the water content in beef meatballs decreased with the increasing quantity of edamame flour added, which consequently led to a proportional reduction in the tapioca flour content. The average value obtained in the water content test in this study ranged from 67.42% to 70.58%. The highest average water content result was 70.58 ± 0.26 % was obtained without the addition of edamame flour (T0), while the lowest value of 67.42 ± 0.12 %. beef meatballs with 9% added edamame flour (T3). Tapioca flour and edamame flour contain relatively high amounts of carbohydrates, at 88.2% and 30.40% respectively (Sonjaya et al., 2022). This carbohydrate content can cause an increase in the bond between starch and meat protein, so that water absorption is less than optimal. The low water content in edamame flour, which is only around 7%, combined with tapioca flour will not affect the increase in water content in meatballs, but will help reduce the water content (Prayitno & Rahman, 2020). Another study by Fadhallah et al. (2024) similarly found that a lower tapioca flour content significantly decreased the water content in meatballs. The water content of beef meatballs showed that the T0 (control) treatment sample was 70.58%, T1 (3%) was 69.26%, T2 (6%) was 68.76% and T3 (9%) was 67.42%. This finding is in line with SNI 3818:2014 which explains that the highest water content in beef meatballs ± 70%.

Fat content

Beef meatballs with the addition of edamame flour did not have a significant effect (P>0.05) on fat content (Table 3). This can be suspected because the high protein content of edamame, which is 36.22%, will cause an interaction between the fat and non-fat fractions to increase, this will allow the interaction of fat in edamame with the non-fat fraction, namely myofibril protein in meat, causing the meatball boiled water to become cloudy after the boiling process. Anindyajati et al. (2022) stated in their research that banana flour added to beef meatballs produced a fat content value of between 1.13% and 1.47% because the fat content in banana flour is only 0.5%, but the difference in treatment in the study was also not significantly different.

Based on the data results in Table 3, it can be seen that there was an insignificant increase in fat content in beef meatballs with the addition of edamame flour. The average value obtained in the fat content test in this study ranged from 8.09% to 8.42%. The highest average fat content result was 8.42 ± 0.66 % beef meatballs with 6% added edamame flour (T2). Sonjaya et al. (2022) stated that the fat content in 100 g of beef was around 14% and the fat content of edamame flour in this study was 21.62%. The addition of edamame flour to beef meatballs has an impact on the fat content which is relatively high because beef and edamame flour contain quite high fat so that it affects the results of meatball products. Fat content in the meat used and additional ingredients in making meatballs affect the high and low fat content in the final product (Anindyajati et al., 2022). The difference in additional treatment concentrations, namely P1 = 3%, P2 = 6%, and P3 = 9% edamame flour did not affect the fat content, the results were almost the same as P0 (control). The addition of edamame flour (*Glycine max* (L.) Merrill) to beef meatballs did not affect the fat content, this could be because the fat content in beef and edamame flour would be dispersed by the protein content in both ingredients (Sonjaya et al., 2022). This study obtained an average fat content of 8.09% to 8.42%. All of these are still in accordance with the SNI 3818: 2014 for beef meatballs, the highest is 10%.

Conclusion

Edamame flour positively affects meatball quality, increasing pH, WHC, texture, protein, and fat content. Edamame flour is an effective additive for improving meatball quality. The optimal addition of 9% edamame flour (T3) resulted in meatballs with the following physicochemical properties: pH 6.58, WHC 54.72%, texture 4.54N, protein content 16.32%, water content 67.42% and fat content 8.14%.

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