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Formulation of food bar based on Moringa leaves as a functional food for nursing mother

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KEYWORDS

Food bar
Formulation
Linier Programming
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ABSTRACT

Indonesian Statistics' survey in February 2018 showed that the number of female labor force continues to increase every year. Currently, from 134 million (69.20%), 55.44% of them are female workers (72.25 million) with 25 million are of reproductive age. Based on Basic Health Research, the number of mothers who breastfeed their babies is only 42% far below the target of 80%. Mother can consider the amount of nutrition based on age during pregnancy and lactation. However, the food products as a substitute for heavy foods with sufficient nutrition and calories for breastfeeding mothers are currently not available. This study aimed to formulating food products for breastfeeding mothers based on the use of local raw materials such as Moringa leaves. The method used in this research was formulation using linear programming (Linear Programming Solver 1.9.4 software). A hedonic sensory test was employed to determine product acceptance with the rating scale of 1-5 in the range of very dislike to really like. The respondents consisted of 40 panelists. The results showed that the optimal formulation of food bar (in each 150 g of food bars) consisted of Moringa leaf powder (5 g), soy flour (5 g), banana flour (20 g), oat (75 g), ant sugar (22.5 g) and skim milk (22.5 g). The results from the hedonic test indicated a good acceptance from the respondents, with the following score: 3.68 on aroma, 3.59 on color, 4.00 on texture, 3.76 on taste and 3.73 on appearance, respectively.

Introduction

Based on Basic Health Research in Indonesia, the number of breastfeeding mothers is only 27%, which is far below the target of 80% (Wendiranti et al., 2017). There are several factors that causing babies not getting breast milk properly. According to Kusumaningrum (2016), these factors include the mother's behavior, factors from the baby, the environment, and family supports, in terms of health education, socio-economic and cultural aspects. For breastfeeding mothers, in addition to eating with sufficient nutrition, where most of them eat 6 times a day depend on the frequency to breastfeed their infants, they are also recommended to drink a lot of water every day, at least 3 liter of water. Therefore, it is necessary to encourage breastfeeding mothers to drink every time they breastfeed and consume an additional 500 calories per day (Ladamay, 2013).

The latest data from World Health Organisation (WHO) indicated that one of the diseases often found in pregnant or breastfeeding female workers is anemia (WHO, 2011). The highest anemia prevalence was in pre-school children by 47.4%, followed by pregnant women 41.8%, non-pregnant women 30.2%, school children 25.4%, elderly 23.9%, and the lowest was for adult men at 12.7%. Iron deficiency anemia can increase the risk of pregnancy and fetal death, physical and cognitive developmental disorders in children, and can reduce work productivity in adults.

Food products for breastfeeding mothers currently circulated in the market are in the form of additional foods such as supplements, milk, or solid biscuits. However, there is no food product as a substitute for heavy foods, in which the nutrients and calories meet the needs of nursing mothers. Such food products are needed, especially for female workers who have long working hours or women with very busy activities. They need food products that do not require a long cooking time or a special

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place to process them into ready-to-eat foods. This gives an idea and market opportunity to create a new product in the form of heavy food prepared for working women or women with high activity who are breastfeeding.

The use of local materials for use in food production has been widely instructed by the government, such as the Instruction of Bantul Regency Number 4 Year 2012 about utilisation of local food raw materials. In this study, local ingredients used were mainly Moringa leaves. Moringa leaves are widely favored by Indonesian local people as food ingredients and healthy vegetables. Yet, there still no development of food products made from Moringa leaves for nursing mothers.

There are 5 characteristics for successfully develop new food products include product quality, production costs, processing time, product development costs, and product development capabilities (Kusumastuty et al., 2015). These five characteristics must be well integrated to develop new product ideas.

Food products require further development ensuring to meet the quality standard requirements as nutritional adequacy of pregnant and lactating mothers. Food products formulation nutritional testing and cost analysis are often needed to meet the five characteristics of successful new products. Therefore, this research was carried out to needs to investigate and formulate food products for breastfeeding mothers based on the use of local raw materials such as Moringa leaves.

Research Methods

Materials

Food bar main ingredients include Moringa leaf powder, soy flour, banana flour, oats, skim milk, brown sugar, and margarine as an adhesive. The characteristics of the food ingredients were analysed by using proximate and fiber tests, and was used for further formulation using linear programming.

The results of the subsequent formulations were then used to make the food bar products. The results of the best food bar formulations were followed by hedonic tests based on the affective methods to determine consumer preferences. Forty (40) panelists were used as respondents, which composed of nursing mothers and productive age women (17 – 40 years old) from Tegalgondoasri, Malang City.

Methods

This study was carried out from April to November 2018 in Faculty of Agricultural Technology, Universitas Brawijaya. The research stage involved the following steps: characterization of raw materials, formulation using linear programming, product manufacture, products acceptance testing using hedonic testing, and analysis and evaluation. The research flow chart is seen in Fig. 1.

Figure 1. Research flow chart

Characterization of Raw Materials

The characterization of raw materials aimed to determine the chemical composition of each material as a basis for designing formulations (Jariyah et al., 2017). The characterization of Moringa leaf powder, soy flour, banana flour, skim milk and ant sugar includes the content of protein, carbohydrate, fat, fiber following the minimum standard values recommended by RDA for the Indonesian nursing mothers (Department of Health, 2003). Additional tests on Moringa leaf powder were carried out to determine the content of lactogagum as a limitation of the addition of Moringa leaf powder. The characterization of raw materials was carried out using SNI testing methods 01-2891-1992. The protein content was analysed using the Kjeldahl method. Fat content was measured using direct extraction methods (for samples other than skim) and Mojonnier method (for skim milk). Crude fiber was analysed using the hydrolysis and gravimetric methods, while carbohydrate was calculated following the formula (Lukitaningsih et al., 2012).

Formulation using Linier Programming

In food formulations, it is necessary to calculate the composition of the ingredients used, including the amount and composition of macro nutrients followed by sensory testing to determine the food quality of the formulated food (Jariyah et al., 2017). The food formulation was carried out after the carbohydrate, protein, fat and fiber content of each 100 g ingredient were determined. The formulation was carried out using the linear programming method with the help of the LiPS linear application program solver. The formulation was as follows:

Minimizing Function of Price:

$$H = C_1X_1 + C_2X_2 + C_3X_3 + C_4X_4 + C_5X_5 + C_6X_6 \quad (1)$$

where:

X_1 = Moringa leaf powder
X_2 = soy flour
X_3 = banana flour
X_4 = oats
X_5 = brown sugar
X_6 = skim milk

while C_i is each price of raw material per g.

Constraints:

$$\alpha_{11}X_1 + \alpha_{12}X_2 + \alpha_{13}X_3 + \alpha_{14}X_4 + \alpha_{15}X_5 + \alpha_{16}X_6 \geq K$$
$$\alpha_{21}X_1 + \alpha_{22}X_2 + \alpha_{23}X_3 + \alpha_{24}X_4 + \alpha_{25}X_5 + \alpha_{26}X_6 \geq P$$
$$\alpha_{31}X_1 + \alpha_{32}X_2 + \alpha_{33}X_3 + \alpha_{34}X_4 + \alpha_{35}X_5 + \alpha_{36}X_6 \geq L$$
$$\alpha_{41}X_1 + \alpha_{42}X_2 + \alpha_{43}X_3 + \alpha_{44}X_4 + \alpha_{45}X_5 + \alpha_{46}X_6 \geq S$$
$$X_1 + X_2 + X_3 + X_4 + X_5 + X_6 = 150$$

$$X_2 \leq 5,\ X_3 \leq 20,\ X_4 \leq 75,\ X_5 \leq 22.5,\ X_6 \leq 22.5$$

Notes:

K= carbohydrate
P = protein
L = fat
S = fiber
α_{11} = carbohydrate content inside Moringa leaf powder
α_{12} = carbohydrate content inside soy flour
α_{13} = carbohydrate content inside banana flour
α_{14} = carbohydrate content inside oats
α_{15} = carbohydrate content inside brown sugar
α_{16} = carbohydrate content inside skim milk
α_{21} = protein content inside Moringa leaf flour
α_{22} = protein content inside soy flour
α_{23} = protein content inside banana flour
α_{24} = protein content inside oats
α_{25} = protein content inside brown sugar
α_{26} = protein content inside skim milk
α_{31} = fat content inside Moringa leaf flour
α_{32} = fat content inside soy flour
α_{33} = fat content inside banana flour
α_{34} = fat content inside oats
α_{35} = fat content inside brown sugar
α_{36} = fat content inside skim milk
α_{41} = fiber content inside Moringa leaf powder
α_{42} = fiber content inside soy flour
α_{43} = fiber content inside banana flour
α_{44} = fiber content inside oats
α_{45} = fiber content inside brown sugar
α_{46} = fiber content inside skim milk

Making of Food bar Products

The making of food bar products was carried out after the food formulations were obtained, following the method described by Anandito et al. (2016) which requires baking temperature of 120ºC for 45 minutes. Furthermore, according to Ekafitri and Rhestu (2014), all food bar ingredients need to be accurately weighted based on the formulation results, following the mixing all ingredient to form a dough. The dough was then molded and baked. In This study, the process of making the food bar is illustrated in Fig. 2.

Hedonic Test for Product Acceptance Testing

Product acceptance is important to assess whether a product is accepted by the target consumer or not. In this study, the variables used for product acceptance include aroma, color, texture, taste and appearance. The scale used was in the range of 1-5 where scale 1 = very dislike, 2 = dislike, 3 = dislike, 4 = like, and 5 = really like.

Food bar hedonic test involved 40 untrained panelists consisting of productive age women and nursing mothers from Tegalgondoasri, Karangploso, Malang. Prior the test, all respondents were agreed and signed the agreement letter which explaining the research procedures. Each panelist was asked to consume a food bar sample and answer all the questions in the questionnaire referring to their preference toward 5 variables tested.

Analysis and Evaluation

Data analysis of the hedonic test results was carried out using descriptive statistics result to determine consumer acceptance of food bar products. Questionnaire results data on the variables of aroma, color, texture, taste and appearance were analysed to determine the consumer's acceptance of food bar and to evaluate further product development, if needed.

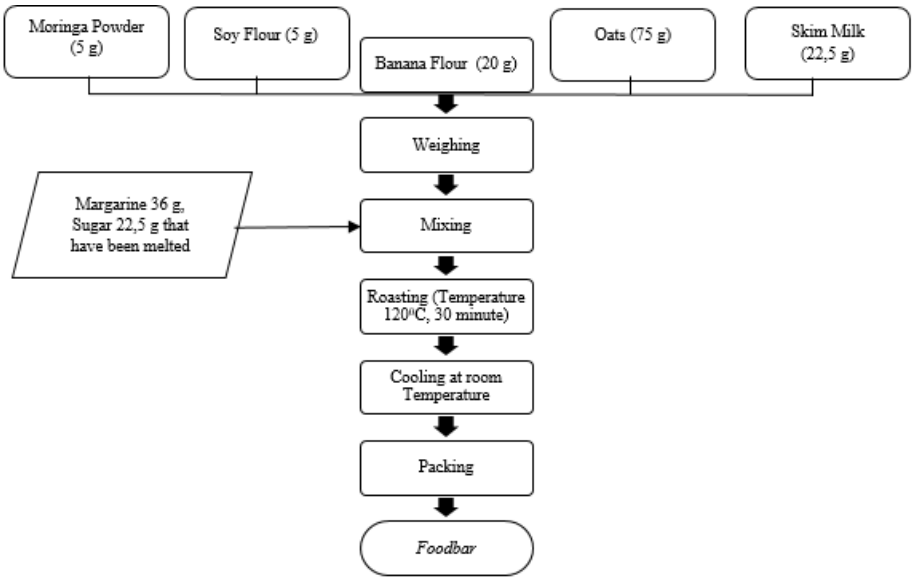

Figure 2. Flowchart of making food bar products

Results and Discussion

The results of characterisation analysis of Moringa leaf powder, soybean flour, banana flour, oats, skim milk and ant sugar produced carbohydrate, protein, fat and fiber per 100 g are shown in Table 1, which were further used as linear programming formulation data.

Based on data on carbohydrates, proteins, fats and fibers, the following formulations were carried out:

Purpose Function:

$$Z_{min} : 150_{X1} + 110_{X2} + 110_{X3} + 38_{X4} + 13_{X5} + 86.5_{X6} \quad (2)$$

The function constraints of the model were as follows:

$0.5257X1 + 0.3425X2 + 0.4085X3 + 0.685714286X4 + 0.96521739X5 + 0.533333X6 \geq 3.54$
$0.2257X1 + 0.361X2 + 0.025X3 + 0.114285714X4 + 0.96521739X5 + 0.533333X6 \geq 0.76$
$0.1093X1 + 0.2X2 + 0.006X3 + 0.1X4 + 0.96521739X5 + 0.533333X6 \geq 0.86$
$0.2058X1 + 0.487X2 + 0.10075X3 + 0.085714286X4 + 0.96521739X5 + 0.533333X6 \geq 0.37$
$X1 + X2 + X3 + X4 + X5 + X6 = 100$
$X_2 \leq 5, X_3 \leq 20, X_4 \leq 75, X_5 \leq 22.5, X_6 \leq 22.5$

The results of the formulations were then included in the linear application of the LiPS solver program to produce the food bar formulation data shown in Fig. 3. This formulation was then used to make the food bar products, as shown in Fig. 4.

Table 2 shows the nutrient content of the food bars which indicated a high carbohydrate, protein and fiber content making it suitable as heavy food substitute for nursing mothers. Table 3 shows the results of sensory analysis. Sensory analysis with scoring preference test methods based on Anandito et al. (2016) was used to determine the level of acceptance of panelists towards food bar through the human senses.

The data in Table 3 are displayed in the form of a bar diagram which can be seen in Fig. 5. In this diagram, the percentage of 40 breastfeeding mothers and women of productive age is shown on the variables of the food bar's aroma, color, texture, taste and appearance.

Based on the data analysis, the aroma variable shows the average preference scale of 3.73. On the variable aroma bar diagram, it was found that less than 10% of panelists were very dislike, more than 30% of panelists did not like it and 60% of panelists

liked the aroma of the food bar. Hedonic test data shows panelists tend to like the aroma of the food bar because of its similiarity with the aroma of biscuits, nuts and stronger oats. The aroma of the food bar is influenced by raw materials, especially Moringa, soybeans, bananas, oats, milk and sugar. According to Kusumastuty et al. (2015), aroma is closely related to the sense of smell, the aroma is said to be delicious if it composed of a combination of components of flavorsome ingredients. According to Rahman et al. (2011), the food bar with the aroma like soybean raw materials is less preferred because it has a unpleasant aroma.

Table 1. Nutrient content of raw materials

Raw Material	Carbohydrate	Protein	Fat	Fiber
Moringa Leaf Powder	47.27	27.585	11.875	20.355
Soy Flour	37.44	29.005	22.79	7.68
Banana Flour	85.48	0.8	2.365	2.71
Oats	71.09	7.975	11.63	2.415
Brown Sugar	91.97	2.5	0.99	0.345
Skim Milk	40.5	5.1	46.22	0.03

Table 2. Nutrient content of food bar per 150 g

Composition	Food bar (g)	Nutrient content			
		Carbohydrate	Protein	Fat	Fiber
Moringa Leaf Powder	5	47.27	27.585	11.875	20.355
Soy flour	5	37.44	29.005	22.79	7.68
Banana flour	20	85.48	0.8	2.365	2.71
Oats	75	71.09	7.975	11.63	2.415
Brown sugar	22.5	91.97	2.5	0.99	0.345
Skim milk	22.5	40.5	5.1	46.22	0.03
Total	150	373.75	72.65	95.87	33.54
The number of minimum nutritional needs (AKG) for nursing mothers		354	76	86	37

Table 3. Respondent's responses in Hedonic test

Scale	Aroma	Colour	Texture	Taste	Appearance
1	0	0	0	0	0
2	0	0	0	0	1
3	14	17	5	13	11
4	24	21	29	23	25
5	2	2	6	4	3
Average	3.68	3.59	4.00	3.76	3.73

Notes: scale from 1= very dislike, 2 = dislike, 3 = do not like it much, 4 = like, 5 = very like

Based on the color hedonic test results, the average scale value for the color of the food bar is 3.60. On food bar color variables, it can be seen that less than 10% of panelists very like it, more than 40% of panelists do not like it and more than 50% of panelists like the color of the food bar. From the test results, it can be seen that the color of the food bar is less preferred by panelists because it is pale and less eyecatching. According to Ladamay and Sudarminto (2014), color is one of the most prominent features seen visually. Although a food product has high nutrients, good tastes and good texture, it is considered not interesting if the food's color is not pleasing to the eye. According to Ekafitri et al. (2013), non-enzymatic browning reactions occur in the roasting process due to the reaction of reducing sugars with amino acid groups, thus darkening the color.

Based on the food bar texture test results, the average value of the scale was 3.98. In the food bar

texture variable, it can be seen that more than 10% of panelists very like it, more than 10% of panelists do not like it and more than 70% of panelists like the texture of the food bar. The texture of the food bar in this study showed a dense but easily broken texture when consumed. From the results of the hedonic test, it was found that most panelists liked the dense texture and were easily destroyed when chewed. According to Kusumastuty et al. (2015), the texture of the food bar can be influenced by the base material, the thickness of the mold and the oven temperature. A high oven temperature can hardened the food texture making it difficult to break.

	X1	X2	X3	X4	X5	X6		RHS
Objective	150	110	110	38	13	86.5	>	MIN
Constraint1	0.5257	0.3425	0.817	0.685714286	0.956521739	0.533333333	>=	3.74
Constraint2	0.2257	0.361	0.045	0.114285714	0.000434783	0.333333333	>=	0.76
Constraint3	0.1093	0.2	0.012	0.1	0	0	>=	0.86
Constraint4	0.2058	0.487	0.2015	0.085714286	0.000434783	0	>=	0.37
Constraint5	1	1	1	1	1	1	=	150
Constraint6	0	1	0	0	0	0	<=	5
Constraint7	0	0	1	0	0	0	<=	20
Constraint8	0	0	0	1	0	0	<=	75
Constraint9	0	0	0	0	1	0	<=	22.5
Constraint10	0	0	0	0	0	1	<=	22.5
Integer	NO	NO	NO	NO	NO	NO		

```
>> Optimal solution FOUND
>> Minimum = 8588.75
```

*** RESULTS ***

Variable	Value	Obj. Cost	Reduced Cost
X1	5	150	0
X2	5	110	0
X3	20	110	0
X4	75	38	0
X5	22.5	13	0
X6	22.5	86.5	0

Figure 3. Food bar formulation result

Figure 4. Food bar

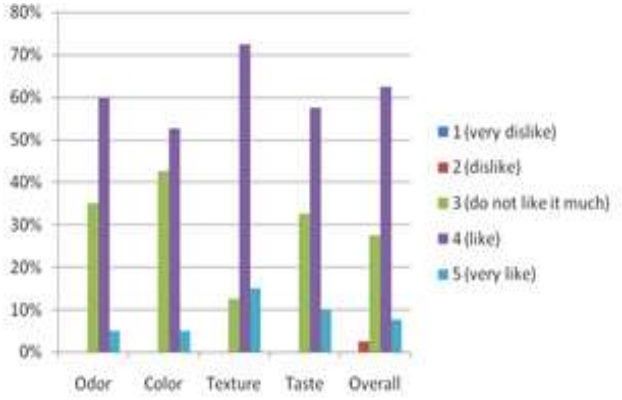

Figure 5. Percentage of respondents to variables of aroma, color, texture, taste and appearance (overall) of food bar products

The hedonic test results of food bar taste produce a scale average value of 3.78. In the food bar taste variable, it can be seen that 10% of panelists very like it, more than 30% of panelists do not like and more than 50% of panelists like food bar products. Based on the hedonic test results, panelists like the taste of the food bar due to the appropriate savory and sweet taste. The flavor is obtained from skim milk, brown sugar and margarine additives. Skim milk contains sugar, together with brown sugar produce the sweeter and savory taste. According to Ladamay and Sudarminto (2014), the taste of solid food is strongly influenced by its constituent ingredients. Sweetness and tenderness caused by sugar and margarine give a savory taste to the product.

The hedonic test results of food bar appearance yield an average scale of 3.73. On appearance variables less than 10% panelists really very like it, less than 5% panelists dislike it, more than 20% panelists do not like it and more than 60% panelists like the appearance of food bar products. The appearance of the food bar shows the overall assessment of the food bar (overall). Based on the hedonic test data, panelists can like the overall food bar. According to Fajri et al. (2013), overall panelists liked the food bars that were not too hard, easy to chew and delicious tast. However, in this study, it was revealed that several panelists thought that the food bar products were still too hard. While, other panelists thought that the product's taste was less sweet.

The results of the overall acceptance test for food bar products in terms of aroma, color, taste, texture and appearance show that almost all attribute variables are preferred by panelists. However, the color variable still needs improvement. Addition of other ingredients such as chocolate, green tea or

food coloring can be considered to improve the color of the food bar. Product reformulation to increase food bar product acceptance is also need to be carried out further. According to Jariyah et al., (2017), the process of making food bar, especially the roasting process requires the right temperature and time, as it can affect the texture and color of the food bar produced. When the temperature is too high, the texture of the food bar may become very hard and smell charred. The roasting time is also important to control, if it is too short then the food bar may easily be destroyed and if too long the food bar can overcook or burn.

Conclusions

Food bar is made with the composition of Moringa leaf powder, soy flour, banana flour, oat, skim milk and ant sugar. The results of the food bar have a aroma that is quite liked by the panelists, the color is less attractive, the texture is quite good and solid, the taste is quite tasty, and the appearance is quite good. The hedonic test results produce an average for each parameter of 4 which shows the scale of "likes" of the panelists.

Conflict of interest

The authors declare that there is no conflict of interest in this publication.

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