Jurnal Sains Boga
Vol. 7 No. 2, 2024
Page 66-75
DOI: https://doi.org/10.21009/JSB.007.2.02
E-ISSN: 2622-5557
Journal homepage: https://journal.unj.ac.id/unj/index.php/boga

Formulation of High Iron Shrimp Meatball for Anaemia Prevention of Teenage Girls

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Abstract

The National Health Survey Riskesdas shows that the prevalence of anaemia among Indonesian teenage girls is still high. The cause of anaemia is partly due to daily low iron consumption. This study aimed to develop high iron food products. The products were formulated based on observations at female boarding schools of which the shrimp meatball was desired. The formulation was carried out using a trial and error approach to obtain the most appropriate proportion of ingredients; namely shrimp, modified cassava flour (mocaf) and eggs at levels of F1=70:30:0, F2=50:40:10, F3=50:45:5, F4=50:50:0 (percent w/w). The products were assessed for macro nutrient contents, iron, vitamin C and sensory qualities. The Kruskall Wallis and Mann-Whitney tests were used to analyze the data. The results showed that the developed shrimp meatballs provide higher energy and protein contents as compared to the most commonly consumed animal side dishes. The shrimp meatballs protein contents of all formulas were higher than that of SNI standard. The digestibility and the protein amino acid scores of the developed meatballs ranged from 96.61 − 97.80 and 92.43 − 100 respectively which are higher than the quality of protein consumed by average population. The panelists preferred firmer and compact shrimp meatballs of F4. The best developed shrimp meatballs was F3 which provided more than 50% of recommended daily iron for teenage girls.

Keywords: anaemia, shrimp meatball, teenage girls, high iron

INTRODUCTION

Adolescent girls are in the period of important growth and development which are characterized by rapid physical, psychological and cognitive changes. This group is very likely susceptible to nutrition anaemia as a result of the periodic loss of iron during menstruation (Angelina et al. 2020). Based on the latest data, the prevalence of anaemia in adolescents in Indonesia is unexpectly as high as 32%. This means that as many as 3 − 4 out of every 10 adolescents would experience anaemia problems. In young non pregnant women, anaemia is diagnosed when haemoglobin concentration is less than 120g/L which is slightly higher than level for children of 110g/L. Anaemia is an important health problem for adolescent as it cause negative effect on both physical and mental developments (Vives-Corrons & Krishnevskaya 2021). The incidence of anaemia is related to nutrient intake habits that are below the nutritional recommendation and low physical activity. According to the National Health Survey Riskesdas 2018 data, in the age group of adolescent girls 15 − 24 years and 25 − 34 years old, there has been an increase in anaemia from 37.1% in 2013 to 48.9% in 2018 (Kemenkes 2018).

Treatment of anaemia can be achieved by increasing the consumption of foods high in iron, protein of high quality and vitamin C. Iron (Fe) is one of the important minerals involved in the process of hemoglobin development (Hamzah & Yusuf 2019). Iron is required in the biosynthesis of heme, which is a component of non-protein compounds in the body such as cytochromes, myoglobin and hemoglobin. Hemoglobin plays a

substantial role in the process of oxygen binding. Iron ions in the blood are bound by transferins and carried to the site of red blood cell production (erythropoiesis) and storage in the liver. Transferin is a glycoprotein synthesized in the liver, a protein that plays a central role in the body's iron metabolism because the function of transferin is to transport iron.

Transferin plays a central role in the body's iron metabolism because it transports circulating iron to where it is needed, such as from the intestines to the bone marrow. Ferritin is another protein that is important for iron metabolism. Under normal conditions, ferritin stores iron and can be recycled as needed (Gallagher 2008) A continuous supply of iron is necessary for the production of red blood Treatment of anaemia can be achieved by increasing the consumption of foods high in iron, protein of high quality and vitamin C. Iron (Fe) is one of the important minerals involved in the process of hemoglobin development (Hamzah & Yusuf 2019). Iron is required in the biosynthesis of heme, which is a component of non-protein compounds in the body such as cytochromes, myoglobin and hemoglobin. Hemoglobin plays a substantial role in the process of oxygen binding. Iron ions in the blood are bound by transferins and carried to the site of red blood cell production (erythropoiesis) and storage in the liver. Transferin is a glycoprotein synthesized in the liver, a protein that plays a central role in the body's iron metabolism because the function of transferin is to transport iron. Transferin plays a central role in the body's iron metabolism because it transports circulating iron to where it is needed, such as from the intestines to the bone marrow. Ferritin is another protein that is important for iron metabolism. Under normal conditions, ferritin stores iron and can be recycled as needed (Gallagher 2008) A continuous supply of iron is necessary for the production of red blood cells to proceed properly considering that red blood cells are damaged after reaching 120 days of age (Purba et al. 2022).

Protein has an important role in the transport of iron in the body, therefore insufficient protein intake causes transport barriers and results in deficiency (Supriadi, Budiana & Jantika 2022). Meanwhile, vitamin C is an essential nutrient that the body needs to form red blood cells. The presence of vitamin C in daily food consumption provides an acidic atmosphere to facilitate the process of reducing ferrous iron to ferrous iron in a such whay that it is more easily absorbed by the small intestine. The absorption of non-heme iron can increase fourfold when vitamin C is involved in the reaction (Almatsier 2010)

Meatballs are a popular food which teenagers like. Studies on the food preferences of teenagers from various provinces in Indonesia show that most teenagers favor meatball products. Based on the study, it is known that 59.7% of adolescent respondents in the study consume fast food such as meatballs more than twice a week (Hendra et al. 2019). In general, meatballs are made from single or combined meat, fish and surimi with the addition of cheating ingredients and spices to get a high taste. In an effort to maintain the quality of meatballs, the government has set national standards for fish balls. The minimum amount of fish in the standard is set to 40% and the protein content in the final product should be at least 7% (BSN 2017).

A food preference study condcuted at teenage girl of Islamic boarding school in Malang, East Java showed that leftovers of fried crispy shrimp side dishes used in the menu cycle were signifiantly high. The leftover for the side dish reached 50% of the portion served. This indicates that the crispy shrimp was not favored by the teenagers. From a nutritional perspective, crispy shrimp is in fact a high-quality animal protein source food and has good potential to meet daily protein needs. Based on this, it nessecitates to modify the crispy shrimp recipe into different prospective product which has more appeal to the teenagers such as meatballs. This study was therefore, aimed to develop meatballs. The formulation of the meatballs was carried out by purposely maintaining the shrimp as the basic ingredient. This is important for preventing the unexpected effect which may accur in the existing food procurement system and menu cycle of the boarding school when the usual foods as ingredients are modifed completely. The developed shrimp meatball formula is expected to improve the adolescent girls' liking for animal food menus that are required to meet their daily nutritional needs.

METHODS

The formulation of shrimp meatballs is carried out by trial and error in the laboratory using different proportions of ingredients to obtain the desired characteristics of the meatballs. The main ingredients of the meatball formula used were fresh shrimp, modified cassava flour (mocaf), and chicken eggs with a weight ratio percentage of F1=70:30:0, F2=50:40:10, F3=50:45:5, F4=50:50:0 (w/w). Other ingredients used for each formula includes spices, namely red onions, garlic, salt and mineral water. The production of the shrimp meatballs started by removing the shrimp skin, washing it thoroughly, then diminuting the shrimp meat using a chopper. The obtained fine shrimp, modified cassava flour, eggs, onions, garlic and salt were then weighed according to their respective proportions in the formulas. The onion and garlic were mashed, then all the ingredients were mixed and stirred until smooth. The dough obtained was then shaped into a typical round of meatball with a weight of approximately 15 grams each, then were put into the boiling water and left to cook. The detailed shrimp meatballs production steps is presented in Figure 1.

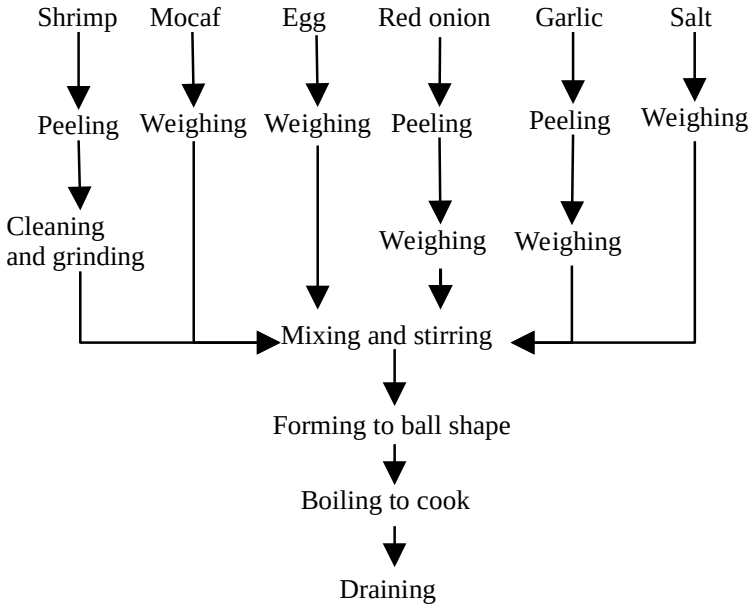

FIGURE 1. The Steps of Shrimp Meatball Production

Data Collection and Analysis

The energy and nutrient contents of the shrimp meatball product, namely protein, fats, carbohydrates, iron and vitamin C were determined based on the nutritional value of Indonesian foodstuffs database in the Nutrisurvey (Erhardt 2007). The protein qualities were determined based on amino acid score (AAS), theoretical digestibility quality (Hardinsyah & Martianto 1992). The assessment of the organoleptic quality of the shrimp meatballs was carried out using 30 semi-trained panelists. Acting as a panelist were undergraduate students of the Nutrition and Dietetics Programme of the Health Polytechnic of the Ministry of Health Malang. The assessment was carried out using a Likert scale of 1 − 4, namely 1 = strongly dislike, 2 = dislike, 3 = like, 4 = strongly like. The study was carried out at the Laboratory of Food Science and Technology of the Health Polytechnic of the Ministry of Health of Malang.

The nutritient contents and protein qualities of the develped shrimp meatballs were analyzed and presented descriptively. The nutrient contents requirements of the SNI 7266:2107 for fish ball (BSN 2017) was used to assess the shrimp meat balls nutrient contents adequacy. The nutrient contens of the product per serving was evaluated using the recommended daily allowance for teenage girls within the age group of 13 − 15 years (Kemenkes 2019). The analysis of the organoleptic data

was carried out using the Wallis Kruskall and the Mann-Whitney follow-up tests at a 95% confidence level. All statistical tests were conducted using SPSS version 16.0. Meanwhile, the determination of the best formula was carried out using the effectiveness index approach.

RESULTS AND DISCUSSION

The developed shrimp meatballs have the similar characteristics as meatballs in general. The color of shrimp meatballs is however slightly yellowish due to the natural color of shrimp used as the ingredient. The intensity of the color of the meatballs appeears to lessen with the decrease in the level used of shrimp in the formula. The shrimp meatballs have a distinctive aroma with relatively the same aroma intensity for all formulas. The density and chewiness of the meatballs tend to increase along with the increase in the use of modified cassava flour.

Energy and Macronutrients

The energy and nutrients of the developed shrimp meatballs are presented in Table 1. According to balanced nutrition guidelines for Indonesians, shrimp belongs to the group of side dishes with low fat content. The unit of exchange for fresh shrimp is five medium fish or equivalent to 35 grams. One unit of shrimp exchange contains energy of 50 Kcal, 7 grams of protein, and 2 grams of fat (Kemenkes 2014). During the preparation of the teenage menus, side dishes are used as a source of protein. The use of meatballs developed as a side dish, which is as much as 50 grams of meatballs from all formulas provides higher energy and slightly lower protein than one serving of shrimp, except for F1. One serving of F1 meatballs contains almost the same protein as one serving of shrimp as a side dish.

TABLE 1. Energy and Nutrient Content of Shrimp Meatballs per Serving (100g)

	Formula			
	F1	**F2**	**F3**	**F4**
Energy (Kcal)	162,0	191,0	203,0	215,0
Protein (g)	13,4	10,6	10,3	10,0
Fat (g)	0,3	1,1	1,0	0,4
Carbohydrate (g)	25,5	34,0	38,3	42,5
Iron (mg)	9,7	10,0	10,7	11,5
Vitamin C (mg)	0,6	0,8	0,9	1,0

Note: Standard protein content according to SNI 7266:2017 is 7%

Apart from being a side dish, the developed shrimp meatballs may also be used as an snack. The portion of snack food for the group of adolescent girls aged 13 − 15 years based on the standard requirement of 10% of the recommended daily allowance, could be fulfilled by serving 100 grams of meatballs. The use of shrimp meatballs as an snack food can be acchieved by further processing it into a form that teenagers more prefer such as in the form of grilled meatballs. The advantage of using shrimp meatballs as an snack in this instance is that the protein content is higher than that of grilled meatball products reported by other studies, which ranges from 4.97 − 5.20% (Wulandari & Zubaidah 2016; Zainatul 2020).

Protein

The formulation of shrimp meatballs produces a high protein content, that is 10.0 – 13.4g/100g. The difference in protein content between formulas may be attributed to the different protein content of the ingredients. The main ingredient in the meatball formula with the highest protein content is shrimp, which is 16.7g/100g of ingredients. Meanwhile, eggs rank the second, tha is 12.4g/100g of ingredients (Kemenkes 2020). Therefore, the use of more shrimp in formulation

contributes to the increase in protein content of the meatball products accordingly. The protein content of the developed meatballs has met the SNI 7266:2017 fish ball standard, which is set to 7% (BSN, 2017). Protein is an important nutrient for the body because it serves as a building substance. Lack of protein intake in adolescent girls can inhibit the production of red blood cells which in turn contribute the developent of anaemia when the iron is also deficent. The protein intake of adolescent girls could be met by consuming 65 grams/day of protein (Ministry of Health, 2019). Lack of protein intake results in impaired iron transport for the formation of hemoglobin and red blood cells leading to anaemia (Permatasari & Soviana 2022).

Apart from quantity, protein quality is equally an important consideration in the development of food products. Among the important parameters in protein quality assessment are digestibility and AAS scores. Digestive quality reflects the portion of food protein that the body absorbs compared to the amount consumed. The development of the meatball formula produced a fairly high digestible socres of F1 = 96.63, F2 = 97.80, F3 = 96.61, and F4 = 97.51. When compared to the digestible score of protein consumption of the Indonesian population in urban areas in general, which ranges from 88 − 92 (Hardinsyah and Martianto, 1992), all the developed meatball formulations have better digestible quality. Based on these data, it can be concluded that almost all proteins in the meatball formula produced in this study could be absorbed in the human digestive tract.

The AAS value is used to determine the amount of essential amino acids that the body utilizes compared to what is absorbed. The AAS values of the meatball formula for F1 to F4 are 89.89, 100, 92.43, and 94.02 respectively. The AAS of all meatball formulas produced in this study is higher than the average AAS of the average food consumption of the avarage Indonesian population, which is 75-83% (Hardinsyah and Martianto, 1992). The high quality of protein in meatball formulations is related to the use of eggs as the ingredient. Eggs have a fairly complete composition of essential amino acids and good digestive value.

Fat and Carbohydrates

The results of fat analysis showed low fat content in all formulations (Table 1). This is very likely due to the use of ingredients that are not a source of fat. The purpose of selecting low-fat ingredients is to maintain the function of meatballs as a formula development to replace the less preferred crispy shrimp formula. Replacement formulas are expected to have equal or better nutritional content. For adolescent girls, fat is necessary for the normal physiological functioning of the reproductive organs because fat plays a role in the secretion of GnRH which functions to spur the pituitary to secrete FSH and LH (Adu-Afarwuah et al. 2016). The nutritional adequacy of fat for adolescent girls aged 13 − 15 years is 70g per day (Ministry of Health, 2019). This can be met by consuming a varied meal. The carbohydrate content of shrimp meatballs increases along with the amount of modified cassava flour used (Table 1). This is because modified cassava flour is a source of carbohydrates with a content of 85g/100g of ingredients, while the carbohydrate content of shrimp and eggs is not more than 1.5g/100g (Ministry of Health, 2020). The selection of modified cassava flour in the meatball formulation is expected to provide better color and chewiness than cassava starch. The modified cassava exhibits enhanced viscosity, gelation, rehydration, and solubility compared to its unmodified counterpart (Khasanah & Helmi 2020). In addition, it also contains phospor and iron which provide better nutrient in relation to anaemia reduction.

Iron and Vitamin C

The highest iron content of the developed meatballs was resulted from F4 formula, which is 11.5 mg/100 grams product. The ingredient that makes up the meatball formula which contributes the highest iron is modified cassava flour, the more the flour is used, the higher the iron content in the final product. The function of modified cassava flour in the formulation, apart from being a contributor of nutrients, is also as a texture modifier. The benefit of using modified cassava flour as compared to wheat flour is it has higher calcium, less fat as well as energy. Moreover, modified

cassava flour does not contain gluten which obviously benefits consumers demanding gluten free products (Khasanah & Helmi 2020). Consumption of one serving or 50 grams of meatballs from all formulas provides more than 50% of the daily iron adequacy of adolescent girls, which is 15 mg (Ministry of Health, 2019).

According to (Purnamasari, Lubis & Gurnida 2020), iron is an important micromineral as a necessary material in the formation of hemoglobin, playing a role in the transportation, storage, and utilization of oxygen. Therefore, iron deficiency generally causes pale skin, weakness, fatigue, dizziness, loss of appetite, decreased physical fitness, decreased working capacity, decreased immunity, and a long wound healing process. Insufficient iron intake is caused by a lack of intake of foods containing iron or iron in foods in a form that is difficult to absorb.

Anaemia in adolescent girls needs to receive serious attention and be treated early. At school age, learning achievement can be affected because anaemia causes a decrease in concentration in the learning process. If anaemia in adolescent girls continues in the next period, it can affect general health and even the health of the child who will be born. Women of childbearing age who are pregnant and suffer from anaemia cannot meet the nutritional needs of their own body and the fetus in their womb. This can increase the risk of bleeding during childbirth, premature delivery, low birth weight (BBLR), and can even lead to maternal and infant mortality (Suminar et al. 2021).

The meatball formulation produces a low vitamin C content. In the development of products for the prevention of anaemia, the high content of vitamin C is expected to help the absorption of iron. In addition, vitamin C inhibits the formation of hemosiderin, which is difficult to mobilize to release iron when needed (Almatsier, 2010). However, considering that the function of meatballs is not a food source of vitamin C, the high vitamin C content in the final product is not the main parameter. Given the perishable nature of vitamin C during processing with hot application, it is generally recommended to obtain vitamin C from fresh food ingredients or products that have undergone minimal processing. Vitamin C damage easily occurs due to oxidation to dehydroascorbic acid, where heat, metal ions, and a neutral to alkaline pH atmosphere are catalysts for the process. In addition, vitamin C damage also occurs due to oxidase enzymes (Combs & McClung 2022). To increase the absorption of iron in the body, the serving of shrimp meatballs is expected to be accompanied by foods that are sources of vitamin C. Good sources of vitamin C come from the group of vegetables and fruits that are served in the form of fresh, juice or salad. The vitamin C needs of adolescent girls, which is 65 mg/day (Ministry of Health, 2019) can be met from source foods that are served in fresh or processed forms that are attractive.

Sensory Score

The results of the organic quality assessment of shrimp meatballs are presented in Table 2. The level of preference of the panelists for meatballs ranged from 2.47 to 3.33 (a higher score indicates that the product is increasingly preferred).

The proportions of shrimp, modified cassava flour and chicken eggs make a noticeable difference to the color preference level of meatballs. The use of more shrimp tends to decrease the panelists' preference for color. The Mann-Whitney test showed a noticeable color difference between F1 and F3 ($p<0.05$). This difference can be due to the use of more shrimp than modified cassava flour in F1. The yellowish intensity of the color in shrimp comes from the shrimp astaxanthin pigment. Astaxanthin is a carotenoid pigment with red, yellow and orange colors (Figueroa et al. 2003). The color of meatballs circulating in the community generally leads to white or brownish-white as a result of the influence of the pigments used, namely fish or meat. In this experiment, the color of F1 meatballs was orange and in F3 white was slightly orange. The color of F3 meatballs is preferred over others.

TABLE 2. The Sensory Quality of The Developed Shrimp Meatballs

	Formula			
	F1	**F2**	**F3**	**F4**
Color	2,90±0,662a	3,07±0,521ab	3,33±0,547b	3,20±0,551ab
Aroma	2,80±0,761a	2,87±0,629a	3,07±0,640a	3,13±0,571a
Taste	2,87±0,571a	2,57±0,626b	3,27±0,691c	2,80±0,847ab
Texture	2,47±0,629a	2,87±0,629b	2,97±0,615b	3,07±0,640b

Note: For the same row, the different letter notations indicate significant different of Mann Whitney test at $p<0,05$. Sensory scale 1= strongly dislike, 2= dislike, 3= like, and 4= strongly like.

Statistical tests on the aroma of meatballs showed that there was no noticeable difference in aroma from all formulas ($p>0.05$). According to the average sensory test F4 (score 3.13) is the most preferred product in terms of aroma. The meatballs produced in this study have a specific shrimp aroma and are not fishy. Similar research showed that since shrimp have a pleasant aroma, the use of shrimp in making chicken nuggets resulted in a final product that the panelists preferred (Maruta, Rosida & Susanti 2021). The formation of the aroma of the final product is determined by the main raw materials and additional ingredients such as spices so that the level of aroma in making these meatballs is not only determined by the use of shrimp.

Statistical tests showed that there was a real difference in taste between the meatball formula ($p<0.05$). The meatball formula that the panelists liked the most in terms of taste was the F3 formula. Previous researchers have proven that shrimp is a determinant of taste in the development of nugget products (Desmelati & Melilin 2019), but in the development of this meatball, the taste is not determined by the increasing use of shrimp. As happens with the aroma of shrimp meatballs, the taste of the meatballs in this case may depend on the combination of ingredients used. Apart from the food aspect, taste is determined by a complex combination of a person's physiological, physical, and social factors (Wistoft & Qvortrup 2021). Physiological factors are related to the cells and nervous system that process sensory responses. Physical factors are formed from consciousness, including knowledge, emotions, and thought outcomes. Meanwhile, social factors are related to physical factors that allow the formation of division and grouping of perception of taste.

The proportion of ingredients in making meatballs has a real influence on the texture ($p<0.05$). The use of more modified cassava flour tends to produce a meatball texture that is preferred by the panelists. A good meatball texture is not only dense and compact, but also must be chewy (BSN, 2017). The texture shaping in meatball products is formed from the addition of binding materials. The binding material in meatballs can be in the form of wheat flour and tapioca flour (Rahmawati & Purnomo 2020). In this experiment, modified cassava flour is used as a binder to get the distinctive shape and texture of meatballs. Modified cassava flour has a higher viscosity characteristic than tapioca flour, so it is expected to provide a texture that is preferred by young women (Table 2). The selection of modified cassava flour as a binding material in product development needs to be done appropriately considering that the properties of water holding capacity, swelling power, and synergy of modified cassava flour are greatly influenced by the milling and fermentation methods in the process of making modified cassava flour (Putri, Herlina & Subagio 2018). Other binding materials that can be used in making meatballs include tapioca flour and carrageenan. Carrageenan that has the best gel-forming effect comes from the kappa type. The gel properties formed from iota-carrageenan are softer and more elastic (BeMiller 2018).

The Most Preferred Formula

The meatball formulation that is considered the best is F3. The characteristics of the selected formula are shrimp meatballs with a light orange color, a distinctive shrimp aroma, savory taste and a

compact chewy texture. Consumption of one serving (50 grams) of selected formula shrimp meatballs contributed 67.67 Cal, 5.15 g of protein, and 5.35 mg of iron to the nutritional adequacy of adolescent girls. As a side dish, one serving of shrimp meatballs can contribute to the daily needs of protein and iron of 7.92 and 35.67%, respectively. The selected formula meatballs contain iron 10.7mg/100g. A food product can be claimed as a source of iron if it contains at least 3.3mg, which is 15% of the reference figure of 22mg, in the form of solid food (BPOM 2016, 2022). Based on these provisions, selected formula shrimp meatballs can be classified as a source of iron needed for adolescent women in the context of overcoming anaemia which is a prevalent nutritional problem.

CONCLUSION

Improving the quality of food for teenage girls could be acchieved by using appropriate ingredients selection with regard to fullfilling specific nutrients requirement of the target group. In this study, shrimp meatballs product were developed to overcome the low acceptance of the conventional recipes for fried crispy shrimp used in the regular menu and formulated based on the nutritional needs of adolescent girls aiming at anaemia prevention. The developed shrimp meatballs are qualified as a side dish according to the portion standards in the balanced nutrition guidelines. The most preferred shrimp meatball formula is produced using shrimp, modified cassava flour, and chicken eggs with a weight ratio of 50:45:5 (w/w). The shrimp meatballs provide approximately 67.67 Kcal energy, 5.15 g protein, and 5.35 mg iron per serving with protein qualities above the average food consumption of the Indonesian population. The protein content of the preferred shrimp meatballs meet the nutrient requirements set by the SNI 7266:2017 for fish meatballs.

ACKNOWLEDGMENTS

The authors expressed their gratitude to the management of the Ar-Rahmah Islamic Boarding School Malang for providing the opportunity to conduct the plate waste study of the teenagers menu. Thanks was also conveyed to the Head of the Food Science and Technology Laboratory of the Ministry of Health of Malang.

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