International Journal of Multicultural and Multireligious Understanding

http://ijmmu.com
editor@ijmmu.com
ISSN 2364-5369
Volume 8, Issue 5
May, 2021
Pages: 519-526

Beef Substitution with Soy Protein Isolate and the Effects on Quality and Meatball Cost

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http://dx.doi.org/10.18415/ijmmu.v8i5.2674

Abstract

Beef meatball is a food product that is originated from beef. Nowadays, the interest of consumers in beef meatball is quite high. However, it experiences a constraint due to beef supply that has an expensive cost. The challenge is on how to fulfill the meatball demand that has affordable raw material, but with the quality that is comparable with the existing beef meatball on the market. According to several studies, soy protein isolate is one of the ingredients that is used as filler for processed meat product due to its high protein value and available in affordable price. This research was done by addition of 0%, 2%, 4%, and 8% soy protein isolate with dry addition method. The observation of meatball quality consisted of: organoleptic quality evaluation, meatball quality stability test, and raw material analysis cost / kg. This research utilised hedonic sensory evaluation and descriptive analysis, CRD, CRD Factorial, and SPSS. The result showed that the product was stable in boiling temperature with juicy texture, chewy, and tender which were favored by the panelists. The meatball also had a low ingredient cost compared to meatball without SPI addition. To conclude this research, the best meatball formulation was meatball with 2% SPI addition which possessed good emulsion properties, with dry addition method, and initial boiling temperature of 65°C.

Keywords: *Beef Meatball; Completely Randomized Design; Food Cost; Process Yield Calculation; Soy Protein Isolate*

Introduction

Meatball is one of the processed food products (Sinaga et al. 2017). Meatball is liked by consumers from all age range, ranging from older generation to younger generation (Saputrayadi et al. 2018). Meatball also has a high market demand level (Nasaruddin et al. 2015). Corresponding to Astati (2013) statement, the quality of meatball is highly affected by its composing ingredients, such as the quality of the meat. Meat with high fat content will produce a coarse meatball texture (Pamungkas 2014). Therefore, in this research, the utilised meat product is imported beef knuckle since it has lower fat content.

In meatball processing, the ingredients that are commonly used consist of salt, seasoning in forms of powder or fresh, ice cubes, flour, and sodium triphosphate (STPP) (Rosita et al. 2015). Flour has important roles in improving the meatball texture, increasing the water holding capacity, reducing the shrinkage due to cooking, and increasing the elasticity level of the product (Montolulu et al. 2013). The flour that is commonly utilised in meatball production is tapioca flour because it has a good adhesion performance (Faturohman et al. 2018). STPP is added due to its capability in retaining the meatball yield and its properties to facilitate the protein meat as emulsifier (Hatta and Murpiningrum 2012). STPP can also form crosslinking with starch molecules (Novitasari et al. 2016). This food additive is safe to be used in processed meat products (Nugraha et al. 2017). The maximum usage limit of STPP is 0.30% from the meat weight total weight (Sari and Widjanarko 2015). Meatball with good quality can be observed on the sensory, such as colour, aroma, taste, and texture attributes (Hayati et al. 2012).

It has been explained above that the main ingredient for beef meatball is the beef itself. However, in reality, the production of beef in Indonesia experienced a decrease of 10% in 2019 from its peak in 2016, which was 518.484 ton (BPS 2020). The demand of beef consumption in Indonesia remains high and increased each year (Haq et al. 2015). Therefore, imported beef is needed to fulfill the market demand (Rusdiana 2019). The quality of imported beef is better than local beef since it has a more tender texture and higher marbling degree (Priyanto et al. 2015). It also has similar physical properties that are not significantly different than fresh meat (Dewi 2012). This was due to the freezing process of meat that does not alter the quality of the meat. Then, how to produce meatball product with a more affordable price and comparable quality?

The application of soy protein isolate (SPI) is the accurate solution. This is caused by the relatively high protein content within the SPI (90%) (Arifandy and Adi 2016). Therefore, it can be used as beef substitute in meatball processing (Cahyani et al. 2020). SPI can also form a stable emulsion (Sofiana 2012). In addition, the incorporation of SPI in a product resulted in chewy texture (Ilma et al. 2019) and increased flavour (Putri 2018).

Materials and Methods

The materials used in this research were 5 types of soy protein isolate, water, beef knuckle, ice cubes, salt, MSG, STPP, beef broth, white pepper powder, and fresh garlic cloves. The equipment used in this research were trained panelists that were calibrated annually, Robot Coupe Blixer 3D model, thermometer probe Eurolac brand type TP103T, meatball forming machine Formac brand type MBM-280, The data processing software used in this research was SPSS 22 from IBM. The methods used in this research completely randomised design (CRD) 1x5 with 3 replicates using SPSS, CRD full factorial 4x3 with 3 replicates using SPSS, raw material cost analysis for per kilogram of raw materials, and yield production process yield calculation.

Findings and Discussions

Preliminary Research

SPI Identification and Emulsification Test.

The result from this research was the protein content from the COA of SPI could not be used as indicator for good emulsification properties although the protein content was stated as minimum of 90% on the COA. This was due to the SPI D and E which had soggy, brittle, and non-adhesive characteristics compared to SPI A, B, and C although the protein contents were not significantly different, which was 90%. The method to determine good SPI emulsification was by observing OE and PG formation. The processes of OE formation were: materials weighing with proportion of = 1 (SPI):4(oil):5(water). Then, the SPI and water were mixed using Robot Coupe with speed of 2500 RPM. Then, the oil was added gradually into the Robot Coupe. The mixture was then mixed until homogenised with minimum speed of

2500 RPM. The process of PG (purine gel) formation was similar with OE, but excluding the addition of oil. The processes consisted of: materials weighing with proportion of= 1(SPI):4(water). The solution was mixed until homogenized using Robot Coupe with minimum speed of 2500 RPM. The OE and PG were rested at chiller temperature (5°C) for 1x24 hours. The changes were observed by 10 trained panelists with the observed parameters such as adhesiveness, aroma, and plasticity on both OE and PG. Then, the data were tabulated into SPSS and resulted in CRD 1x5 for both OE and PG experimental design with 3 replicates as shown in Table 1 and 2. Figure 1 and 2 were the results of SPI emulsification of OE and PG. From the result, the best SPI rankings were consecutively SPI B, SPI A, and lastly SPI C.

Table 1. Adhesiveness, chewiness, and aroma of OE emulsion

Type_OE	**Subset for alpha = 0.05**				**Type_OE**	**Subset for alpha = 0.05**			**Type_OE**	**Subset for alpha = 0.05**		
	1	**2**	**3**	**4**		**1**	**2**	**3**		**1**	**2**	**3**
SPI_E	3				SPI_D	2			SPI_E	3		
SPI_D		3			SPI_E	2			SPI_D	3		
SPI_A			4		SPI_C		3		SPI_C		3	
SPI_C			4		SPI_A		3		SPI_A		3	
SPI_B				**4**	**SPI_B**			**4**	**SPI_B**			**4**
Sig.	1	1	1	1	Sig.	1	1	1	Sig.	0	0	1

Table 2. Adhesiveness, chewiness, and aroma of PG emulsion

Type_PG	**Subset for alpha = 0.05**			**Type_PG**	**Subset for alpha = 0.05**				**Type_PG**	**Subset for alpha = 0.05**		
	1	**2**	**3**		**1**	**2**	**3**	**4**		**1**	**2**	**3**
SPI_D	3			SPI_D	3				SPI_E	3		
SPI_E	3			SPI_E	3				SPI_D	3		
SPI_C		3		SPI_C		3			SPI_C		3	
SPI_A		3		SPI_A			3		SPI_A		3	
SPI_B			**4**	**SPI_B**				**4**	**SPI_B**			**4**
Sig.	1	1	1	Sig.	1	1	1	1	Sig.	0	0	1

Figure 1. OE emulsification

Figure 2. PG emulsification

Meatball Skin Formation Test.

The research was proceeded by producing 12 meatballs, where the control meatball (A1B1) was processed first to determine the initial boiling temperature for best meatball skin formation (Suarti et al. 2016). The meat was thawed rapidly (Diana 2018), and formed into spehres with set weight of 20 grams (Chakim et al. 2013). At 65°C, the best meatball skin was obtained. The sample was juicier compared to other samples treated with on initial boiling temperature treatment of 75°C and 85°C which had harder texture. The result was in accordance with water content result. The water content of sample with initial boiling temperature of 65°C was 62.88%, the sample with initial boiling temperature of 75°C was 54.90%, while the sample with initial boiling temperature of 85°C was 51.70% (the lower the meatball water content, it would result in a firmer meatball texture) (SNI 3818:2018). Then, the meatballs were packed in a vacuum plastic (Nasution et al. 2017) with plastic type of NYL15/LDPE60 (75 mic) (Candra and Sucita 2015).

Main Research

Sensory Evaluation Test

In this research step, 12 trained panelists assessed the flavour of the 12 meatball products. The tested parameters consisted of aroma, taste, texture, and colour. The applied hedonic scale in the test was 1-7 scale with numerical expressions as followed: extreme dislike = 1, highly dislike = 2, dislike = 3, neither like nor dislike = 4, like = 5, highly like = 6, extreme like = 7. Then, the data was processed into CRD 4x3 full factorial with 3 replications (Nurhayatin and Puspitasari 2017). The result showed that A2B2 meatball was more preferred by 12 panelists. The panelists stated that A2B2 meatball was juicier compared to other meatballs. According to the result, the parameter testing results showed that the texture test, elasticity test, and water content test for A2B2 meatball had value of neither too high nor too low (average). Therefore, A2B2 had chewy, tender, and juicy characteristics. The data was inserted into SPSS to be processed using CRD full factorial 4x3 experimental design with 3 replications (Muhammad et al. 2014). The result of the test showed that A2B2 meatball received the best respond compared to other products as shown in Table 5.

Table 5. CRD 4x3 with 3 replications

Duncan[a,b]	Aroma			Taste			Texture			Colour		
Composition_SPI	Subset											
	1	2	3	1	2	3	1	2	3	1	2	3
8%	3			4			3			3		
4%		4			4			4			4	
0%		4			4			4			4	
2%			**5**			**5**			**5**			**5**

Raw Material Cost

From the overall research, A2B2 meatball received the best assessments in terms of panelists preferences, texture, formula stability and juiciness level. Therefore, A2B2 meatball was proceeded to final analysis, which was the calculation of raw material cost and comparison of A2B2 meatball with control meatball (A1B1). After the calculation of raw material cost was performed, it is shown that A2B2 meatball could save as much as 2% raw material usage compared to meatball without SPI addition as shown in Table 6. And table 7 for calculation yield process production

Table 6. Raw material cost calculation

No	RM	Control (No SPI)		2% SPI B	
		A1B1		A2B2	
		100 Kg	%	100 Kg	%
1	Beef Knuckle	63.79	64%	61.79	62%
2	STPP	0.74	1%	0.74	1%
3	Salt	1.27	1%	1.27	1%
4	MSG	0.74	1%	0.74	1%
5	White Pepper Powder	0.55	1%	0.55	1%
6	Beef Flavour	1.27	1%	1.27	1%
7	Potassium Sorbate	0.02	0%	0.02	0%
8	SPI	0	0%	2	2%
9	Tapioca Flour	5.45	5%	5.45	5%
10	Fresh Garlic Cloves	0.79	1%	0.79	1%
11	Ice Cubes	25.38	25%	25.38	25%
Total		**100**	**100%**	**100**	**100%**
Cost Per Kg Before Yield		**Rp 60,552**		**Rp 59,572**	
Cost Per Kg After 90% Yield		**Rp 67,280**		**Rp 66,191**	
				Rp 1,089	
				2%	

Based on the calculation results, if a producer wanted to produce 10 ton of meatball using A2B2 formula, the raw material cost for the meatball had a cost reduction of Rp 1.089 x 10.000 = Rp 10.089.000 or equal to 2% efficiency.

Table 7. Production process yield calculation

Code	Initial Weight (Kg)	Final Weight (Kg)	GAP (Kg)	YIELD
A1B1	100	90.2	9.8	90%
A1B2	100	90.4	9.6	90%
A1B3	100	90.4	9.6	90%
A1B4	100	90.4	9.6	90%
A2B1	100	90.2	9.8	90%
A2B2	100	90.5	9.5	91%
A2B3	100	90.4	9.6	90%
A2B4	100	90.4	9.6	90%
A3B1	100	90.2	9.8	90%
A3B2	100	90.3	9.7	90%
A3B3	100	90.3	9.7	90%
A3B4	100	90.3	9.7	90%

Conclusion

The best meatball formulation was meatball with 2% SPI addition that had good emulsion properties by using dry addition method and initial boiling temperature of 65°C. The meatball with SPI addition had better quality parameters than meatball with no SPI addition, which were observed on the product stability, liking, juiciness, as well as lower raw material cost that could be beneficial for meatball producer. It also had a more appealing taste that could increase its added value in consumer's perception.

Acknowledgments

This research was supported by PT Estika Tata Tiara Tbk and Bogor Agricultural University through Thesis scheme. The author would like to thank Mr. Juan Permata Adoe for the permission to author to undergo postgraduate study as well as Research and Development Team for the valuable feedbacks during this research.

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