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Development of Biscuits Made from Maggot Flour and Whey Protein Isolate as a High-Protein Snack for School-Age Children

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A B S T R A C T

Intake of nutrients has an important role in the growth and development of school-age children; one of them is protein. A sufficient protein intake can support brain development and intelligence so that they can learn well. In general, making biscuits using only wheat flour, which only contains macronutrients and contains few other nutrients, Through the addition of maggot flour and whey protein isolate, it is expected to increase the nutritional value of biscuits, especially protein. The method used in this study was experimental. The organoleptic test using the VAS (Visual Analog Scale) method was performed by 25 semi-trained panelists. The results showed that the addition of different maggot flour and whey protein isolates had a significant effect (p≤0,05) on the quality and content of the biscuits. Treatment with the addition of 70 gr maggot flour and 50 gr whey protein isolate resulted in the highest protein value of 19,28%. While the results of the acceptance test of biscuits treated with the addition of 50 gr maggot flour and 70 gr whey protein isolate were the most preferred biscuits overall, The more maggot flour added to the biscuit dough, the higher the protein value.

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INTRODUCTION

The percentage of students in Indonesia who have difficulty in capturing lessons from year to year also continues to increase, in 2010 there were 28% of students, in 2011 it became 65% of students and in 2012 it reached 78% of students (UNESCO, 2012., Putri, 2018). The low cognitive ability of children in Indonesia is influenced by various factors, one of which is due to low macronutrient intake in the form of protein. Children need adequate protein intake to support brain development and intelligence so they can learn well (Istiani & Rusilanti, 2013). Protein can affect the level of physical activity. Active children have higher protein requirements. As a source of energy, protein is in line with carbohydrates as a source of energy when doing activities (Almatsier, 2009).

Currently, many people do not know and use alternative animal protein sources as snack ingredients, one of which is maggot. Maggot is an organism derived from Black Soldier Fly (BSF) larvae that has high protein (Fauzi & Sari, 2018). BSF maggot is considered fast in decomposing organic waste (within one day). In addition, the nutritional value of maggot protein is almost equal to the nutritional value of soy protein. This makes maggot contains high protein with a range between 30-45%, contains essential fatty acids (linoleic acid and linolenic acid) and essential amino acids (Surya, 2020). In this study will use whey protein isolate to add protein value, whey protein isolate is a type of whey protein that is purer than whey protein concentrate with a protein content of 90-92%. Whey protein isolate only contains lactose and very little fat around 0.5-1% (Andriani et al., 2019).

Several efforts can be made to meet children's nutritional needs, one of which is by providing additional food in the form of healthy snacks that can help meet children's nutritional needs while at school, children tend to like sweet and savory or salty foods (Permatasari & Adi, 2018). One of the healthy snacks that children love is biscuits. However, commercial biscuits on the market often contain unbalanced nutrients, such as high carbohydrates and fat but low protein (Kanaka & Ayustaningwarno, 2015).

Biscuits are dry products that have high durability, so they can be stored for a long period of time, which is about 2 months, if made without using preservatives (Kusnandar, 2010).

LITERATURE REVIEW

Maggot is an organism derived from Black Soldier Fly (BSF) larvae that has high protein (Fauzi & Sari, 2018). BSF maggot is considered fast in decomposing organic waste (within one day). In addition, the nutritional value of maggot protein is almost equal to the nutritional value of soy protein. This makes maggot contains high protein with a range between 30-45%, contains essential fatty acids (linoleic acid and linolenic acid) and essential amino acids (Surya, 2020). In this study will use whey protein isolate to add protein value, whey protein isolate is a type of whey protein that is purer than whey protein concentrate with a protein content of 90-92%. Whey protein isolate only contains lactose and very little fat around 0.5-1% (Andriani et al., 2019).

METHODOLOGY

This research is included in the experimental type of research using a complete randomized design (CRD) and 4 (four) treatment levels. The research was conducted at SIG Laboratory PT Saraswanti Indo Genetech Bogor for proximate test, amino acid analysis and Total Plate Count (TPC). While in the scope of Esa Unggul University to test organoleptic on semi trained panelists. There are 4 treatment groups which can be seen in table 1. Each group was repeated 2 times or duplo test includes proximate analysis, amino acid analysis and Total Plate Count (TPC).

Table 1. Raw Material Composition of Maggot Flour Biscuits and Whey Protein Isolate

Composition	Treatment Code			
	F0	**F1**	**F2**	**F3**
Maggot Flour	-	50	60	70
Whey Protein Isolate	-	70	60	50
Wheat Flour	200	120	120	120
Refined Sugar	70	70	70	70
Egg Yolk	30	30	30	30
Margarin	100	100	100	100
Milk Powder	15	15	15	15
Salt	2	2	2	2
Baking Powder	3	3	3	3
Vanilla Extract	2	2	2	2

The main ingredients used in making this biscuit are Maggot Flour and Whey Protein Isolate. With the comparisons used are: F0 (0%: 0%), F1 (50%: 70%), F2 (60%: 60%), F3 (70%: 50%). The manufacturing process starts from mixing wet ingredients such as margarine, eggs and sugar using a mixer until light yellow in color. After that, dry ingredients such as wheat flour, maggot flour and Whey Protein Isolate, Milk Powder, Salt, Baking Powder and Vanilla Extract were added. The dough is mixed until evenly distributed, then molding and baking in the oven at 160oC for 15 minutes.

Nutritional Value Analysis Of Biscuits

Proximate tests in processed products include analysis of carbohydrate content (by difference method), protein content (Kjeldahl method), fat content (Weibull method), moisture content (oven method), ash content (dry ashing method), amino acid content (HPLC method), and total plate count (pour plate method).

Hedonic Analysis And Hedonic Quality

The results of the organoleptic test (hedonic and hedonic quality) use the One Way Anova Test. If the ANOVA test produces a p value <0.05, then proceed with the Duncan further test.

RESULTS AND DISCUSSION

Nutrient Content

Nutritional value test was conducted on all biscuit formulations, with the aim to see the differences of each formulation and then compared with SNI regarding biscuit quality requirements. Mean±SD values of the nutritional value test results of biscuits with the addition of maggot flour and Whey Protein Isolate are presented in Table 2.

Carbohydrate

Judging from the results of testing the carbohydrate content of biscuits with the treatment of the addition of maggot flour and Whey Protein Isolate, it shows that there is a significant effect along with the increase in the addition of maggot flour and Whey Protein Isolate in each formulation, but the highest carbohydrate content in the F0 formulation is thought to be because maggot flour and whey protein isolate contain low carbohydrates compared to wheat flour which has a higher carbohydrate value. According to (Piona Pitricia, 2019), carbohydrate levels can also be influenced by other nutritional components (protein, fat, water and ash), the lower the other nutritional components, the higher the carbohydrate levels and vice versa, the higher the other nutritional components, the lower the carbohydrate levels.

When compared to the quality requirements of biscuits according to SNI No. 01-2973-1992 of at least 70%, the four formulations have not met the quality requirements.

Protein

Based on the results of the protein content test, the four biscuit formulations show significant results or significantly different between each protein value. The highest value is in formulation F3 which uses the most maggot flour and the lowest protein value is in formulation F0 which does not use the addition of maggot flour or whey protein isolate. In research conducted by Kurniawan et al, 2018 mentioned that increasing maggot flour in feed increases protein levels in tilapia. Meanwhile, research conducted by (Manihuruk, 2021) showed an increase in biscuit protein levels along with the addition of whey protein isolate. From these two studies, protein levels increase along with the addition of ingredients that have high protein levels.

Table 2. Mean and Standard Deviation of Nutritional Value Test Results of Biscuits with the Addition of Maggot Flour and Whey Protein Isolate

Parameters	**Formulation (mean ± standard deviation)**				**P value**	**Standard**
	F0	**F1**	**F2**	**F3**		
Water Content	6.75±0.091[a]	8.44±0.113[b]	6.92±0.495[a]	**8.47±0.49[b]**	0.0001	Max 5 %[a]
Ash Content	1.08±0.035[a]	2.60±0.021[b]	2.65±0.042[b]	**3.06±0.084[c]**	0.0001	Max 2 %[a]
Energy	491.3±1.216[a]	501.2±0.593[b]	**540.6±1.852[c]**	489.7±0.417[a]	0.0001	Min 400 kal/100 gr[a]
Protein	6.50±0.141[a]	19.15±0.14[c]	17.87±0.318[b]	**19.28±0.091[c]**	0.0001	Min 9%[a]
Fat	24.54±0.197[a]	29.09±0.226[c]	**35.78±0.296[d]**	27.17±0.190[b]	0.0001	Min 9,5%[a]
Carbohydrate	**61.12±0.000[a]**	40.71±0.502[c]	36.77±0.523[d]	**42.00±0.417[b]**	0.0001	Min 70%[a]

Amino Acid

Based on the results of the amino acid content test, it can be seen that there are 8 essential amino acids (histidine, threonine, arginine, valine, phenylalanine, isoleucine, leucine and lysine). And 7 non-essential amino acids (aspartic acid, glutamic acid, proline, serine, glycine, alanine and tyrosine) in the four formulations all have significant differences.

In all four formulations, there were significant differences. In general, the five amino acids that are often deficit in children's food are lysine, methionine, cysteine, threonine, tryptophan (Annisaa & Afifah, 2015). The test results of amino acid levels can be seen in Table 3.

Table 3. Test Results of Amin Acid Levels in Biscuits with the Addition of Maggot Flour and Whey Protein Isolate

Parameter	F0	F1	F2	F3
Essential				
Histidine	1862.13	5720.84	5213.89	**5989.44**
Treonine	2484.65	14412.41	11954.79	14199.93
Arginine	3168.86	8166.83	7632.49	**8934.65**
Valin	2997.1	11822.96	10375.55	**12220.92**
Phenylalanine	4245.89	10758.48	10119.68	**10859.26**
Isoleusine	2450.61	**11664.36**	9960.3	11575.38
Leusine	2809.88	**18423.09**	15745.6	18237.67
Lysine	1762.25	**11014.71**	10009.72	11052.05
Non Essential Amino Acids				
Aspartic acid	2784.91	14144.86	13799.91	**14469.37**
Glutamic Acid	17023.43	**30755.03**	29602.81	30405.96
Proline	5544.42	11765.16	10530.05	**11776.05**
Serin	3565.45	10680.06	9214.25	**10979.82**
Glycine	2644.56	6721.74	6207.75	**7535.57**
Alanine	1960.95	8849.3	8227.49	**9360.4**
Tirosine	1254.52	5587.95	5519.31	**6085.89**

Based on the table above, it can be seen that the level of lysine amino acids in this study is in F3 with a value of 110552.05 mg/kg or 110.55 g. The function of lysine is for the growth and repair of body tissues. According to Baker (2007) in (Arvianto et al., 2016) the average lysine amino acid intake requirement per day is 1 - 1.5 g. These results show that biscuits with lysine amino acid content are better than biscuits with lysine amino acid content. These results show that biscuits with the addition of maggot flour and whey protein isolate have met the Nutritional Adequacy Rate of lysine.

Fat

Based on the results of the fat content test, the value of the four biscuit formulations showed significant results or significantly different between each formulation. The highest fat content of biscuits was found in formulation F2 with an equal composition of maggot flour and whey protein isolate. equivalent. Supposedly, the biscuit formulation that has the highest fat value is F3 because the use of maggot flour in F3 is more dominant. The cause of F2 biscuits having higher fat content is thought to be due to fat breakdown. The content of free fatty acids in a food material accelerates the hydrolysis process which causes food damage (Irmawati et al., 2014). Products containing fat tend to spoil faster. This is due to the unstable nature of fat to the heat process. The longer the heating process occurs, the fat will undergo a hydrolysis reaction (Hermanto et al., 2010). The quality requirement for fat in biscuits according to

SNI No. 01-2973-1992 is at least 9.5%, meaning that the value in each formulation has met the quality requirements.

Calorie

Based on the results of the calorie content test, the calories in each formulation are significantly different. Formulation F0 has the lowest calorie content because formulation F0 is processed without the addition of maggot flour and whey protein isolate. Whereas F2 has the highest calories presumably due to the treatment of adding maggot flour and whey protein isolate equally. Fat and protein in milk can affect the calorie content of the formulation. If the intake of fat and protein has a high content, the resulting calories are also high (Dini Primashanti & Sidiartha, 2018). If we follow the recommended calorie requirement for school snacks, which is around 200-300 kcal, then the biscuits needed to be consumed are only 55 grams. Total calories are a concern because consuming foods with excess calories can increase the tendency of obesity (Pratama & Ayustaningwarno, 2015).

Water Content

Based on the results of the water content test, the four biscuit formulations showed significantly different results. The highest moisture content was found in F3 and the lowest in F0. Based on SNI biscuits N0. 01-2973-1992 the standard requirement for moisture content is a maximum of 5%, then the four formulations have not met the requirements of SNI biscuits. The moisture content contained in whey protein isolate is 4.5% (Mardiana et al., 2022) while in maggot flour it is 3.60% (Gunawan et al., 2022). When viewed from the moisture content of both, the levels of the four biscuit formulations should meet the SNI requirements of 5%. The moisture content above 5% can be caused by the high protein content in maggot flour, which is 36.83% (Gunawan et al., 2022) and whey protein isolate of 90-92% (Mardiana et al., 2022). Protein has the ability to bind or hold water content or commonly referred to as water holding capacity (WHC), so the increase in protein content in biscuit formulations increases the water content (Setyawati et al., n.d.).

Ash Content

Based on the ash content test results, the four biscuit formulations showed significantly different results. The highest ash content of biscuits was found in formulation F3 with a moisture content of 3.06% with the highest composition of maggot flour addition while the lowest ash content was found in formulation F0 with a composition without the addition of maggot flour. Ash content ash content of a product is also related to the mineral content of an ingredient (Sulistyoningsih et al., 2019). The mineral content contained in maggot is 30.46 g/kg or 3.046% (Ahmad et al., 2022), while whey protein isolate contains 0.7% minerals (Norris et al., 2020). The higher mineral content of maggot flour resulted in the highest ash content of F3. Based on SNI biscuits No. 01-2973-1992, the standard requirement for ash content is a maximum of 2%, so the formulation that meets the requirements of SNI biscuits is F0.

Total Microbial Contamination (TPC)

Based on the results of the analysis, the total microbes contained in maggot biscuits are still below the maximum limit for all formulations, so biscuits with maggot flour and whey protein isolate are suitable for consumption. If you look at the four formulations, F1 and F2 biscuits have the highest total microbes and the lowest total microbes are in the F0 formulation. It is suspected that the cause of high microbes is due to environmental conditions or during processing. lack of hygiene. To prove this allegation, further research is needed.

Biscuit Acceptability

Looking at tables 4 and 5, the color should be too brown in formulation F3 because biscuit formulation F3 with the addition of maggot flour dominates so that the brightness of the color is not good, but there are also some panelists who think that F2 has a less good color brightness level. So, it shows that the increasing addition of maggot flour and whey protein isolate will affect the color level of the biscuits. This makes the color of the biscuits visibly less preferred by the panelists. Which F0 formulation biscuits are more preferred because without the addition of maggot flour and whey protein isolate.

Table 4. Semi-Trained Hedonic Quality Test Results

Parameters	**Formulation (mean ± standard deviation)**				**P value**
	F0	**F1**	**F2**	**F3**	
Colour	**7,00 ± 2,550**^{a}	6,08 ± 2,100^{ab}	5,56 ±2,383^{b}	5,76 ±2,278^{ab}	0,1411
Scent	**8,08 ± 1,382**^{a}	7,96 ± 1,428^{ab}	6,96 ±2,336^{b}	5,84 ± 2,211^{c}	0.0001
Texture	4,76 ± 2,758^{a}	**6.96 ± 1,904**^{b}	4,96 ±2,131^{a}	5,58 ± 2,018^{a}	0,0031
Flavour	**7,20 ± 1,472**^{a}	7,00 ± 1,803^{a}	6,92 ±1,605^{a}	6,68 ± 1,701^{a}	0,7361
Overall	7,08 ± 2,139^{a}	**8,16 ± 1,143**^{b}	6,20 ±2,041^{a}	6,64 ± 1,868^{a}	0,0021

Description:

[1]Tested with Visual Analog Scale (VAS) 0.0-10.0. Different superscript letters indicate significant differences between formulations in the Duncan test (P≤0.05).

[2]Signs ^{a,b,c} = Duncan's further test to state the difference in each formula.

Table 5. Hedonic Quality Test Results

Parameters	SEMI HEDONICS				P value
	F0	F1	F2	F3	
Semi Trained[1]					
Colour	**7,60 ±1,780**[a]	6,08 ± 2,216[b]	5,48 ± 2,084[b]	5,16 ± 1,864[b]	0,0001
Scent	**6,96±1,947**[a]	6,44 ± 1,583[c]	5,44 ± 2,142[bc]	5,28 ±1,882[bc]	0,005
Texture	5,48 ±1,503[a]	**6,88 ± 1,481**[b]	5,64 ± 1,705[a]	5,72 ± 1,458[a]	0,007
Flavour	6,84±1,248[a]	**7,64 ± 1,150**[a]	5,60 ± 1,848[b]	5,44 ± 2,181[b]	0,0001
Overall	6,88±1,716[a]	**7,08 ± 1,525**[a]	5,80 ± 1,826[b]	5,52 ± 1,503[b]	0,002
Consument[2]					
Colour	3.29 ±1.274[a]	**4.03 ± 0.822**[b]	2.91 ± 0.951[a]	3.29 ± 1.017[a]	0,0001
Scent	3.26 ±1.120[a]	**4.17 ± 0.747**[b]	3.11 ± 0.993[a]	3.46 ± 1.010[a]	0,0001
Texture	3.34 ±1.282[a]	**4.29 ± 0.893**[b]	2.69 ± 1.157[c]	3.31 ± 0.867[a]	0,0001
Flavour	3.23 ±1.190[a]	**4.14 ± 0.912**[b]	3.00 ± 1.029[a]	3.20 ± 0.994[a]	0,0001
Overall	3.23 ±1.330[a]	**4.20 ± 0.833**[b]	2.94 ± 1.027[a]	3.31 ± 1.022[a]	0,0001

Description:

[1]Mark 1 was tested with Visual Analog Scale (VAS) 0.0-10.0. Different superscript letters indicate significant differences between formulations in Duncan's test (P≤0.05).

[2]Marks were tested on a 1-5 Likert scale. Different superscript letters indicate significant differences between formulations in the Duncan test (P≤0.05).

[3]Signs a,b,c = Duncan's further test to state the difference in each formula.

Thus, it shows that the increasing addition of maggot flour and whey protein isolate will affect the color level of the biscuits. This makes the color of the biscuits visibly less preferred by the panelists. Where the F0 formulation biscuits are more preferred because without the addition of maggot flour and whey protein isolate. maggot flour and whey protein isolate so that it looks bright in color. Whey protein isolate has a yellowish white color (Fatma et al., 2015) and dark brown maggot flour (Dengah et al., 2015) causing a biscuit color that is browner than the control biscuit. This is in accordance with research (Arsyad, 2016) that the color of raw materials affects the color of the biscuits produced.

Based on the aroma parameter, it shows that the addition of maggot flour and whey protein isolate greatly affects the aroma of biscuits. In formulation F0 there was no rancid aroma from maggot flour because there was no addition of maggot flour and whey protein isolate and only the aroma of biscuits was smelled. Whereas in the F1, F2 and F3 formulations there is maggot flour and whey protein isolate content. In the F3 formulation, there is a slightly rancid maggot aroma due to the addition of the most maggot flour in the F3 formulation. Thus, it can be concluded that the higher the concentration level of maggot flour addition, the lower the level of panelist preference for the aroma

of biscuits due to the odor of the maggot. Whey protein isolate has a strong milk aroma even in small amounts (Lesme et al., 2020), while maggot flour has a rancid aroma. The rancid aroma in maggot flour can be caused by the high fat content so that the fat is oxidized more quickly (Manzocco et al., 2020).

Based on the texture parameters in the F0 formulation, the biscuits tend to be rather hard, unlike the F1, F2 and F3 biscuit formulations which have a texture that tends to be crisper when eaten. The fat content in maggot flour increases the crispness of the biscuits. This is in line with research (Laguna et al., 2014), that during the kneading process, fat will envelop the surface of starch and protein to produce crispy biscuits. Meanwhile, the high protein content in whey protein isolate will increase the firmness and adhesiveness of the biscuits (Raymundo et al., 2014). Crispness in a food product is also related to moisture content, this is because the more water that is evaporated during baking, air cavities will form so that the resulting product is crispier (Talahatu, 2011).

Based on the flavor parameter, the F0 biscuit formulation has a sweet taste. Meanwhile, the F1, F2 and F3 biscuit formulations have a sweet taste but the more concentration of maggot flour, leaving a slightly bitter aftertaste. Whey protein isolate has a flavor profile that tends to be sour and bitter due to aldehyde compounds resulting from the oxidation of unsaturated fatty acids either non-covalently or covalently with amino acid residues in proteins (Zhang et al., 2021). In a study conducted by (Khan et al., 2018), there was no significant effect on the taste of food added to maggot. So that the bitter aftertaste in biscuits is caused by the addition of whey protein isolate.

Overall, formulation F2 was less preferred due to the texture of F2 which was too crunchy, easily crushed, and there were many crumbs in the biscuits, which affected the panelists' opinion of the biscuits as a whole.

CONCLUSIONS AND RECOMMENDATIONS

Based on this research, there are four biscuit formulations using the ratio of maggot flour to whey protein isolate. whey protein isolate, namely F0 (0%: 0%), F1 (50%: 70%), F2 (60%: 60%), F3 (70%: 50%). Based on the results of nutrient analysis, the best treatment is the F1 formulation. With an energy value of 501.2 kcal, carbohydrates 40.71%, fat 29.09%, protein 17.87%, amino acids in the form of isoleucine 11.66 mg and leucine 18.42 mg, moisture content 8.44%, ash content 2.60%. 2,60%. Because, based on the results of the acceptability test, F1 is the formulation that is most acceptable to panelists.

Based on the results of Total Plate Count (TPC) analysis, all formulations are below the maximum limit, so that biscuits with maggot flour and whey protein isolate are suitable for consumption.

Based on the organoleptic test results, the overall biscuit formulation that was selected based on the quality test and hedonic test was formulation F1 with 50% maggot flour and 70% whey protein isolate. The characteristics of the formulation have a slightly brown color, a non-rancid aroma, a texture that is not too hard and does not crumble easily, and has an appropriate sweet taste.

FURTHER STUDY

Future research is expected to make the taste or aroma of biscuits that have the highest protein content so that their acceptance is more favorable and to eliminate the bitter aftertaste and rancid aroma that arises from maggot flour.

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