Optimization of Food Bar Formula Based on Pumpkin, Edamame, Moringa Leaves and Snakehead Fish as Supplementary Food to Prevent Stunting

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Abstract. Based on the SSGI Survey by the Indonesian Ministry of Health's, stunting prevalence decreased from 24.4% in 2021 to 21.6% in 2022. However, based on WHO (World Health Organization) criteria it is still classified as a high category (>20%) so it has not reached the target of WHO. Referring to "Factors That Cause Nutritional Problems in The Indonesian Context" the direct causes of stunting are lack of food intake and infectious diseases (infections). On the factor of food intake, a history of lack of protein, zinc and iron consumption is associated with malnutrition and a compromised immune system which leads to stunting. Therefore, we need supplementary food that is nutritious and can improve the immune system. The form of supplementary food is in the form of a food bar. Food bars can be developed from local foodstuffs such as pumpkin, snakefish, edamame and moringa leaves. Optimization of the food bar formula uses design expert 13 with D-optimal mixture design. The formula suggested by design expert 13 software was 50% pumpkin paste, 25% edamame flour, 5% moringa leaves flour, 20% snakehead fish flour. Then the optimal food bar formula has a protein content 24.77%, fat content 10,63%, carbohydrates content (by different) 46,44%, ash content 2,68%, water content 15,48%. The physical test of the food bar showed a brightness value 46,16 ± 0.1387 and a breakability value 14.6 ± 0.2646 N.

Keywords: Food Bar, Pumpkin, Edamame, Moringa Leaves, Snakehead Fish, Design Expert.

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1 Introduction

Malnutrition and stunting are two interrelated problems. Stunting is a chronic malnutrition problem caused by insufficient nutritional intake for a long time, especially in the first 1,000 days of life. Toddlers are classified as stunting if their length or height according to their age is below minus two standard deviations (< -2 SD) compared to children their age [1]. Health National Research data shows the prevalence of stunting toddlers in Indonesia in 2013 reached 37.2% while in 2018 slightly decreased to 30.8 %. Based on the SSGI Survey (study of the nutritional Status of Indonesian toddlers) by the Indonesian Ministry of Health's, in 2022 the National stunting prevalence decreased from 24.4% in 2021 to 21.6% in 2022 [2]. The prevalence has decreased, but based on WHO criteria is still classified as high Category (> 20 %) so it has not reached the target of WHO.

Prevention of stunting is important as early as possible to avoid adverse long-term effects such as stunted growth and development of toddlers. Stunting can affect brain development so that the child's intelligence level is not optimal. These risks reducing productivity in adulthood. Referring to the “Factors Causing Nutritional Problems in The Indonesian Context”, the direct causes of stunting are lack of food intake and Infectious Diseases [3]. On the food intake factor, stunted toddlers have a history of protein, zinc and iron consumption levels in the lower category than non – stunting toddlers [4]. Lack of protein intake has a risk of 1.6 times suffering from stunting. Protein has a very important role in the growth of toddlers, in general the function of protein for growth and antibody formation [5]. The problem of stunting in Indonesia, led to a change that is an alternative food product that can prevent stunting, such as food bars. Food bar is a ready-to-eat food that meets people's daily energy needs and can be used as emergency meals in disaster zones [6]. Food bars are high calorie foods made from a combination of some ingredients, fortified with nutrition and shaped to be compact and solid [7]. Food bars are expected to provide the daily calorie contribution needed, with 10-15% protein, 35-45% fat and 40-45% carbohydrates [8].

Food bars can be developed from local food raw materials such as pumpkin, snakehead fish, edamame and moringa leaves. Pumpkin, edamame, moringa leaves and snakehead fish are ingredients that have the potential to be developed because of their content. Pumpkin has flavonoid, protein and β-carotene content. β-carotene in pumpkin serves as an antioxidant activity in the human body [9]. Fresh pumpkins have a protein content of 1.7 g in 100 g [10]. The addition of a significant quantity of pumpkin increased the protein of the product [11]. Edamame has protein, zinc and iron content of 11.7 g/100 g, 1.4 mg/100 g and 2.7 mg / 100 g [12]. Edamame has potential as a complementary food that can help prevent stunting as it contains high nutrients [13]. Moringa leaves have a protein content of 6.7 g/100 g, 13.7 mg/100 g and 175 mg / 100 g [14]. These leaves have impacts that contribute to improving the nutritional status of toddlers based on body mass index by age [15]. In 100 grams of snakehead fish contains protein by 76.9%, zinc 3.09 mg and Fe 4.43 mg [16]. Consumption of snakehead fish can increase energy intake for toddlers, so that can increase body weight and nutritional status [17]. Food bar products have the potential to be an alternative food product to prevent stunting.

2 Research Method

The main raw materials of the food bar (pumpkin paste, snakehead fish flour, edamame flour and moringa leaves flour) were optimized using optimal mixture design (custom) from design expert 13 with previous research to determine the limits of the quantity of ingredients. Response data was obtained by macerating a mixture of the four main ingredients. Response test data were analyzed to obtain optimal formula recommendations as a basis for making food bar products. Food bar products were tested for proximate and physical characteristics.

3 Result and Discussion

3.1 Optimizing Food Bar Formula

Optimization of food bar formulations using mixture (optimal) on design expert 13 software. The expected result is an optimal food bar formula that has maximum total protein content, maximum total iron (Fe), maximum total zinc (Zn) and maximum antioxidant activity. Mixture (optimal) design expert 13 analyzes the upper limit and lower limit data and generates a design with 20 runs or formulations. The response values of total protein, total iron (Fe), total zinc (Zn) and antioxidant activity are presented in Table 1.

Table 1. Response values of total protein, total zinc (Zn), total iron (Fe) and antioxidant activity in 20 mixture formulations.

Run	Pumpkin paste (%)	Edamame flour (%)	Moringa leaves flour (%)	Snakehead fish flour (%)	Total protein (%)	Total Zn (%)	Total Fe (%)	Antioxidant activity (mg TE/g)
1	58,94	20,44	3,62	17,00	24,77	10,56	66,99	3,39
2	54,29	21,84	4,03	19,85	29,45	8,95	64,98	3,44
3	51,70	25,00	3,30	20,00	29,91	10,95	73,11	3,17
4	53,73	25,00	3,30	19,43	29,22	9,67	68,58	2,87
5	55,82	22,66	3,02	18,50	26,61	9,52	75,06	2,64
6	53,67	23,01	5,00	18,33	27,28	9,16	72,07	4,86
7	52,76	24,87	4,24	18,12	23,10	9,20	74,94	3,92
8	57,58	22,32	3,10	17,00	27,95	11,46	78,30	2,85
9	55,82	22,66	3,02	18,50	26,93	9,93	74,85	2,96
10	55,00	25,00	3,00	17,00	28,10	11,34	68,95	3,11
11	55,29	22,71	5,00	17,00	25,39	10,65	73,60	4,82
12	54,29	21,84	4,03	19,85	28,51	9,92	61,25	3,72
13	57,19	20,89	4,92	17,00	25,97	10,13	67,42	4,14
14	57,00	20,00	3,00	20,00	27,08	10,66	59,72	2,95
15	56,35	20,00	4,92	18,74	26,93	10,94	76,22	4,36
16	52,76	24,87	4,24	18,12	23,05	9,18	75,10	3,94
17	54,29	21,84	4,03	19,85	28,85	8,92	68,70	3,61
18	56,35	20,00	4,92	18,74	26,70	10,96	73,31	4,20
19	52,34	22,66	5,00	20,00	30,76	11,45	80,81	4,14
20	50,85	24,15	5,00	20,00	32,68	10,68	78,98	4,87

Stage of Response Formulation Optimizing for Food Bar. The target optimal response value is determined based on the desired variable values: maximum total protein, maximum total zinc, maximum total iron, and maximum antioxidant activity (Table 2), while the main ingredient components are still within the limit range in the initial experimental design matrix. At this stage, design expert 13 software is used to analyze the response simultaneously from 20 formulas using the response optimizer menu to find the optimal mixture formula with the desired response or closest to the target value. The formula with the best solution is the formula with the maximum desirability value closest to 1 (one) because it indicates the closeness of the response to its ideal value. The optimal mixture composition recommended by design expert 13 for making food bars is pumpkin paste 50%, edamame flour 25%, moringa leaves flour 5% and snakehead fish flour 20% and has the highest desirability value (0.966).

Table 2. Target optimal value of food bar formulation.

	Goal	Lower limit	Upper limit	Important
A : Pumpkin paste	In range	50	60	3
B : Edamame flour	In range	20	25	3
C : Moringa leaves flour	In range	3	5	3
D : Snakehead fish flour	In range	17	20	3
Total protein	Maximize	23,05	32,68	3
Total Zn	Maximize	8,92	11,46	3
Total Fe	Maximize	59,72	80,81	3

Stage of Verification for Optimal Response of Food Bar Formula. After obtaining the optimal formula solution by the design expert 13 software, proceed to the verification stage where the mixture of the main ingredients with the optimal formula is prepared in the laboratory and then followed by a response test again (total protein, total zinc (Zn), total iron (Fe) and antioxidant activity). This aims to determine whether the application in the laboratory will get the same results as the calculations predicted by the design expert 13 software. The predicted values and test results of the optimal formula are presented in Table 3. Laboratory test results were statistically compared with predicted values using a two-sample T-test to verify the adequacy of the regression model. The experimental values were very close to the values predicted by the model as shown in the two-sample T-test results that the p value > 0.05. This result indicates that there is no significant difference between the predicted values and the actual test values of the four responses. So it can be indicated that the model is suitable and the optimal formula solution provided by the design expert 13 software is acceptable.

Table 3. Optimal formula solution, predicted values and verification results.

Variable					Respon			
	Pumpkin paste (%)	Edamame flour (%)	Moringa leaves flour (%)	Snakehead fish flour (%)	Total protein	Total Zn	Total Fe	Antioxidant activity
Prediction	50	25	5	20	33,21	11,41	83,12	4,63
Verification					33,37	11,56	82,87	4,19
	T-test result (p-value)				0,385	0,273	0,698	0,215

3.2 Production and Characterization of Food Bar

Manufacturing Food Bar. The food bar formula in this study consists of pumpkin paste (50%), edamame flour (25%), moringa leaves flour (5%), and snakehead fish flour (20%). The making of this nutrient-dense food bar consists of several stages, namely the preparation and making of pasta or flour from the four raw materials and the stages of making food bars. The first step is making pumpkin paste, edamame flour, moringa flour, and snakehead fish flour. The second step is making food bar products. Measuring the raw materials according to the optimal formula. Then mix the main ingredients with margarine, milk powder, powdered sugar, eggs, dried strawberries, and cornstarch. After the dough is evenly mixed, it is baked in the oven for 15 minutes at 125°C, then placed on the oven tray and reheated for 1 hour at 125°C.

Characteristics of Food Bar. *Proximate Analysis.* Proximate analysis of food bars with parameters of moisture content, ash content, fat content, protein content and carbohydrate content. The results of the proximate analysis can be seen in Table 3.4. Moisture content in the formulated food bar at 15,48%. So, the moisture content of the food bar is following the standard. The high and low moisture content in a product affects the shelf life of the product. Moisture content also affects the texture of the food bar where the lower the moisture content, the texture becomes hard and dry. The ash content of the food bar formulation is 2,68%. Ash content can indicate the total minerals in a food ingredient. The ash content of each ingredient is varied depending on the mineral content of the ingredient. The high ash content in an ingredient means that the number of inorganic substances in it is also high. The fat content of the food bar formulation was 10,63%. Fat sources in the food bar formulation were obtained from pumpkin, edamame, moringa leaves, snakehead fish, butter, eggs, milk powder, cornstarch and powdered sugar. The protein content of the food bar formulation was 24.77%. The protein sources in the food bar formulation were obtained from pumpkin, edamame, moringa leaves and snakehead fish. The carbohydrate content of the food bar formulation using the by difference method was 46,44%. The high carbohydrate content in the product can be a source of energy and a protein saver. Based on USDA (2019) chemical compound of the snack bar/100 g has a water content 11,3%, ash content 1,72%, fat content 10,9%, protein content 9,38%, carbohydrate content 66,7% [18].

Table 4. Proximate analysis result of food bar formulation.

Parameter	Result ±sd
Moisture content (%)	15,48 ± 0,148
Ash content (%)	2,68 ± 0,024
Fat content (%)	10,63 ± 0,212
Protein content (%)	24,77 ± 0,088
Carbohydrate content (%)	46,44 ± 0,211

Physical Analysis. Physical analysis of the breakability of food bar products was carried out using a tensile strength tool to determine the textural characteristics of the brittleness and crispness of food bar products. The interpretation of the breakability value is that the higher the breakability the value of a product, the stronger the product. The resulting breakability value is 14.6 ± 0.2646 N. The breakability value of a product can be influenced by the ingredients used. The characteristics of food bars with formulations have a breakability value that tends to be high or tends to be compact. The compactness of this food bar product is influenced by the composition of pumpkin paste which is quite high at 50%. The addition of margarine can also make the food bar crisp and soft [19]. The less margarine added, the greater the value of the product's breakability. The baking process using an oven on the dough can affect the hardness of the food bar texture due to the decrease in product water content. Physical analysis of color in food bar products is carried out using a color reader. In the color reader the parameters read are L, a, b. The food bars have L value 46,16 ± 0.1387, a value 0,3 ± 0.1764, and b value 19,2 ± 0.2411. The results of the color darkness in a food product are influenced by the composition of the raw materials used. The use of raw materials like moringa flour and edamame flour are green, making the brightness of this product tend to decrease and the level of green color intensity tends to increase.

4 Conclusion

In this study, the optimized food bar formula suggested by design expert 13 software was 50% pumpkin paste, 25% edamame flour, 5% moringa leaves flour, 20% snakehead fish flour. The t-test result between the prediction and verification has a p-value > 0.05, indicating that there is not significant data. These results mean that the optimal formula solution suggested by design expert 13 is acceptable.

The optimal food bar formula has a protein content 24.77%, fat content 10,63%, carbohydrates content (by different) 46,44%, ash content 2,68%, water content 15,48%. The physical test of the food bar showed a brightness value 46,16 ± 0.1387 and a breakability value 14.6 ± 0.2646 N. From the result, the food bar products have the potential to be an alternative food product to prevent stunting.

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