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Physicochemical properties and sensory evaluation of dried vegetable meatballs from soy protein isolates

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ABSTRACT

Meatballs are a popular food in Indonesia. Vegetable meatballs (VM) are not as popular as meatballs. The utilization of soy protein isolate (SPI) in vegetable meatballs is expected to improve the functional quality of the meatballs. SPI is useful as a source of essential amino acids the body needs. SPI acts as a binder and gelling agent during processing and improves emulsion stability. This study aims to investigate the use of soy protein isolate in making vegetable meatballs (VM) and its effect on sensory and characteristic properties. The treatment material in this study was the use of SPI in meatball dough as a substitute for meat. The study used a completely randomized design (CRD) consisting of five treatments, namely the ratio of tapioca flour and SPI with treatments (VM0) 100:0%, (VM1) 80:20%, (VM2) 70:30%, (VM3) 60:40% and (VM4) 50:50% and analyzed triplicate. The investigated parameters of this investigation were: volume, weight, bulk density, cooking yield, water retention, proximate, and sensory evaluation. The results showed that using SPI 30% by weight of starch gave the best results. The value of the volume expansion ratio is 1.52 ml/ml, water reabsorption is 308.20%, bulk density is 0.64 g/ml, cooking yield is 218.84 %, and moisture retention is 227.54%. Crude protein content 29.417%. The preference score of vegetable meatballs is quite good, which is between 4 to 4.5 for color, aroma, and elasticity, while for taste and aroma, it is an average of 3.5. Although it is still lower than meatballs, vegetable meatballs provide a choice of healthy meatballs. It is expected that the results of this study will be able to produce VM that contains high vegetable protein and lower prices.

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INTRODUCTION

Meat-based products such as meatballs, kebabs, and samosas have been widely recognized worldwide. One type of food product that is quite popular in Indonesia is meatballs. Generally, meatballs are made from meat (beef, duck, goat, and chicken) mixed with flour and formulated with other additives so that the taste is better and is preferred (Evivie et al. 2015, Patria et al. 2022). Using vegetable protein in manufacturing meatballs benefits health (Fernández-Ginés et al. 2005). Several studies have been reported that to improve the quality and nutrition of meatballs have been carried out such as studies on the physicochemical and sensory characteristics of low-fat meatballs with the addition of wheat bran (Yilmaz 2005), improvement of characteristic low-fat meatballs by adding powder containing legume flour as a thickener (Serdaroğlu et al. 2005). Soy protein in concentrate, isolates, and textured protein is the most used in food products (Maphosa and Jideani 2016). Using soy protein in meat-based food products is a binder and gelling agent that increases emulsion stability and acts as a meat substitute to reduce costs. (Rentfrow et al. 2004). Based on the nutritional aspect, soy protein is a source of essential amino acids that play a role in health. It prevents cardiovascular disease, cancer, and osteoporosis (Kilic et al. 2010). Isoflavones and soy protein have attracted the interest of researchers to develop them. The ability of the protein to form a gel, retain water, enhance flavor, and improve nutrition, making it useful in food applications and enhancing protein functionality (Maphosa and Jideani 2016).

This study aims to investigate the use of soy protein isolate in making vegetable meatballs (VM) and its effect on sensory and characteristic properties. It is expected that the results of this study will be able to produce VM that contains high vegetable protein and lower prices.

METHOD

Materials

The main materials used in this research are tapioca flour and soy protein isolate (SPI). Tapioca flour (Pak Tani Gunung), soy protein isolate (Shandong Protein), garlic, pepper, salt, food-grade Sodium Three Poly Phosphate (STPP).

Preparation of dried vegetable meatballs

The main raw material is the tapioca flour and soy protein isolate ratio in the dry vegetable meatball research, as shown in Table 1.

Vegetable meatball (VM) dough, according to the formula in Table 1, was stirred with a medium-speed mixer for 5 minutes and added 120 mL/100 g of iced water, then shaped into a round shape with a diameter of 1 ± 0.1 cm. The resulting shape is in boiling water for 5 minutes, then drained for 10 - 15 minutes. All vegetable meatballs (VM) were dried at 60 ^oC – 70 ^oC for 24 hours.

The study used a completely randomized design (CRD) consisting of five treatments, namely the ratio of tapioca flour and SPI with treatments (VM0) 100:0%, (VM1) 80:20%, (VM2) 70:30%, (VM3) 60:40% and (VM4) 50:50% and analyzed triplicate. Significant differences between data were analyzed using ANOVA followed by Duncan's multiple distance test (DMRT) (α = 0,05).

Table 1 Treatment of the ratio of tapioca flour and soy protein isolate in dry vegetable meatball

Materials (g)	VM_0	VM_1	VM_2	VM_3	VM_4
Tapioca flour	100	80	70	60	50
Soy Protein Isolate (SPI)	0	20	30	40	50
Sodium Three Poly Phosphate (STPP)	0.4	0.4	0.4	0.4	0.4
Salt	2.0	2.0	2.0	2.0	2.0
Pepper	0.5	0.5	0.5	0.5	0.5

Volume

Changes in the volume of dry VM and boiled VM in the following method: the measuring cup is added with 50 mL of mustard greens seeds (A), then 5 pieces of dry meatballs (B) were put into it, and the volume of green mustard seeds was the size (mL). The same method is also used to measure the volume of vegetable meatballs after boiling/gelatinization. The volume of VM is calculated using the formula 1:

$$Volume\ of\ VM(ml) = B - A \quad (1)$$

Bulk Density

The bulk density (BD) vegetable meatballs sample was determined based on the procedure described by Fang et al. (2019) modified as follows, weighing 5 vegetable meatballs, then measuring the volume of the 5 vegetable meatballs. The following formula 2 calculates bulk density:

$$BD = \frac{m}{v} \quad (2)$$

m = mass of VM

v = volume of VM

Cooking Yield

Cooking yield (CY) was determined based on the procedure as described by Ikhlas et al. (2011) as follows: dried vegetable meatballs were weighed (C_0), dried VM was soaked in water for 6 hours, then cooked/boiled in boiling water for 10 minutes and weighed while still hot (C_1). Cooking yield (CY) is calculated using the formula 3:

$$CY(\%) = 100x\frac{C_1}{C_0} \quad (3)$$

Water Retention

Water retention value (WRV) was determined based on the procedure as described by Ikhlas et al. (2011). WRV describes the amount of water in VM products cooked every 100 grams. The water retention calculation is following formula 4:

$$WRV(\%) = \frac{CY\ x\ moisture\ in\ cooked\ VM}{100} \quad (4)$$

Sensory Evaluation

A total of 10 panelists were asked to perform sensory tests on taste, aroma, color, and texture. The test uses a hedonic scoring scale. The sample is coded with a random three-digit letter. Sample preparation was done by soaking dry VM for 6 hours and then gelatinization by boiling in water for 6 minutes. Samples were presented to the panelists at random for observation. Mineral water is provided to neutralize the mouth between tasting samples. After gelatinization, panelists were asked to assess the sensory properties (taste, aroma, color, and texture) of dry VM.

Proximate Analysis

AOAC (2005) method was used to do a rough analysis of the nutrient content of water, carbohydrates, and crude protein.

RESULT AND DISCUSSION

The results of the observations on the physical form are shown in Figure 1. In contrast, the physical properties of VM, which consist of the ratio of volume expansion and water reabsorption, bulk density, cooking yield, and moisture retention, are shown in Table 2.

Figure 1 shows that the higher the SPI (VM_3 and VM_4), the dry VM surface becomes irregular, and the color becomes darker. It is due to excessive bubble collapse during gelatinization.

Figure 1 The physical form of VM

Water reabsorption ratio & Volume expansion

Based on the results, water reabsorption of VM was significantly ($p<0.05$) different. The water reabsorption of VM samples ranged from 107.37 to 308.20%, with the VM_2 sample having the highest value. Meanwhile, the volume expansion of VM was no significant ($p>0.05$) difference between VM_0, VM_3, and VM_4. The volume expansion of VM samples ranged from 1.51 to 1.72 ml/ml, with the VM_2 sample having the highest value (Table 2). The volume expansion ratio before and after boiling/gelatinization showed that using SPI increased the volume expansion ratio. The 70% tapioca and 30% SPI ratio reached the optimal ratio. If the use of SPI is increased, it does not lead to the development of larger volumes. This condition relates to the amount of water absorbed and retained in the dough. The volume expansion ratio increases as water absorption increases during boiling. Post-boiling water absorption in the treatment (VM_2) was the highest (308.2%). This happens because SPI's hydrophilic and hydrophobic nature causes the protein and water phases to form a stronger matrix, more fat globules can be coated, and the emulsion becomes stable (Zhang et al. 2010, Patria et al. 2021). Soy protein isolate has a high protein content which is hydrophilic and can be integrated into the meat analogs mixture to reduce cooking loss (Astuti et al., 2014).

Bulk Density

Bulk density (BD) describes the mass (g) with the volume of VM. The results of the observation of BD values are shown in Table 2. The results of bulk density were significant ($p<0.05$) differences. VM_2 treatment (ratio of 70% tapioca and 30% SPI) showed the lowest BD (0.64 g/mL). Although the SPI is increased by 40% and 50%, the BD value tends to decrease. The density ratio is strongly influenced by the formation of pores of the VM after drying. It is suspected that in VM_2, the bubbles formed are small and evenly distributed throughout the dough, so there is no excessive bubble collapse when it is gelatinized (boiled). This condition, if dried, causes the VM volume to be relatively more stable.

Cooking Yield

VM's cooking yield (CY) shows the percentage change in weight after cooking to before cooking. Based on the results, the cooking yield of VM was significantly ($p<0.05$) different. The cooking yield of VM samples ranged from 167.53 to 218.84%. The results showed that the highest CY was obtained from the VM2 treatment (70% tapioca ratio and 30% SPI), where the CY value reached 218.84% (Table 2). The amount of CY is highly dependent on the ability to absorb and retain water during gelatinization. In the VM_2 treatment, the water reabsorption ability was the highest compared to other treatments. Cooking properties are important in meat processing products substituted with non-meat ingredients. Cooking loss predicts product behavior during cooking due to the influence of non-meat ingredients or other factors (Pietrasik and Li-Chan 2002). The cooking yield of VM was much higher than the cooking yield of meatballs using cassava (85.22%), sago (84.50%), wheat (84.00%), and corn flour (82.58%) which was reported (Ulu 2004, Serdaroğlu et al. 2005). This is due to differences in the initial sample, in VM using dry samples to produce high cooking yields.

Table 2 Physical properties of vegetable meatballs from the ratio treatment of tapioca flour with soy protein isolate

Ratio Tapioca: SPI (%)	Physical characteristics					
	Moisture (%)	Water reabsorption (%)	Volume expansion ratio (ml/ml)	Bulk density (g/ml)	Cooking yield (%)	Water retention (%)
100:0 (VM_0)	11.4^{a}	107.37^{a}	1.66^{b}	1.13^{e}	167.53^{a}	167.53^{a}
80:20 (VM_1)	12.08^{a}	208.60^{b}	1.51^{a}	0.86^{c}	200.60^{c}	207.60^{c}
70:30 (VM_2)	13.7^{a}	308.20^{e}	1.72^{c}	0.64^{a}	218.84^{e}	227.14^{e}
60:40 (VM_3)	13.2^{a}	290.36^{d}	1.64^{b}	0.82^{b}	211.97^{d}	220.17^{d}
50:50 (VM_4)	14.0^{a}	215.25^{c}	1.64^{b}	0.87^{cd}	186.44^{b}	195.44^{b}

Values with different superscript letters within the column are significantly different ($p<0.05$)

Table 3 Sensory properties of dry vegetable meatballs from various treatment ratios of tapioca flour and SPI

Ratio Tapioca:SPI (%)	Sensory Evaluation			
	Color	Aroma	Texture	Flavor
100:0 (VM_0)	3.90	4.30	3.70	4.10
80:20 (VM_1)	3.90	4.03	3.90	3.10
70:30 (VM_2)	4.10	4.20	4.40	4.00
60:40 (VM_3)	3.95	4.10	4.00	3.80
50:50 (VM_4)	4.30	4.00	3.95	3.58

Water Retention

The results of water retention (WR) were significant ($p < 0.05$) differences. The water retention of VM samples ranged from 167.53 to 227.54%. Water retention (WR) in VM2 treatment (ratio of 70% tapioca and 30% SPI) was the highest at 227.54% (Table 2). It shows that in the VM2 treatment, the amount of water after cooking was the most compared to the other treatments. The hydrophilic group on the SPI protein makes it easier for water to bind to it. The hydrophobic group on the SPI protein makes it hard to move. The optimal condition is the ratio of 70% tapioca flour and 30% SPI. The protein and water phases can form a stronger matrix, more fat globules can be coated, and the emulsion become stable (Zhang et al. 2010). The MR of all treatments was lower than the WR of meatballs that were treated with cassava, corn, wheat, sago, and potato flours, respectively, 64.99%, 59.19%, 60.00%, 63.28%, and 64.67% (Ikhlas et al. 2011). It is because the difference in the initial sample in this study was VM in dry form with a moisture content between 11.47% - 14.02%.

Sensory Evaluation

Sensory test results of dried vegetable meatballs after cooking from various treatments, the ratio of tapioca flour and SPI are shown in Table 3.

The sensory test results involving 10 panelists showed that the vegetable meatballs made from the main raw materials of tapioca flour and soy protein isolate were acceptable to the panelists with a preference level of moderate to liking. The texture of VM using SPI tended to be preferred to those without SPI because they were chewy and less sticky after gelatinization. Similar results occurred with the texture of the samosas (Omwamba and Mahungu 2014), which utilized 50% textured soy protein (TSP) added to the samosas and had a significantly higher effect ($p<0.05$), rated higher than the control group. The increase in texture scores was associated with soy protein, which improved functional properties. The value of taste preference was lower than the control group (without SPI). This condition is thought to be because the panelists are still not used to the taste of SPI, which is very different from the taste of meat. (Omwamba and Mahungu 2014). Samosa products that use beef and TSP up to 50% have no significant difference in their preference for taste because beef tastes better, but they tend to dislike the increase in TSP.

Chemical Composition

Moisture content

The moisture content of dried vegetable meatballs as a result of the treatment from the tapioca flour and SPI ratio ranged from 11.47%-14.027%. The results showed that the water content was not significantly different in the treatment of the ratio of tapioca flour to SPI in the manufacture of dry Vegetable meatballs. It is thought to be because the water in the gelatinized VM dough is mostly water-bound by hydrogen and hydrophobic bonds so that at a drying temperature of 60 ^oC – 70 ^oC for 24 hours, the water contained in the VM is easily evaporated so that there is no significant difference between treatments.

Protein

The highest protein content of dry vegetable meatballs is 47.123%, which is the result of treatment from the ratio of tapioca flour and SPI 50%:50%. The lowest protein content of dry vegetable meatballs in the control group (without SPI) was 0.682. The higher the SPI used, the higher the protein content of dry Vegetable meatballs because soy protein isolate contains more than 70% protein (Syida et al. 2018).

Starch

The highest starch content of dry vegetable meatballs was 89.863%, resulting from the tapioca flour ratio treatment and 100%:0% SPI as control. The lowest starch content of dry vegetable meatballs is 46.416%, resulting from treatment from the tapioca flour ratio and SPI 50%:50%. The more use of SPI in manufacturing Vegetable meatballs dough, the lower the starch content in dry VM. The starch content of tapioca flour from several types of cassava is 81.4% - 89.55% (Murtiningrum et al. 2018), so the increase in the use of tapioca flour will increase the starch content in dry VM

CONCLUSION

Based on the results of the study, it can be concluded that the ratio of tapioca flour with the use of SPI 70%:30% provides good physicochemical and sensory properties. The value of the volume expansion ratio is 1.52 mL/mL, water reabsorption is 308.20%, bulk density is 0.64 g/m, cooking yield is 218.84%, and moisture retention is 227.54%. The crude protein content is 29.417%. The preference test score for vegetable meatballs is quite good, which is between 4 to 4.5 for color, aroma, and texture, while for taste and aroma, it averages 3.5. Although it is still lower overall than meatballs, plant-based meatballs provide an alternative choice of healthy meatballs. It is recommended to improve the taste. It is necessary to add natural flavorings such as mushroom extract.

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