

Formulation of Emergency Food in Biscuit-Form Made From Proso Millet Flour (*Panicum miliaceum*) and Snakehead Fish (*Channa striata*) –Tempeh Flour Koya

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Abstract. Indonesia is a natural disaster-prone country. Food availability appears as the post-disaster main problem. Emergency food is an effort to overcome it. An ideal emergency food is expected to have a complete nutritional composition. Fulfilling macronutrient needs, proso millet flour and snakehead fish-tempeh flour *koya* were being used in this research. The objective of this research was to determine the formulation of emergency food in biscuit form made from proso millet flour and snakehead fish-tempeh flour *koya* based on its sensory, chemical and physical properties. This research was using a completely randomized design with one factor affecting. The variations of proso millet flour and snakehead fish-tempeh flour *koya* composition were 100:0 ; 80:20 ; 60:40 ; and 40:60. All treatments were carried out sensory evaluation using hedonic test, proximate analysis, calories analysis using bomb calorimetry methods. and physical analysis using texture profile analyzer. The compensatory model was used to determine the best formula based on all parameters. The result indicated that the best biscuit formula had compositions of proso millet flour 80% and snakehead fish-tempeh flour *koya* 20%. It had a brownish color, not-strong-fishy aroma, a strong-enough bitter aftertaste and crunchy texture. Chemical analysis showed that its moisture, ash, protein, fat, carbohydrate and total calories content were 1,146%; 4,827%; 12,536%; 26,325%; 56,312% and 5,033 kcal/gram, respectively. The physical analysis shows that its hardness and fracturability values were 8,037 N and 2,403 N, respectively.

Keywords : emergency food, biscuit, proso millet, snakehead fish, tempeh flour, *koya*

1. Introduction

Natural disaster is an incident that cannot be avoided or prevented. In Indonesia, it is increasing each year in amount [1]. These lead to many new post-disaster problems. One of them is food availability problem. Food becomes a scarce stuff at that time, whereas the victims need adequate nutrition. Resolving these nutrition need, Emergency Food Product (EFP) is intended to provide a compact, self-contained, high-energy, nutrient-dense emergency food for refugees and victims of disasters for a short duration at the initial stages of an emergency. EFP should contain 10-15% of protein, 35-45% of fat, and 40-50% of carbohydrates. Furthermore, the EFP must be safe, palatable, easy to dispense, easy to use, and nutritionally complete [2].

There are many alternative forms of EFP, one of them is biscuit [3]. Biscuit is a food made from wheat flour with the addition of other foodstuffs, with the process of heating and molding [4]. Biscuit form is used because it is easy to be fortified or substituted, high palatability and good shelf-life. Past studies showed that many designed EFP (e.g. food bars) didn't meet emergency food standards, especially on its calories and macronutrient composition. Fulfilling macronutrient needs, proso millet flour and snakehead fish-tempeh flour *koya* were being used in this research.

Proso Millet is the fourth economic ingredient after rice, wheat, and corn. Proso millet is a group of cereals used as a bird feed. Chemical analysis of proso millet flour showed that water, ash, fat, protein, carbohydrate and crude fiber content were 9.19%; 1.80%; 2.58%; 11.29%; 74.52%; And 2.01% [5].



Koya is a tasty food supplement in the form of powder [6]. This research used snakehead fish-tempeh flour koya with the percentage of 60% snakehead fish and 40% tempeh flour which has been studied in previous research. Koya has a protein content of 42.201% [7]. The use of koya is expected to increase the content of macro nutrient biscuits made in order to meet emergency food standards.

Koya is made from snakehead fish as main ingredient and tempeh flour as an additional ingredient. The nutritional value contained in snakehead fish is high enough, that is with protein equal to 42% and 1.7 % of fat [8]. Snakehead fish is one of good albumin source. Albumin is a soluble protein that is soluble in water and plays an important role in the formation of new cell tissues, boosts the recovery of damaged cell tissues and maintains fluid balance in the blood vessels [9].

Tempeh flour is added to the koya to disguise a distinctive fishy scent. In addition to disguising the fishy aroma, which is not desirable, the use of tempeh flour increases protein content in koya. Tempeh has a content of protein, fat, carbohydrate, water, and ash in a row is 46%; 24.7%; 19.3%; 7.7%; And 2.3% [10].

2. Materials and methods

2.1. Preparation of Koya Flour

Koya flour was made using snakehead fish obtained from Cengklik Lake, Boyolali with a length of 16-23 cm and tempeh obtained from Manang Village, Sukoharjo with incubation period for 2 days. First, snakehead fish was filleted and steamed and tempeh was cut and dried at a temperature of 70°C for 6-7 hours. Then, steamed fish meat was cooked with spices and coconut milk until dry. Tempeh flour was added afterward, then roasted for 5 minutes.

2.2. Preparation of Proso Millet Flour

Proso millet flour was made using millet obtained from Depok Market, Surakarta city. Millet was sorted from dirt then its epidermis was removed from the endosperm by crushing. Afterward, it was sorted again from the epidermis using winnowing method. Then, the endosperm was diminished in size and sieved with a particle size of 80 mesh [5].

2.3. Preparation of Biscuit Samples

Preparation of biscuit samples began with the calculation of total calories predictions. The formula was made using the previous study about biscuit (**Table 1**) [11]. Afterward, all ingredients in each formula were mixed until homogeneous. Then, the dough was flattened with a thickness of 3 mm and molded in a circle shape. Then, it was baked with a temperature of 200°C for 10 minutes.

Table 1 Biscuit's Formula

Ingredients	Formula			
	Control	F1	F2	F3
Proso Millet Flour (gram)	50.0	40.0	30.0	20.0
Snakehead Fish-Tempeh Flour Koya (gram)	0.0	10.0	20.0	30.0
Sugar (gram)	6.0	6.0	6.0	6.0
Salt (gram)	1.5	1.5	1.5	1.5
Full Cream Milk (gram)	8.0	8.0	8.0	8.0
Baking Soda(gram)	0.5	0.5	0.5	0.5
Vanilla (gram)	0.5	0.5	0.5	0.5
Shortening (gram)	20.0	20.0	20.0	20.0
Egg yolk (gram)	7.0	7.0	7.0	7.0
Egg white (gram)	8.0	8.0	8.0	8.0
Water (ml)	5.0	5.0	5.0	5.0
Total	105.0	105.0	105.0	105.0

2.4. Determination of Sensory Properties

The sensory properties were determined using the hedonic testing method. Color, aroma, taste, texture and overall of all biscuit formula was observed by 40 semi-trained panelists [12].

2.5. Determination of Chemical Properties

The chemical properties observed using standard analysis protocol from AOAC [13] in koya flour, proso millet flour and all biscuit formulas are moisture (935.29), ash (942.05), protein (total) (984.13), fat (Crude) (991.36), carbohydrate (986.25) and total calories content (only for all formulas) [14].

2.6. Determination of Physical Properties

The physical properties were determined using Texture Profile Analyzer (TPA) [15]. Observed parameters are hardness and fracturability.

2.7. Statistical Analysis Methods

All collected were analyzed using one-way analysis of variance (ANOVA) using SPSS Statistics 24. Difference between means was determined using Duncan's least significant difference. Then additive weighting technique of compensatory model used to determine the best formula [16].

3. Result and discussion

3.1. Chemical properties of ingredients

Main ingredients in this study are proso millet flour and snakehead fish-tempeh flour koya. These need to be observed to make a proper formula as an emergency food. Chemical properties of proso millet flour and snakehead fish-tempeh flour koya are showed in Table 2.

Table 2 Chemical Properties of Proso Millet Flour and Snakehead Fish-Tempeh Flour Koya

Chemical Component	Proso Millet Flour	Snakehead Fish-Tempeh Flour Koya
Moisture (%wb)	11.459±0.033	4.266±0.042
Ash (%db)	1.651±0.100	4.897±0.186
Protein (%db)	11.715±0.076	48.186±0.106
Fat (%db)	5.754±0.326	18.429±0.396
Carbohydrate (%db)	80.880±0.392	28.488±0.511

Notes: wb : wet basis

db : dry basis

As seen in Table 2, proso millet, which used in this study, has similarly protein content to the wheat flour which has 11.6 grams of protein in 100 grams wheat flour [17]. All chemical component of proso millet flour used in this study had meet standard requirements such as moisture content (maximum 14,5%) and protein content (minimum 7%) [18].

Koya used in this study has a high protein content of 48,186%. Koya was suggested in previous studies to be able to establish emergency food products that can meet the needs of protein by 10-15 percent [7]. All chemical component of Snakehead Fish-Tempeh Flour Koya used in this study had meet standard requirements such as moisture content (maximum 7%), ash content (maximum. 7%), fat content (maximum 30%) and protein content (minimum 15%). But, it has contrast in moisture content and protein content. The difference in moisture content is caused by cooking time. The previous study cooked koya for approximately 45 minutes, but in this study, it needs 90 minutes of cooking. Another difference, protein content, is caused by the length of snakehead fish used in this study. Some research reported that snakehead fish with 16-23 cm of length has higher protein content than others [19].

3.2. Sensory properties

The result of hedonic (Table 3) test shows that the use of koya causes a decrease in the level of liking on biscuit's color. It is caused by non-enzymatic browning. When reducing sugar (e.g. glucose) meets amino acid (e.g. lysine), Maillard reaction was done and led the raising of a brown pigment called melanoidin [20]. Furthermore, caramelization occurs during the process of biscuits making and bring a charred color up. Caramelization occurs when sucrose is heated at 200°C and forming caramelan.

Table 3 Sensory Properties of Biscuit

Formula	Color	Aroma	Flavor	Texture	Overall
Control	4.075 ^a ±0.888	3.825 ^b ±0.844	3.100 ^b ±0.982	3.925 ^b ±0.730	3.500 ^b ±0.906
F1	2.650 ^a ±0.975	3.125 ^a ±0.911	2.575 ^a ±0.712	4.075 ^b ±0.859	2.750 ^a ±0.630
F2	3.075 ^b ±0.917	3.075 ^a ±0.971	2.725 ^{ab} ±0.933	3.325 ^a ±0.694	2.875 ^a ±0.790
F3	2.625 ^a ±0.839	2.800 ^a ±0.939	2.475 ^a ±0.847	3.225 ^a ±0.768	2.625 ^a ±0.774

Notes : Values within the same row followed by the same letter are not statistically different (p < 0.05)

1= very dislike, 2= dislike, 3= Neutral, 4= like, 5= very like.

Control : 100% proso millet flour and 0% snakehead fish-tempeh flour koya

F1 : 80% proso millet flour and 20% snakehead fish-tempeh flour koya

F2 : 60% proso millet flour and 40% snakehead fish-tempeh flour koya

F3 : 40% proso millet flour and 60% snakehead fish-tempeh flour koya

Biscuits with greater use of koya have worse aromas. Showed in Table 3, greater koya used in the formula made the biscuit more disliked by the panelist. This is caused by poly carbonyls and mono carbonyls compounds that comes up during Maillard reaction and formed burnt aromas (pungent, empyreumatical) [20].

Biscuits with greater use of koya have worse flavor. in Table 3, greater koya used in the formula made the biscuit more disliked by the panelist. This is caused by caramelan pigment which is soluble in water or ethanol and has a bitter taste. This pigment comes up during caramelization process [20].

Biscuits with greater use of koya have worse texture. Showed in Table 3, greater koya used in the formula made the biscuit more disliked by the panelist. It is caused by waxy mouth feels contributed by koya's fats [21]. As seen in Table 4, fat content in biscuit increases with the addition of koya. These results bear a resemblance to the results of the physical analysis. The overall parameter is an evaluation of all parameters (e.g. Color, Aroma, Flavor, and Texture). As seen in Table 3, palatability of the biscuit decreases with the addition of koya.

3.3. Chemical properties of biscuits

In Table 4, the Moisture content of biscuit increases with the addition of koya. Koya donates sucrose and polar amino acids. Sucrose and polar amino acid have the ability to bind with water [22]. The moisture content of all formula has met the standard at a maximum of 5% [4].

Ash contains minerals. In Table 4, Ash content of biscuits increases with the addition of koya. As known in Table 2, koya donates greater minerals than proso millet flour. This makes biscuits with the greater addition of koya has a greater amount of minerals within. These results haven't met the standard at a maximum of 1.6% [23].

Protein content increases with the addition of koya as seen in Table 4. It is caused by donated koya has a greater amount of protein than proso millet flour. As seen in Table 2, the protein content of koya is 48.186% whereas flour only has a protein content of 11.715%. These results have met protein requirement as a biscuit and as an emergency food product. The minimum protein content of a product in the form of the biscuit is 5% [4]. As an EFP, the product should contain 10-15% of the protein [2].

Table 4 Chemical Properties of Biscuit

Formula	Mositure (%wb)	Ash (%db)	Protein (%db)	Fat (%db)	Carbohydrate (%db)	Total Calories (kcal/gram)
Control	2.556 ^b ±0.139	3.941 ^a ±0.085	9.909 ^a ±0.292	25.828 ^a ±0.150	60.322 ^a ±0.498	5.364 ^b ±0.004
F1	1.146 ^a ±0.032	4.827 ^b ±0.017	12.536 ^b ±0.058	26.325 ^a ±0.678	56.312 ^b ±0.610	5.033 ^a ±0.017
F2	2.677 ^b ±0.012	5.083 ^c ±0.068	15.999 ^c ±0.105	29.773 ^b ±0.276	49.145 ^c ±0.312	5.390 ^b ±0.019
F3	3.041 ^c ±0.755	5.448 ^d ±0.027	18.049 ^d ±0.222	31.131 ^c ±0.447	45.372 ^d ±0.501	5.579 ^c ±0.067

Notes : Values within the same row followed by the same letter are not statistically different ($p < 0.05$)

Control : 100% proso millet flour and 0% snakehead fish-tempeh flour koya
 F1 : 80% proso millet flour and 20% snakehead fish-tempeh flour koya
 F2 : 60% proso millet flour and 40% snakehead fish-tempeh flour koya
 F3 : 40% proso millet flour and 60% snakehead fish-tempeh flour koya

Fat content increases with the addition of koya as seen in Table 4. It is caused by donated koya has a greater amount of fat than proso millet flour. As seen in Table 2, the fat content of koya is 18.429% whereas flour only has a protein content of 5.754%. These results have met fat requirement as a biscuit but not as an emergency food product. The minimum fat content of a product in the form of the biscuit is 9.5% [4]. As an EFP, the product should contain 35-45% of fat [2].

In Table 4, the carbohydrate content of biscuit decreases with the addition of koya. It's happened because koya doesn't has sufficient amount of carbohydrate replacing carbohydrate donated by proso millet flour. These results have met carbohydrate requirement as an emergency food product. As an EFP, the product should contain 40-50% of carbohydrate [2].

The results of total calories analyses showed in Table 4. It's showed that with a greater addition of koya make the biscuit has greater total calories. These results have met total calories requirement as a biscuit and as an emergency food product. The minimum total calories of a product in the form of the biscuit is 4.000 kcal/gram [23]. As an EFP, the product must have minimum 4.660 kcal/gram [2].

3.4. Physical Properties

Hardness is the perceived force required to break the sample into several pieces during the first bite by the molars. Hard as a texture characteristic describes a product which displays substantial resistance to deformation or breaking [15]. The results of total physical analyses showed in **Table 4**. It's showed that with a greater addition of koya make the biscuit has a harder texture. The result relates to the moisture content of each formula. Higher moisture content, harder the texture of the biscuits. A product at moisture content lower than 10% has a brittle state. In this state, the cracks formation is so frequent that this process becomes to be the important source of strength decreases with decreasing moisture content [24]

Table 5 Physical Properties of Biscuit

Formula	Hardness (N)	Fracturability (N)
Control	12.878 ^b ±0.336	6.906 ^{ab} ±0.230
F1	8.037 ^a ±1.030	2.403 ^a ±0.305
F2	20.380 ^c ±2.372	9.859 ^b ±1.491
F3	29.329 ^d ±0.427	22.247 ^c ±3.014

Notes : Values within the same row followed by the same letter are not statistically different ($p < 0.05$)

1= very dislike, 2= dislike, 3= Neutral, 4= like, 5= very like.

Control : 100% proso millet flour and 0% snakehead fish-tempeh flour koya
 F1 : 80% proso millet flour and 20% snakehead fish-tempeh flour koya
 F2 : 60% proso millet flour and 40% snakehead fish-tempeh flour koya
 F3 : 40% proso millet flour and 60% snakehead fish-tempeh flour koya

Fracturability (originally called brittleness) was defined as the force of the initial break in the curve on the first bite [15]. The results of total physical analyses showed in Table 4. It's showed that with a greater addition of koya make the biscuit has more firm texture. The result relates to the moisture content of each formula. Higher moisture content, harder the texture of the biscuits. A product at moisture content lower than 10% has a brittle state. In this state, the cracks formation is so frequent that this process becomes to be the important source of strength decreases with decreasing moisture content [24]

3.5. Determination of the best formula

Compensatory model was used in this study to determine the best formula. The determination was done based on its sensory, chemical and physical parameters. The method was started with non-dimensional scaling and followed by the additive weighting technique [16]. The highest total score showed the best formula. As seen in Table 6, F1 formula is the best formula followed by F2 and F3 formula.

Table 6 Determination of the best formula using Compensatory model

Table 6. Determination of the best formula using Compensatory model								
Component	Relative Rank	Normalized Weight	F1		F2		F3	
			DV	Score	DV	Score	DV	Score
Sensory								
Color	1	0.077	0.056	0.004	1.000	0.077	0.000	0.000
Aroma	1	0.077	1.000	0.077	0.846	0.065	0.000	0.000
Flavor	1	0.077	0.400	0.031	1.000	0.077	0.000	0.000
Texture	1	0.077	1.000	0.077	0.118	0.009	0.000	0.000
Overall	1	0.077	0.500	0.038	1.000	0.077	0.000	0.000
Chemical								
Moisture content	1	0.077	1.000	0.077	0.192	0.015	0.000	0.000
Ash content	1	0.077	1.000	0.077	0.588	0.045	0.000	0.000
Protein content	1	0.077	1.000	0.000	0.283	0.048	0.000	0.000
Fat content	1	0.077	0.000	0.077	0.628	0.022	1.000	0.077
Carbohydrate content	1	0.077	1.000	0.077	0.345	0.027	0.000	0.000
Total calories	1	0.077	0.000	0.000	0.654	0.050	1.000	0.077
Physical								
Hardness	1	0.077	1.000	0.077	0,420	0.032	0.000	0.000
Fracturability	1	0.077	1.000	0.077	0,624	0.048	0.000	0.000
Total	13		8.956	0.689	7,498	0.592	2.000	0.154
Control : 100% proso millet flour and 0% snakehead fish-tempeh flour koya								
F1 : 80% proso millet flour and 20% snakehead fish-tempeh flour koya								
F2 : 60% proso millet flour and 40% snakehead fish-tempeh flour koya								
F3 : 40% proso millet flour and 60% snakehead fish-tempeh flour koya								

Conclusion

The best biscuit formula contains of 80% proso millet flour and 20% snakehead fish-tempeh flour koya. It had a brownish color, not-strong-fishy aroma, a strong-enough bitter aftertaste and crunchy texture. Chemical analysis showed that its moisture, ash, protein, fat, carbohydrate and total calories content respectively were 1.146%; 4.827%; 12.536%; 26.325%; 56.312% and 5.033 kcal/gram. The physical analysis showed that its hardness and fracturability values respectively were 8.037 N and 2.403 N.

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