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Formulation and characterization of emergency food based on instan corn flour supplemented by instan tempeh (or soybean) flour

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Abstract

A special disasters emergency food that can be directly consumed, practical and nutritious was formulated. It was developed based on local food rmaterials, namely corn-soybean and corn-tempe flour. The aim of the research is to produce an emergency food formula made from corn-soybean flour and corn-tempe flour that adequately fulfills the standard for emergency food, acceptable and feasibly produced in large quantities. It was found that the best formulation model of emergency food is produced from Srikandi corn flour and tempe flour. Its composition is 42% of corn flour, 20% of tempe flour, 10% of full cream milk powder, 16% of sugar, and 12% of frying oil. Nutrient composition of every piece (each 50 grams of product) was 8.1 g of protein, 20.67 g of lipid, 20.58 g of carbohydrate, and 298.04 kcal of energy. In terms of protein and energy, emergency food already fulfills the adequacy standard, which is the minimum energy 233 kcal and 7.9 to 8.1 g protein. Lipid content of emergency food is too high (9.1 to 11.7 g), while level of carbohydrate is too low (23-35 g). This product is most easily swallowed, most delicious, no after taste, and most preferably compared to other formulas.

Introduction

The disaster in Indonesia has claimed many lives in a short time, and some of people live at the evacuation site. To avoid a new disaster after natural disasters, namely the emergence of hunger, emergency feeding is absolutely necessary (Rivera and Char, 2004). Emergency food is a special type of food that is consumed during or following an emergency time to fulfill the requirements of daily human consumption (2100 kcal), and is ready to eat and nutritious (Sheu, 2007).

Materials of emergency food should be from local ingredients to raise the potential of local food. Corn is a potential source of food in Indonesia because it contains functional food components such as dietary fiber, vitamin A and iron (Scott and Eldridge, 2005; Aini *et al*., 2010). Corn was classified as having a moderate glycemic index and being able to be consumed by people with autism (Mulloy *et al*., 2010).

Another requirement of emergency food is it must be sufficient nutrients. Protein is an essential nutrient that has a role on the absorption of other nutrients, i.e. non-heme iron and calcium. Soybean is one source of vegetable protein. Tempe derived from soybean protein contains high bioavailability and iron (Tyug *et al*., 2010). Some disaster conditions often also cause the problem of drinking water availability. Intermediate moisture foods (IMF) is the name given to a category of food that is sufficiently wet to be eaten without rehydration and still remain stable during storage (Furmaniak *et al*., 2009).

Corn-based IMF has potential as an emergency food in its ready-to-eat form. It contains high nutritional value, especially in providing sufficient energy. To fulfill the quality standards of emergency food, the focus is to supply of protein, vitamins and minerals. It is necessary to improve the nutritional quality of emergency food by combining corn flour with high protein flour (Chen *et al*., 2006). The addition of soybeans and tempe flour will enrich nutrition. Soybeans and tempe also act as antioxidants, are anti-diarrheal and stimulate growth (Tyug *et al*., 2010). The existence of the fermentation process will increase the levels of B vitamins, including cobalamin, riboflavin, pyridoxine, niacin, biotin, folate and pantothenic acid compounds (Eklund-Jonsson *et al*., 2006). Formulation of corn-soybean flour and corn-tempe flour into an emergency food with an intermediate moisture food is expected to be an alternative in the provision of food, especially for refugees of natural disasters. The aim of the research is to produce an emergency food formula made

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from corn-soybean flour and corn-tempe flour that adequately fulfills the standard for emergency food, acceptable and feasibly produced in large quantities.

Materials and Methods

Three varieties of corn, i.e. Pioneer, Srikandi and Canggal, were purchased from local corn farmers in Temanggung, Central Java. The soybean variety used was Slamet, while tempe was obtained from a producer in the 'Pliken' Village, Banyumas. Additional ingredients were milk powder, refined sugar, cooking oil, sorbitol, glycerol and water.

The experiment was conducted in three steps. The first step was the formulation of emergency food from three varieties of corn and the prediction of the nutritional adequacy of each formula. The second was the determination of the amount of water and a humectant to be added in each formula. It was followed by the production of the emergency food formula. This step also included an analysis of water content, ash, protein, lipids (AOAC, 1995), carbohydrates (by difference) and water activity. The last step was a further analysis of the selected formula for energy value and microbiological properties (total microbial amount and yeasts).

Instant soybean flour was prepared by soaking soybeans for 6 hours and peeling the skin. The soybeans were then washed and blanched for 15 minutes. Afterwards, the soybean seeds were drying, milling and sieving by 80 mesh. The process of making instant corn flour is similar to that of making soybean flour.

Instant tempe flour was prepared by cutting tempe into 1x1x1 cm pieces then steam blanching for 20 minutes. The next step was drying the tempe until thoroughly dried. Finally, the tempe was milled and sieved through 80 mesh.

The calculation of the formula was based on the nutrient requirements of emergency foods, which should contain at least 233 kcal per piece, with 7.9-8.1 g of protein, 9.1-11.7 g of lipids, and 23-35 g of carbohydrates. This value is based on the assumption that one piece is equal to 50 g of dry weight.

Emergency food was made by mixing ingredients until it was homogeneous. In the mixing stage, water (at 80^{o}C) was added while the mixture was stirred. The next stage tasted the product; if it was easy to swallow, a humectant (sorbitol) was added. Sorbitol was added at three concentrations, namely 4, 5 and 6%, to discover the percentage of sorbitol that can cause a bitter taste.

Results and Discussion

Preparation of formula and nutritional adequacy prediction

Preparation of the emergency food formula is based on the macronutrient content of the raw material. Calculations on the macronutrient content of the instant flour are done through an analysis of lipids, protein and carbohydrates. Instant corn flour has moisture content in the range of 12.2 to 13.59%, while instant tempe flour and soy flour have moisture contents of 11.62 and 11.77%, respectively.

Based on calculations, the emergency food formula from corn-soybean and corn-tempe flours can be seen in Table 1. The composition of corn flour in the emergency food formula ranged from 34.4 to 42%. Formulas II and III have the same composition, which is 42% corn flour, 20% soybean flour, 10% milk powder, 16% icing sugar and 12% cooking oil. Formula I also has almost the same composition as formulas II and III: 40% corn flour, 18% soybean flour, 12% milk powder, 18% sugar and 12% cooking oil. These formulas have the same composition, as they are both made from corn flour and soybean flour with other similar additives.

According to Aini *et al.* (2010), of the three varieties of maize, Srikandi corn has the highest protein content compared to the Canggal and Pioneer varieties. Processing corn into flour will not change its chemical composition. Emergency food based on corn-soybean flour has a less sweet flavor than emergency food from corn-tempe flour, due to fewer added sugars. However, based on its aroma, corn-soybean flour formula has a better aroma than corn-tempe flour formula due to the amount of oil and higher milk content. Lipids provide a delicious aroma for food. Milk powder, which has a lipid content of 25.93%, also contributes to the aroma of products.

Based on proximate analysis, we calculated the percentage composition of the materials for the emergency food formula. The prediction of emergency food nutritional adequacy based on every piece (50 g) can be seen in Table 2. The protein content of the emergency food is in the range of 7.06 to 7.97 g every piece of the product. Based on the nutritional requirements, the emergency food should contain 7.9 to 8.1 g of protein (Zoumas *et al*., 2002). Based on these requirements, the products that are eligible are formulas III and VI. Formula III has a protein content of 15.86%, equivalent to 7.93 g. Formula VI has a protein content of 15.92%, equivalent to 7.96 g.

The protein content of the emergency food made from Srikandi corn flour is higher (9.86%) than Pioneer (7.35%) and Canggal (7.63%). Tempe flour,

Table 1. Emergency food formulation based on corn flour

Ingredients	Formula (%)					
	I	II	III	IV	V	VI
Corn flour	40	42	42	36	36	34.4
Soybean flour	-	-	-	23	23.6	25
Tempe flour	18	20	20	-	-	-
Milk powder	12	10	10	15	16	16
Icing sugar	18	16	16	10	8	8
Frying oil	12	12	12	16	16.4	16.6

Explanation: I = Canggal corn-tempe flour; II = Pioner corn-tempe flour; III = Srikandi corn-tempe flour; IV = Canggal corn-soy flour; V = Pioneer corn-soy flour; VI = Srikandi corn-soy flour

soybean flour and milk powder have high protein contents, i.e., 50.46, 36.66 and 25.93%, respectively. High levels of protein in these materials increase the protein content of emergency food.

Lipids in emergency food are required to amount of 9.1 to 11.7 g every piece of product. This product has a lipid content predicted at 10.72 to 11.68 g, making it eligible. Lipids as an effective source of energy will maintain the health of the human body. One gram of oils and lipids can produce 9 kcal. Zoumas *et al.* (2002) argue that the source of lipids recommended in the development of emergency food as a source of macro nutrients is the partial hydrogenation of soybean oil, canola oil and sunflower oil. Carbohydrate levels of the emergency food are in the range of 26.29 to 27.11 g for every piece of product. The amount of carbohydrates required for emergency food is 23 to 35 g every piece. Based on the above data, the predicted formula of emergency food has exceeded the minimum recommended caloric value of emergency food.

Determination of the amount of water and humectants

Emergency food formulation aims to fulfill the desired energy sufficiency and flavor. Added to the main ingredients of corn-soybean flour and corn-tempe flour, other materials used are whole milk powder, sugar and cooking oil. The water used is preheated to a temperature of 80°C to facilitate the dissolving and mixing processes.

In making emergency food was added water to produce a homogeneous and easy to swallow. Mineral water that has been heated to a temperature of 80^{o}C was gradually added until the dough was homogenous. Homogeneous dough is then subjectively tested by researchers with a limited sensory test to obtain dough that is easy to swallow and does not cause thirst.

Table 2. Prediction of the nutritional adequacy of emergency food formula

Nutrition	Formula					
	I	II	III	IV	V	VI
Protein (g)	7.06	7.87	7.93	7.83	7.72	7.97
Lipid (g)	11.20	11.68	11.41	10.72	11.36	11.27
Carbohydrate (gram)	27.11	26.62	26.58	27.19	26.63	26.29
Total energy (kkal)	241.55	243.16	240.79	237.02	239.65	238.47

Explanation : I = Canggal corn-tempe flour; II = Pioner corn-tempe flour; III = Srikandi corn-tempe flour; IV = Canggal corn-soybean flour; V = Pioneer corn-soybean flour; VI = Srikandi corn-soybean flour.

The amount of water added varied from 39 to 47.7 g. Differences in the addition of water were affected by the composition of the formula. A formula that has more milk powder and icing sugar requires more added water. Milk powder and icing sugar has a smaller particle size compared with corn flour and soybean flour. According to Aini *et al.* (2010), small particles have a larger surface area that absorbs more water, so formula IV to require more water than the others.

The use of sorbitol as a humectan, which include a polyol group, can affect the texture, flavor and acceptance of the product. Based on these trials, sorbitol was added at a concentration of 5%, or 2.5 g in each of the pieces of emergency food formula. The use of sorbitol is classified as generally recognized as safe (GRAS), but if it is consumed in a greater amount than 50 g/day, it will cause a laxative effect or diarrhea.

Nutritional value of emergency food

There are six emergency food products that were produced and had their nutritional values analyzed, as shown in Table 3. The protein content of emergency food was in the range of 12.69 to 16.25%, equivalent to 6.34 to 8.12 g in every piece. Based on the nutritional requirements, the emergency food should contain 7.9 to 8.1 of protein in each piece of the product (Zoumas *et al.*, 2002), so the product that is eligible is formula III, namely Srikandi corn and tempe flour. Every piece of product has a protein content of 16.25%, equivalent to 8.13 g.

High levels of protein in these materials increase the protein content of the emergency food. Srikandi corn flour has a protein content of 9.86%, higher than Pioneer (7.35%) and Canggal (7.63%). Tempe flour

Table 3. Nutrition content of emergency food

Formula	Ash content (% db)	Lipid content (% db)	Protein total (% db)	Carbohydrate (% db)
I	1.79	45.12	12.69	40.39
II	1.02	46.79	15.25	36.94
III	1.25	41.34	16.25	41.16
IV	1.85	47.83	14.56	35.76
V	1.07	50.49	13.38	35.06
VI	1.19	44.71	15.26	38.85

Explanation : I = Canggal corn-tempe flour; II = Pioner corn-tempe flour; III = Srikandi corn-tempe flour; IV = Canggal corn-soybean flour; V = Pioneer corn-soybean flour; VI = Srikandi corn-soybean flour.

and soybean flour also have high protein contents, which amount to 50.36% and 36.66%, thereby increasing the protein content of the emergency food. The addition of milk powder in the amount of 10 to 12% also increases the levels of emergency food proteins. Milk powder has a protein content of 25.93%. According to Zoumas *et al.* (2002), a source of protein recommended for emergency food can be derived from nut products, like isolates or concentrates, and milk powder, such as casein and its derivatives. The protein amino acids must fulfill score of ≥ 1.0.

The quality of protein supplementation can be improved by increasing the levels of limiting amino acids. This can be done by adding limiting amino acids from a pure protein source or mixing two or more types of different protein sources of limiting amino acids. Corn has a limiting amino acid, i.e. lysin and tryptophan, while soybeans have a different limiting amino acid, i.e. methionine. By taking these ingredients together, the deficiency of amino acids from each material can be covered. The use of tempe flour for increase the protein content of the food emergency in this study was appropriate, because in addition to increasing the quantity of protein, it also provided quality of protein.

The emergency food should have lipids in amount of 18.2 to 23.4%. This products have a lipid content of 41.4 to 50.5%, which is greater than the targeted. Corn flour has a lipid content of 0.32 to 1.61%, while tempe flour and soybean flour have lipid contents of 24.7 and 6.74%, respectively. High levels of lipids due to the addition of high amounts of oil, are 12 to 16.6%, and are 10 to 16% due to whole milk powder. To reduce the levels of lipids in the product, skim milk powder should be used, which has low levels of

Table 4. Nutrition composition of selected emergency food

Types of nutrients	Composition of product (every 50 grams)	Emergency food nutrition standard (every 50 grams)*
Protein (% of db)	8,13	7,9 – 8,1
Lipid (% of db)	20.67	9,1 – 11,7
Carbohydrate (% of db)	20.58	23 – 35
Energy (kcal)	298.04	Minimal 233
Water activity	0.93	

*Zoumas *et al.* (2002)

lipids but high protein content, so that the nutritional requirements are achieved.

Carbohydrate values are in the range of 35.2 to 41.2%. The total carbohydrate amount was lower than recommended, i.e. 46 to 70%, with donations valued at 40 to 50% energy. Carbohydrates play an important role in determining the characteristics of the material, such as flavor, color, texture and others. FAO/WHO indicates that the proportional carbohydrate should be of a sufficient quantity in the emergency food to give a sense of function, palatability, stability and metabolic functions.

The presence of sorbitol also affects the carbohydrate content. Sorbitol is a polyol compound belonging to the carbohydrates group that can increase the levels of carbohydrates. Sorbitol is hygroscopic and has a sweet taste, and it can protect the components contained in the carbohydrate content of food.

The addition of sorbitol as a humectant for emergency food has a water activity of 0.6 to 0.8. Water activity is the amount of free water that can be used by microbes for growth. According to Maltini *et al*. (2003), water activity is a thermodynamic concept that is becoming an important factor in the destruction of foodstuff. When water is more strongly bound, it is more difficult to use, both for microbiological activity and chemical hydrolytic activity. The main characteristics of emergency food are easy to swallow without a dry sensation, able to be directly consumed without further preparation, and having a sufficient shelf life because microorganisms cannot grow at specified intervals.

These emergency foods have water activity levels in the range of 0.94 to 0.96. Water activity has not been achieved as expected, i.e. 0.6-0.8. Aw product remains high due to the addition of water in large amounts so that the product is easy to swallow. This is presumably due to the amount of added water

Table 5. Microbiological analysis of selected emergency food

Week	Total (CFU/gram)	
	Yeast	Microbial
0	1.99×10^2	$6,92 \times 10^3$
1	1.99×10^3	$3,47 \times 10^4$
2	2.95×10^3	$2,29 \times 10^5$
3	2.95×10^3	$2,75 \times 10^5$
4	$2,95 \times 10^3$	$4,17 \times 10^5$

not being quite right or the addition of sorbitol being less effective in lowering water activity. Addition of sorbitol is expected to lower A_w, but it was not, so we need research on the use of other humectants.

Characterization of selected product

The selection of an emergency food formula is based on the nutritional value, sensory properties, and water activity approaching product. Emergency food from Srikandi corn flour and tempe flour with an additional 2.5% of sorbitol has the lowest water activity, i.e. 0.94. Sensory test results indicate that the product most preferred that fulfills nutritional standards has a composition of 42% Srikandi corn flour, 20% soybean flour, 10% milk powder, 16% icing sugar and 12% cooking oil. The nutrition value of the selected emergency food can be seen in Table 4.

The emergency food contributed an energy total of 298.04 kcal in every piece, up from the prior addition of sorbitol, which was 241.55 kcal. There was an increase in emergency food calories after the addition of humectants. The addition of sorbitol in the amount of 2.5 g can increase calorie emergency food to 2.6 kcal every gram. This is consistent with the results of Ahmad *et al*. (2007), that sorbitol is a carbon source that can provide additional energy to the product.

Total microbial and yeasts during storage

Microbiological testing conducted on emergency food was selected to determine the level of product safety. Food safety is one of the main characteristics of emergency food products (Sheu, 2007). Microbiological stability testing is conducted by storing the products in packed aluminum foil, because it has low water vapor permeability. Storage is done for four weeks, and every week, an analysis of microbial and fungal amounts is conducted. The results of microbiological analysis for four weeks can be seen in Table 5.

The initial microbial count on the emergency food was 6.92×10^3 CFU/g. There was microbial growth in the first week of 3.47×10^4 CFU/g, whereas after four weeks, it had increased by 4.17×10^5 CFU/g. Liu *et al.* (2009) explained that the increase of microbial amounts in food is influenced by intrinsic and extrinsic factors. Intrinsic factors include pH, water activity, relative humidity, nutrient content, structure and biological anti-microbial ingredients, while external factors are influenced by the storage temperature, RH and type and amount of gas in the environment. The water activity level of emergency food is still high, at 0.93, so that the microbial growth is still high.

Referring to yangko and bakpia as intermediate moisture foods, this emergency food has a similar texture and taste. Yangko refers to SNI 01-4325-1996, with a maximum standard value of microorganisms of 1×10^5 CFU/g, while bakpia refers to SNI 01-4291-1996 with a maximum value of total microbial as 104 and of yeast as 103. Based on the microbiological standards, the product is safe to consume in the first and second weeks.

Sensory and microbiological characteristics indicate that the product in the third week is not able to be consumed because it has undergone changes in aroma and flavor. According to Chen *et al.* (2010), microbial growth can result in changes in sensory and nutritional properties, which can result in toxicity and mortality.

Total fungi also significantly increased from the first until the fourth week of storage. At the beginning, the total fungi of the product were as much as 1.99×10^2 CFU/g. In the first week, the yeast increase by 1×10^3 CFU/g and in the fourth week was as much as 2.95×10^3 CFU/g. The addition of sorbitol can have a dual role as a barrier to the growth of yeast and a plasticizer of the texture. Sorbitol can also increase the level of dissolved solids in the liquid phase.

Water activity plays an important role in inhibiting the growth of microorganisms (Liu *et al*., 2009). The water content in the food, especially the free water content, greatly affects the durability of food against invading microorganisms, represented by aw (Sablani *et al.*, 2007). Selected products have a high aw of 0.93, which allows the bacteria lactobacillus to grow. A high water activity level can cause the growth of *Lactobacillus* due to the composition of a complete nutritional in high quantities. Protein, starches and lipids are a good media for microbial growth; therefore, microbes can grow in considerable numbers (Gidenne *et al*., 2004).

Conclusion

The best prototype of emergency food is produced from Srikandi corn flour and tempe flour. The best composition is 42% corn flour, 20% tempe flour, 10% whole milk powder, 16% sugar and 12% frying oil. The nutrient composition of each 50 g of product was 8.1 g of protein, 20.67 g of lipids, 20.58 g of carbohydrate and 298.04 kcal of energy. In terms of protein and energy, emergency food already fulfils the adequacy standard, which is a minimum energy of 233 kcal/piece and 7.9 to 8.1 g protein. The emergency food's lipid content is too high (9.1 to 11.7 g), while the levels are too low for carbohydrates (23-35 g). This product is swallowed easiest, delicious, with no bitter aftertaste and most preferable compared to other formulas.

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