



Characteristic and Self-Life Test of Food Bar with Combination of White Millet, Snakehead Fish and Soy Flour

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Abstract

Emerging food is needed when a disaster occurs. Emergency conditions encourage the provision of ready-to-eat-food with sensory properties which can be accepted by people, has sufficient nutrient content to meet the body's calorie needs and resistant during storage. This study was aimed to obtain the best formulas of the food bar based on the parameters observed, such as sensory, chemical, total calorie, a_w and shelf life estimation with the Accelerated Shelf Life Test. The food bar made from white millet flour and fish koya made from snakehead fish and soy flour. Intermediate moisture food (IMF) applied in this study with the initial formulation specified by using the mass equilibrium. The effectiveness test used to determine the best formula based on all observed parameters. The results showed that the best food bar formula was F2 with moisture content ($20.99 \pm 0.21\%$); ash ($3.45 \pm 0.35\%$); fat ($18.10 \pm 0.13\%$); protein ($12.24 \pm 0.28\%$); and carbohydrates ($45.22 \pm 0.32\%$), a_w (0.76 ± 0.01); and total calories (per 50 g) 232.04 ± 1.96 kcal. The shelf life was 19 days. Based on the results, the total calories produced from the best formula did not meet the standards.

Keywords: emerging food, fish *koya*, shelf-life

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INTRODUCTION

Snakehead fish (*Channa striata*) can be found in Indonesia, especially in Java, Kalimantan and Sulawesi (Asfar et al., 2014; Ndobe et al., 2017). Snakehead fish has a high protein content around 66% (dry) (Prastari et al., 2017). Snakehead fish contains essential amino acids and high essential fatty acids, especially arachidonic acid and omega-3 fatty acids, called $C_{22:6}$ which beneficial for health (Haniffa et al., 2014; Rahman et al., 2018). During this time, Snakehead fish are widely used as raw materials for pharmaceutical industries (Ndobe et al., 2017). Besides, fish protein concentrate as a source of Snakehead fish albumin can be used as a functional food (Asfar

et al., 2014; Romadhoni et al., 2016). Based on these advantages, Snakehead fish has the potential to be used as a source of protein in processed foods such as food bars.

The food bar is fast food in the form of sticks, rich in nutrition and filling, suitable for emerging food. This food is essential, especially during disasters and minimum water, considering that Indonesia is a disaster-prone country such as landslides, volcanic eruptions and floods. As an emerging food, the food bar is expected to meet the daily calorie needs of humans, which is around 233–250 kcal 50 g⁻¹ of material (Kusumastuty et al., 2015), with a moisture content of 15-40%, 35-45% fat, 40–50% carbohydrates and 10-15% protein (Zoumas et al., 2002).

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Food bar can be made from local Indonesian ingredients. Several studies have been conducted to produce food bar formula such as banana based (Rahman et al., 2011), rice bran, corn (Kusumastuty et al., 2015) and taro flour (Jariyah et al., 2017). Research on food bars then developed using high-protein ingredients such as soybean flour (Ekafitri and Isworo, 2014), green bean flour (Ladamay and Yuwono, 2014) and tempeh flour (Aini et al., 2018).

Other local ingredients such as cereals are also potentially used as ingredients in making food bars, one of them is millet seeds (*Panicum miliceum* L.). Nowadays, millet seeds mostly used as bird feed. Millet seeds have the potential to be used as food because the nutritional content is close to rice and wheat (Marta et al., 2016). Several studies used millet as an ingredient in the formulation of mother's milk supplementary food products (Husna et al., 2012; Ardhianditto et al., 2013; Anandito et al., 2016a) and flake making (Malinda et al., 2013). Millet utilization in food bar is still rare.

Due to the high carbohydrate content in millet, encourages the addition of other high-protein ingredients in the manufacture of food bars. Anandito et al. (2016) used white millet flour as an ingredient in making food bars, combined with red bean flour as a source of protein. Need further research on the use of millet flour and animal protein in the manufacture of food bars, so this research was conducted.

The snakehead fish addition in the form of koya expected to produce rich nutrients and functional benefits, also facilitate the food bar formulation. Fish koya is a powder food supplement by sprinkled (Regina et al., 2012). Food bars must be acceptable to the community based on their sensory. One of the sensory properties of the food bar is the odor. Fishy odor in fish will affect the sensory characteristics of the food bar. Therefore, the Snakehead fish koya is added by soy flour (*Glycine max*) to cover the fishy smell. Also, adding soy flour also contributes to increasing the protein content of food bars.

A food bar as emerging food is expected to survive during storage. Food bar might decrease in its quality both physically and chemically. During storage, the food bar might change in sensory quality attributes such as discoloration, texture, aroma and taste and decreasing its nutritional value. Therefore, determining the shelf

life of a food bar is very important. The purpose of this study was to determine the chemical characteristics of a food bar combination of white millet flour, snakehead fish and soy flour and to determine the shelf life estimation of food bar formulation.

MATERIALS AND METHOD

Material

The material used was white millet (*Panicum miliceum* L.) obtained from Depok Market, Surakarta, Central Java, Snakehead fish (*Channa striata*) obtained from Cengklik Reservoir, Boyolali, Central Java and local soybeans obtained from Grobogan, Central Java. The ingredients for making koya such as red onion, garlic, candlenut, coriander, ginger, galangal, lemongrass leaves, bay leaves, kaffir lime leaves, brown sugar, salt and coconut milk obtained from Depok Market, Surakarta, Central Java.

Equipment

The equipment that used for the manufacture of food bars were disk mill (SMJIM Models: FFC-15, Indonesia), drum dryers (Armfiel, UK), oven (Mommert, Germany) and kitchen appliances. Equipment for shelf life testing used an incubator (Mommert, Germany). Beside, glassware was also used for analyzing food bars.

Instant white millet flour production

The flour made based on Anandito et al. (2015) by sifting 80 mesh size on white millet flour after removing the husk. White millet flour then heated by adding water with a ratio of white millet flour and water 1: 2 (white millet flour: water = 1: 2 (b:v)) until boiling. Heating process finished if white millet pulp formed. Instant white millet flour produced by grinding white millet pulp on a drum dryer at 115 °C with a rotational speed of 2 rpm.

Minced snakehead fish

Snakehead fish was cleaned by removing the head, tail, scales and viscera. Snakehead fish was then washed and filleted. Furthermore, the fish meat was steamed at ± 100 °C for 10 minutes. After steaming process, the meat was minced.

Making soybean flour

Soybeans were roasted for approximately 30 minutes until the color becomes browned. Roasted soybeans then crushed and sifted to a size of 60 mesh.

Making snakehead-soybean *koya*

Koya was made based on Regina et al. (2012). *Koya* spices consisted of mashed shallot, garlic, candlenut and coriander. The spices mixed with thick coconut milk, ginger, galangal, crushed lemongrass leaves, bay leaves, kaffir lime leaves, brown sugar and salt and then boiled. After the coconut milk and spices boiled, the ground snakehead was inserted and stirred for ± 1 hour until browned. After that, the soy flour was added and mixed until it was even to dry. The ratio between ground Snakehead fish and soy flour 3: 2. The mixture was then mashed.

Determination of the initial formula

Determination of the initial formula of the product based on Anandito et al. (2016) using the principle of mass equilibrium. Calculating the amount of input material must be equal to the amount of output produced (incoming material = result material). The initial formula for the product was determined based on the nutritional requirements of emerging food, which contains minimum calories of 233 kcal bar⁻¹. This value based on the assumption that one bar was equal to 50 g. The formula of the food bar presented in Table 1.

Table 1. Food bar formulation

Ingredient	Results (% w w ⁻¹)		
	F1	F2	F3
White millet flour	22	26	30
Snakehead-soybean <i>Koya</i>	30	26	22
Sugar	16	16	16
Margarine	14	14	14
Full cream milk	18	18	18

Note: F1 = Formula 1; F2 = Formula 2; F3 = Formula 3

The ingredients used in the formulation were millet flour as a source of carbohydrates, snakehead-soybean *koya* as a source of protein, powdered full cream milk as a source of protein, fat and enhance the flavor and margarine as a source fat. Sugar added to sweeten the product and as carbohydrate sources. Nutritional content of macronutrient constituent of food bars used to calculate the total calorie. The ingredients of the food bar and its macronutrient content showed in Table 2.

Table 2. Macronutrient content of food bar ingredients

Ingredient	Macronutrient (g 100 g ⁻¹ materials)		
	Carbohydrate	Fat	Protein
Millet instant flour ^a	83.27	2.26	8.23
Snakehead-soybean <i>Koya</i> ^b	32.57	15.53	36.61
Margarine Refined	0.40	81.00	0.60
sugar	94.00	0.00	0.00
Full cream milk	40.00	26.00	27.00

Note: ^a = proximate analysis by Anandito et al. (2015);
^b = proximate analysis by Saputro (2016);
^c = ingredients composition based on DKBM (Prawiranegara, 1989)

Each macronutrient had a calorific value (carbohydrate 4 kcal g⁻¹, 4 kcal g⁻¹ protein and 9 kcal g⁻¹ fats), so the total calorie value of the food bar is known by multiplying the calories of each macronutrient with the amount of macronutrient input from the food bar. The total calorie value of the food bar based on the formula showed in Table 3.

Table 3. Food bar total calorie

Macronutrient	Food bar formulation					
	F1		F2		F3	
	Calorie (kcal)	% of total calorie	Calorie (kcal)	% of total calorie	Calorie (kcal)	% of total calorie
Carbohydrate	97.03	41.29	101.08	43.11	105.14	44.95
Protein	35.50	15.10	33.23	14.17	30.96	13.24
Fat	102.58	43.63	100.19	42.73	97.81	41.81
Total calorie	235.11 kcal		234.51 kcal		233.91 kcal	

Note: F1 = Formula 1; F2 = Formula 2; F3 = Formula 3

Making a food bar

Food bar made based on Anandito et al. (2016) with modifications to the temperature and baking time. The ingredients were used to make a food bar were instant white millet flour, fish *koya* (Snakehead fish and soy flour), margarine, refined sugar, full cream milk powder and water. The ingredients was mixed then was stirred and added water until blended. Next, the blended mixture was formed on the pan. After that, the dough was baked in an oven at 140 °C for 30 minutes. Removed the food bar from the oven and let it set. The food bar then packed using aluminum foil.

Analysis of the food bar

The food bar then subjected to sensory analysis (test of preference), chemical composition, water activity (a_w) and caloric value. Sensory analysis used as preference test based on Setyaningsih et al. (2010) by using 60 untrained panelists, with parameters of color, aroma, taste, texture and overall, with scales of 1-5 in the order: (1) like, (2) rather like, (3) neutral, (4) rather dislike, (5) dislike.

Chemical analysis including moisture content using the thermogravimetric method, ash content using ignition method, fat content using the Soxhlet method, protein content using the Kjeldahl method and carbohydrate content using a method called *by difference* (AOAC, 1995). Water activity measured using a_w meter (Apriyantono et al., 1989) and caloric value using *Bomb Calorimeter* method (Mulyaningsih and Rosida, 2002).

In order to determine the best food bar formula-tested by, the effectiveness test was conducted (de Garmo, 1984). The test was carried out by giving the weight or score on each parameter observed according to its importance on a product, with a range of values 0-1, referred to as variable weight (VW). Normal weight (NW) is the value of VW divided by total VW. The effectiveness value (NE) calculated by dividing the difference in parameter values and the lowest parameter value with the difference between the highest and lowest parameter values. While the yield value (YV) obtained by multiplying NE and NW.

$$\text{Effectiveness value (NE)} = \frac{(\text{Parameters value} - \text{lowest values})}{(\text{Highest values} - \text{lowest values})}$$

$$\text{Yield value (YV)} = \text{NE} \times \text{normal weight (NW)}$$

Food bars self-life

Estimating the shelf life of a food bar was tested by Accelerated Shelf Life Test Arrhenius (ASLT) method. Samples then stored in an incubator at 3 different temperatures, 40 °C, 45 °C and 50 °C for 28 days. Sensory tests including color, taste, texture, ease of swallowing and overall were carried out on days 0, 7, 14, 21 and 28. The sensory test results then processed into an Arrhenius plot so the reaction rate constants can be known as a function of temperature. Shelf life was calculated based on the reaction rate order of the reaction, with zero order $t = (Q_0 - Q) / k$ and first-order $t = (\ln(Q_0 / Q)) / k$

Description:

Q_0 = Score of the first day to 0

Q = Critical score

k = reaction speed constant

t = storage time (in days, months or years)

Statistical analysis

This study using a completely randomized design of one factor, the composition of white millet flour and a mixture of Snakehead fish and soy flour as a primary ingredient in making the food bar. The data obtained was carried out statistical analysis using one-way ANOVA (Analysis of Variance). If there was a significant difference, then proceed using DMRT (Duncan Multiple Range Test) at the significance level $\alpha = 0.05$.

RESULTS AND DISCUSSION

Food bar characteristic

Sensory properties

The result of sensory analysis of food bar based on white millet flour with snakehead-soybean *koya* showed in Table 4. Based on the sensory analysis, the three formulas of food bar were not significantly different in color and texture parameters, while for taste parameters and overalls were significantly different.

Table 4. Sensory properties

Formula	Parameter				
	Color	Aroma	Taste	Texture	Overall
F1	2.28±0.90 ^a	2.13±0.89 ^a	2.23±0.74 ^b	2.30±0.87 ^a	2.40±0.85 ^b
F2	2.12±0.80 ^a	2.05±0.67 ^a	1.68±0.81 ^a	1.98±0.70 ^a	1.87±0.77 ^a
F3	2.22±0.76 ^a	2.43±0.87 ^b	1.93±1.12 ^a	2.17±0.99 ^a	2.12±0.90 ^{ab}

Note: the same letter in the same column showed no significant different $\alpha = 0.05$

F1 = Formula 1, F2 = Formula 2, dan F3 = Formula 3;

The sensory properties of food bars for color parameters ranged from 2.12 to 2.28 with a range of preference levels of *rather like*. The results of the sensory analysis showed no significant difference in the color parameters of the three formula food bars. The color of the three formulas food bar was dark brown. The dark brown color in

the food bar came because the *koya* from Snakehead fish and soy flour which had a rather dark brown color. The colors of the three formulations food bar were not significantly different, in other words, the three formulas have almost the same color, dark brown. The result of the food bar showed in Figure 1.



Figure 1. Food bar

The color was formed during the oven process. During the heating process, the Maillard reaction occurred between the reducing sugar and amino acids in the ingredients causing the product became brownish (Tamanna and Mahmood, 2015). The brown coloring was a melanoidin compound produced from the Maillard reaction.

The results of sensory analysis based on aroma parameters showed that the scores ranged from 2.05 to 2.43 with a preference level of *rather like*. The results of the sensory analysis showed that there was a significant difference in the aroma parameters, especially in the F3 formula, whereas for F1 and F2 formulas were not significantly different. It happened because of the addition of white millet flour and *koya* from Snakehead fish and soy flour for F1 and F2 formulations. So the formulas produced almost the same aroma. The aroma produced in the food bar was obtained from a mixture of margarine, full cream milk and *koya* from Snakehead fish and soy flour. The strong aroma of this food bar was the aroma of soybeans. Pertiwi et al. (2013) stated that the typical aroma

of soybeans was unpleasant which could be reduced during the processing. Adiandri et al. (2012) stated that soybean aroma could be reduced by boiling. In this study, soybean aroma could be reduced because it was combined with other ingredients in the making of *koya*, so the more addition of snakehead-soybean *koya* in F1 and F2 formula were preferred by panelists.

Based on Table 4, the taste parameter had a score ranging from 1.68 – 2.23 with a range of preference level of *like*. The results of the sensory analysis showed that there were significant differences based on taste parameters. F1 formula was significantly different from F2 and F3 formulas. The assessment obtained for F1 was 2.23; for F2 was 1.68 and for F3 was 1.93. The F1 formula showed that the food bar with the highest part of snakehead-soybean *koya* and the lowest part of instant millet had a low value that means the panellist like the product. The taste score was low in F1 formula because it had a strong fishy smell and slightly bitter aftertaste. This result was following the research by Anandito et al. (2015),

food bars of white millet flour, green bean flour and soy flour have a bitter aftertaste. Bitter taste arose due to the content of tannins presented in white millet and soybeans. Kutsukutsa et al. (2014) stated that tannin could cause a bitter taste. Millet had a tannin content which was an anti-nutrient agent (Rani et al., 2018). The tannin content in millet flour had decreased during high temperature processing. Micahel and Admassu (2017) stated that tannin decreased during the extrusion process at 130°C. The tannin content in white millet was 1255.3 mg 100g⁻¹ and decreased by 78.19% during the extrusion process. Soybeans also had tannin content. Wardani and Wardani (2014) stated that soybeans contained tannins which caused a bitter taste. According to Jiao et al. (2012) the tannin content in soybeans ranged from 1.76–3.6%. Therefore, the lower addition of instant millet flour and the higher snakehead-soybean *koya* provided an increasingly bitter taste.

Based on the sensory analysis, the three formulas tended to be favored by panelists. The results of this study showed different things from previous studies using white millet flour. Anandito et al. (2015) made food bars by using white millet flour by adding pulses of flour and glycerol to produce a sensory parameter for taste with a rather like to neutral level of preference. Anandito et al. (2016) added parboiled kidney beans to food bars to produce flavor with a range

of acceptance rather dislike to rather like. The addition of snakehead-soybean *koya* could improve the sensory properties of the food bar in taste parameter.

Texture parameters showed scores ranging from 1.98 - 2.30 with a range of like to rather like. The result for F1 was 2.30; for F2 was 1.98 and for F3 was 2.17. The results showed no significant difference based on texture parameters. The three formulas of food bar had not too hard texture, nor too dry and dense. The texture of the food bar did not cause thirst and easily swallowed when consumed.

Based on the overall parameters, F1 formulation was significantly different from F2 formulation, while the F1 with F3 and F2 with F3 formulation was not significantly different. The assessment obtained for F1 was 2.40; F2 was 1.87 and F3 was 2.12. Overall, the food bar formulation preferred by the panelist was F2 formula.

The chemical composition of food bar

The chemical composition analysis was carried out to determine the chemical content presented in the food. In this study, the chemical composition analysis of the food bar was carried out for all formulas so it could be known which formula had the chemical composition following the standards. The chemical composition of the three formulas showed in Table 5.

Table 5. The chemical composition of food bar

No.	Chemical composition	F1	F2	F3	Standard (adapted from Zoumas et al., 2002)
1.	Moisture content (% wb)	21.14±0.68 ^a	20.99±0.21 ^a	20.78±0.26 ^a	10-40
2.	Ash (% wb)	3.85±0.06 ^a	3.45±0.35 ^a	3.48±0.05 ^a	-
3.	Fat (% wb)	17.91±0.66 ^a	18.10±0.13 ^a	17.71±0.32 ^a	-
	(% total calories)	41.38	41.47	40.72	35-45
4.	Protein (% wb)	13.26±0.28 ^c	12.24±0.28 ^b	11.27±0.24 ^a	-
	(% total calories)	13.61	12.46	11.51	10-15
5.	Carbohydrate (% wb)	43.84±0.87 ^a	45.22±0.32 ^b	46.76±0.29 ^c	-
	(% total calories)	45.01	46.06	47.77	40-50
6.	Calorie (kcal 50 g ⁻¹)	223.61±2.54 ^b	232.04±1.96 ^c	209.99±2.27 ^a	>233
7.	Water activity	0.78±0.02 ^a	0.76±0.01 ^a	0.75±0.00 ^a	0.60-0.85

Note: the same letter at the same row showed no significant different $\alpha = 0.05$

F1 = Formula 1, F2 = Formula 2, F3 = Formula 3

Table 5 showed the moisture content of the three formulas, F1 21.14%; F2 20.99% and F3 20.78%. The moisture content of the three

formulas was not significantly different and following the requirements, between 15-40% (Zoumas et al., 2002). The more *koya* from

Snakehead fish and soy flour, the higher the moisture content of the food bar. The raw material for making *koya* was Snakehead fish and soy flour and each had high protein content. The protein had ionic strength which able to bind water (Trianto et al., 2013), the more *koya* to produce food bars would increase the moisture content.

The ash content of the three formula was 3.85% F1; 3.45% F2 and 3.482% F3 and significantly different in the three formulas. The ash content produced from this study was higher than Anandito et al. (2016) which produced a food bar with 1.45% ash content. This due to the high ash content of snakehead and soybean. Prastari et al. (2017) stated that the ash content of Snakehead fish was 15.4% while soybean ash content ranged from 5-6% (Astawan et al., 2013).

The three formulas showed not significantly different on fat content that was. F1 fat content was 17.91%; F2 18.10% and F3 17.71%. The fat content of food bar based on white millet flour with the addition of snakehead-soybean *koya* per bar (50 g) for F1 8.96 g or equivalent to 41.38% of total calories, for F2 9.05 g or equivalent 41.47% of total calories and for F3 8.86 g or equivalent to 40.72% of total calories and in accordance with emerging food standards, which had 35-45% of total calories (Zoumas et al., 2002).

The protein content of the three food bar formulas showed significantly different results. F1 protein content was 13.26%; F2 12.24%; and F3 11.27%. Table 5 showed that the protein content of food bar based on white millet flour with the addition of snakehead-soybean *koya* per bar (50 g) for F1 was 6.63 g or equivalent to 13.61% of total calories. For F2 6.12 g or equivalent to 12.43% of total calories and for F3 5.63 g or equivalent to 11.51% of total calories and following emerging food standards which had 10-15% of total calories (Zoumas et al., 2002)

The addition of Snakehead-soybean *koya* in the food bar formulations was increased the protein content. Due to the high protein content in snakehead fish and soybean. The protein content in Snakehead fish was 66.67% in dry weight (Prastari et al., 2017) while the protein content in soybeans ranged from 37-41% (Astawan et al., 2013). Therefore, the more *koya*, the higher the protein content of the food bar.

The three food bars formula had significantly different carbohydrate levels. F1 carbohydrate content was 43.84%; F2 45.22% and F3 46.76%.

Carbohydrate content per bar (50 g) based on white millet flour with the addition of Snakehead-soybean *koya* for F1 amounted to be 21.92 g or equivalent to 45.01% of total calories, for F2 22.61 g or equivalent 46.06% of total calories and F3 23.38 g or equivalent to 47.77% of total calories. Zoumas et al. (2002) stated that emerging food standards had carbohydrates content about 40-50% of total calories. The results of the carbohydrate content of the food bar in this study were following the standards.

Total calories

The standard for total calories in emerging food was 233 kcal 50 g⁻¹ (Zoumas et al., 2002; Kusumastuty et al., 2015). The total calories of food bar that produced from this study per bar (50 g): F1 223.61 kcal; F2 232.04 kcal and F3 209.99 kcal. Based on the three formulas, the highest calories were obtained in the F2 formulation and the lowest in the F3 formulation. All three formulas had total calories below emerging food standards. However, the total calorie that was close to the emerging food standard was F2 of 232.04 kcal 50 g⁻¹. This result was also lower than the predicted result. Based on predictions, the total calories for the F2 formula were 234.51 kcal 50 g⁻¹. The result was lower than this prediction due to the fiber content in millet and soybeans. Food fiber was a part of plants that cannot be digested in the small intestine but fermented in the large intestine, so it did not produce energy or calories (Lattimer and Haub, 2010; Dhingra et al., 2012). White Millet contained fiber as much as 2.20% (Singh, 2016), while soybeans were known as a source of food fiber with a total fiber of 5.56-8.58% (Ratnaningsih et al., 2017). Calorie needs per day, which is equal to 2100 kcal, could be met by consuming as many as 3-4 bars per consumption (one meal) and done three times a day.

Water activity (a_w)

Emerging food must have water activity between 0.60 – 0.80 (Zoumas et al., 2002) associated with microbial growth. The three formulas had a_w: F1 0.78; F2 0.76 and F3 0.75. The results of the water activity (a_w) showed no significantly different and following the standard. The value of a_w was related to the shelf life of the food bar in terms of microbiology. Microbes could grow in food, especially yeast (a_w 0.88) and bacteria (a_w > 0.90) (Yusuf et al., 2016). All of them had a_w ranging from 0.7-0.8. Although it had

fulfilled the standard for food bar, it should be kept in dry place and not damp to prevent the growth of fungus.

Determining for the best formula for food bar

The best formula for the food bar was determined by the effectiveness index test (de Garmo, 1984) showed in Table 6. The principle of effectiveness index testing was to give weights or scores on the quality characteristics of each formula (Sappu et al., 2014). Determination of the

best formula done by considering all parameters, in this study was sensory parameters, including color, aroma, taste, texture and overall. Besides, the chemical parameters which include moisture, ash, protein, fat, carbohydrate and total calorie values and a_w . All parameters had the same weight as the characteristics of a food bar. Based on the calculations in Table 6, the best food bar formula was the F2 formula with a yield value (NH) of 0.74.

Table 6. Food bar effectively result

Parameter	VW	NW	F1		F2		F3	
			NE	YV	NE	YV	NE	YV
Color	1	0.08	0.00	0.00	1.00	0.08	0.37	0.03
Aroma	1	0.08	0.79	0.07	1.00	0.08	0.00	0.00
Taste	1	0.08	0.00	0.00	1.00	0.08	0.55	0.05
Texture	1	0.08	0.00	0.00	1.00	0.08	0.41	0.03
Overall	1	0.08	0.00	0.00	1.00	0.08	0.53	0.04
Water	1	0.08	1.00	0.08	0.58	0.05	0.00	0.00
Ash	1	0.08	1.00	0.08	0.00	0.00	0.07	0.01
Fat	1	0.08	0.51	0.04	1.00	0.08	0.00	0.00
Protein	1	0.08	1.00	0.08	0.49	0.04	0.00	0.00
Carbohydrate	1	0.08	0.00	0.00	0.47	0.04	1.00	0.08
Total calories	1	0.08	0.62	0.05	1.00	0.08	0.00	0.00
Water activity	1	0.08	1.00	0.08	0.33	0.03	0.00	0.00
Total	12			0.49		0.74		0.24

Note: VW = variable weight, NW = normal weight, NE = effectivity value, YV = yield value

Food bar shelf life

Shelf life is the time of a food product that still acceptable and fulfills consumer desires for the quality of the product. Estimated shelf life aimed to control the quality and safety of food products (Martins et al., 2008). F2 was the best formula based on the effectiveness index test. F2 tested its shelf life estimation that aimed to determine the quality attribute changes during storage based on consumer acceptance (Corrigan et al., 2012). Food bars had decreased panelists acceptance of

each quality attribute which includes color, taste, texture, ease of swallowing and overall over 28 days of storage at different temperatures.

Table 7 showed the decrease in panelists acceptance of all quality attributes based on the zero-order reaction and first order reaction. Based on the coefficient of determination (R^2) which close to 1, changed in quality attributes such as color, texture and easy to swallow following the 1st order equation while for taste and overall attributes following the zero-order reaction. The calculation of k values showed in Table 8.

Table 7. Decreasing panelists acceptance based on food bar quality

Parameter	Storage temperature (°C)	Equation	
		Zero order reaction	First order reaction
Color	40	$y = -0.1302x + 6.3111$ $R^2 = 0.9893$	$y = -0.0298x + 1.8754$ $R^2 = 0.9971$
	45	$y = -0.1392x + 6.1926$ $R^2 = 0.9740$	$y = -0.0335x + 1.8598$ $R^2 = 0.9960$
	50	$y = -0.1503x + 6.1407$ $R^2 = 0.9639$	$y = -0.0379x + 1.8557$ $R^2 = 0.9940$
Taste	40	$y = -0.1439x + 6.9926$ $R^2 = 0.9924$	$y = -0.0311x + 1.9934$ $R^2 = 0.9597$
	45	$y = -0.1529x + 6.8222$ $R^2 = 0.9982$	$y = -0.0344x + 1.9694$ $R^2 = 0.9892$
	50	$y = -0.1598x + 6.7704$ $R^2 = 0.9953$	$y = -0.0372x + 1.9664$ $R^2 = 0.9927$
Texture	40	$y = -0.1413x + 6.6148$ $R^2 = 0.9925$	$y = -0.0315x + 1.9277$ $R^2 = 0.9950$
	45	$y = -0.1503x + 6.4296$ $R^2 = 0.9679$	$y = -0.0355x + 1.8998$ $R^2 = 0.9803$
	50	$y = -0.1529x + 6.4296$ $R^2 = 0.9779$	$y = -0.0372x + 1.9103$ $R^2 = 0.9855$
Ease to swallow	40	$y = -0.1280x + 6.3481$ $R^2 = 0.9620$	$y = -0.0284x + 1.8729$ $R^2 = 0.9678$
	45	$y = -0.1328x + 6.2519$ $R^2 = 0.9751$	$y = -0.0306x + 1.8628$ $R^2 = 0.9964$
	50	$y = -0.1529x + 6.2296$ $R^2 = 0.9742$	$y = -0.0386x + 1.8761$ $R^2 = 0.9954$
Overall	40	$y = -0.1254x + 6.7407$ $R^2 = 0.9915$	$y = -0.0266x + 1.9442$ $R^2 = 0.9671$
	45	$y = -0.1460x + 6.4667$ $R^2 = 0.9595$	$y = -0.0338x + 1.9028$ $R^2 = 0.9569$
	50	$y = -0.1545x + 6.2889$ $R^2 = 0.9675$	$y = -0.0383x + 1.8815$ $R^2 = 0.9935$

The panelist acceptance decrease in color attributes because of the storage duration at different temperatures and discoloration from brown to blackish brown. The Maillard reaction that increased the brownish color during storage. Raisi and Aroujalian (2010) stated that the temperature affects the speed of the formation of brownish color due to the Maillard reaction. Food bars changed in taste parameter from savory sweet to slightly bitter cause a decrease in panelists acceptance of taste attributes. This change due to the formation of the Maillard reaction, especially

the furan component which caused a bitter taste (Karangwa et al., 2017). Maillard reaction also caused a change in the texture of the food bar. Maillard reaction and disulfide reaction caused protein aggregation that affects the texture (Rao et al., 2013). Besides, the texture also influenced by changes in product moisture content (Banach et al., 2016). The texture of the food bar changed from not too hard to hard and dry. The change in the texture of the food bar affects the ease of the product to be swallowed.

Table 8. k-Value and ln k equation based on quality parameters

Parameter	Storage temperature (T= °C)	Storage temperature (T=K)	1T ⁻¹	Selected order reaction	k	ln k
Color	40	313	0.00319	y = -0.0298x + 1.8754	0.0298	-3.5132
	45	318	0.00314	y = -0.0335x + 1.8598	0.0335	-3.3962
	50	323	0.00310	y = -0.0379x + 1.8557	0.0379	-3.2728
Taste	40	313	0.00319	y = -0.1439x + 6.9926	0.1439	-1.9386
	45	318	0.00314	y = -0.1529x + 6.8222	0.1529	-1.8780
	50	323	0.00310	y = -0.1598x + 6.7704	0.1598	-1.8338
Texture	40	313	0.00319	y = -0.0315x + 1.9277	0.0315	-3.4578
	45	318	0.00314	y = -0.0355x + 1.8998	0.0355	-3.3382
	50	323	0.00310	y = -0.0372x + 1.9103	0.0372	-3.2914
Ease to swallow	40	313	0.00319	y = -0.0284x + 1.8729	0.0284	-3.5614
	45	318	0.00314	y = -0.0306x + 1.8628	0.0306	-3.4868
	50	323	0.00310	y = -0.0386x + 1.8761	0.0386	-3.2545
Overall	40	313	0.00319	y = -0.1254x + 6.7407	0.1254	-2.0762
	45	318	0.00314	y = -0.1460x + 6.4667	0.1460	-1.9241
	50	323	0.00310	y = -0.1545x + 6.2889	0.1545	-1.8676

Based on the calculation of the values of k and ln, an Arrhenius plot equation value showed in Figure 2. The slope of the Arrhenius equation

used to calculate the activation energy. The Arrhenius equation also used to calculate the shelf life of a food bar.

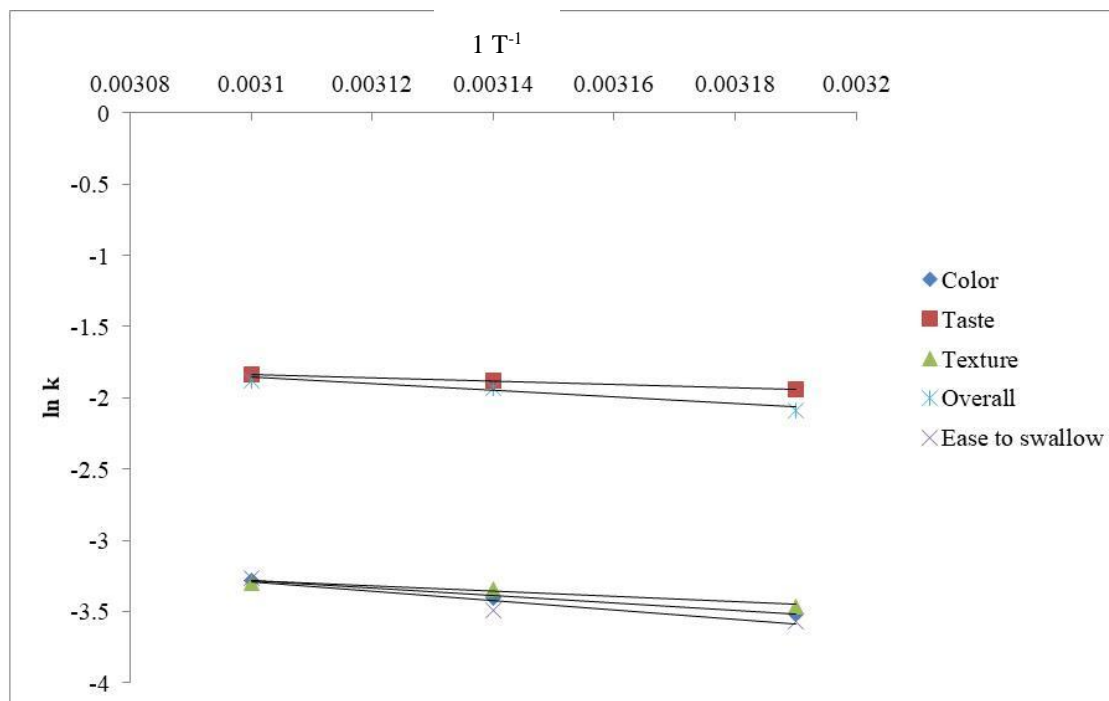


Figure 2. Plotting arrhenius in quality attribute

Table 9. Food bars shelf life

Parameter	Temperature (°C)	Temperature (K)	$1/T$	$\ln k$	k	Activation energy (J mol K ⁻¹)	Order reaction	Storage time (day)
Color	28	301	0.0033	-3.8694	0.0209	22094.455	1	39
Taste	28	301	0.0033	-2.0926	0.1234	9697.450	0	19
Texture	28	301	0.0033	-3.6971	0.0248	15556.325	1	32
Easy to swallow	28	301	0.0033	-4.0304	0.0178	27697.260	1	44
Overall	28	301	0.0033	-2.3761	0.0929	19517.115	0	24

Based on Tables 9, two attributes met the criteria in determining shelf life including the highest k value and the lowest activation energy in the taste attribute, which were 0.1234 and 9697.450 J mol K⁻¹. Activation energy was capable of measuring reaction sensitivity to temperature. Activation energy showed the amount of energy that needed to start a reaction based on the Arrhenius reaction slope (Hosseini et al., 2014). The parameter that had the lowest activation energy was the key parameters that affect product shelf life. Also, the higher reaction rate constant could accelerate the product damage reaction (Wahyuni et al., 2018). Based on taste parameter, the food bar had a shelf life at room temperature (28 °C) for 19 days. Different results were shown by Pulungan et al. (2016) which stated that based on its water content, plastic packaged apple pie produced a shelf life prediction at 25 °C for 164 days with water activity ranging from 0.77 - 0.83. This difference in shelf life was affected by packaging materials and storage conditions (Bouzo et al., 2012; Nayik and Muzaffar, 2014).

CONCLUSIONS

The best formula for a food bar was the F2 formula with a composition of instant white millet flour 26%; snakehead-soybean *koya* 26%; sugar 16%; margarine 14% and full cream milk 18%. Based on the composition, it was produced food bar with moisture content (20.99±0.21%); ash (3.45±0.35%); fat (18.10±0.13%); protein (12.24±0.28%); carbohydrates (45.22±0.32%); a_w (0.76±0.01) and total calories per bar (per 50 g) 232.04±1.96 kcal. Based on taste parameters, F2 formula had a shelf life for 19 days. However, the total calories produced by the F2 food bar have not met emergency food standards.

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