Optimization formulation of high protein biscuit made from denaturated whey protein concentrate and sweet potato flour supplemented with mineral as emergency food

D R E Pradipta and R Andoyo
Departement of Foods Industrial Technology, Faculty of Agro-Industrial Technology, Universitas Padjadjaran, Indonesia
Email: r.andoyo@unpad.ac.id

Abstract. High-protein biscuit formulations that develop as emergency food preparations must contain high enough nutrients, not only filling but also contain appropriate calories. Denaturated whey protein concentrate, sweet potato flour and mineral can be added to increase nutritional value of the biscuit. The different concentration of ingredients may have some implication of characteristic of biscuit. The aim of this work was to formulate biscuit with acceptable characteristic especially texture properties made from different concentration of denaturated whey protein concentrate and sweet potato flour supplemented with different mineral concentration in order to make available foods with added nutritional value as other options to consumers especially in emergency condition. Response Surface Methodology (RSM) using the Central Composite Design (CCD) model was used to optimize the formulations of high protein biscuit. Different concentrations of denaturated whey protein, sweet flour and minerals were used to prepare the biscuit. The textural property increased by bigger amount of denaturated whey protein concentrate and mineral added in formulation. The optimized formulation was characterized and evaluated. The results shows that biscuit which contain 12.49% of denaturated whey protein concentrate and 3.28% mineral were quite acceptable to consumers.

1. Introduction
High-protein biscuits and high-energy biscuits have been used since decades ago in an emergency especially to meet the nutritional needs of children. High protein biscuits are foods that are designed in such a way by adding proteins with high concentrations of food ingredients. High-protein biscuit formulations that develop as emergency food preparations must contain high enough nutrients, not only filling but also contain calories according to the nutritional adequacy rate (RDA), which is 2100 kcal/day [1] (Institute of Medicine, 2005).

The groups that are most vulnerable and need special handling of nutrition, especially in emergency situations, are toddlers and children. Giving inappropriate food intake can lead to a decrease in health and even death. The risk of death is higher in infants and children who experience malnutrition, especially the group suffering from a lack of micronutrients. The development of high-protein biscuit products as emergency food generally focuses on the composition of macro nutrient content with
relatively low micronutrient content. Emergencies can result in non-fulfillment of nutrition so that it can cause malnutrition. Addition of the components of micronutrients to the composition of emergency foods can increase nutritional value and complete nutrition in emergency food products. One micro component that can be added to the formulation is minerals [2].

Mineral is one of the micronutrient content that must be fulfilled. Minerals play an important role in the growth process, especially in infants and toddlers who are in their infancy. The body's mineral needs can be fulfilled from food or supplements/pills. Addition of minerals causes food products to be less favored especially by children and toddlers. The unpleasant taste of Mineral Mix makes not all toddlers accept products with Mineral Mix [3]. Palatability of emergency food products is very important because according to the US Agency of International Development (USAID, 2001) emergency food has important properties, namely safe consumption, acceptable sensory quality, easily distributed, easy to use and has sufficient nutritional content. Therefore, in emergency food formulations, flavoring needs to be added to help minimize the taste caused by the addition of the mix mineral. In addition, the addition of various types of minerals contained in Mineral Mix can affect other characteristics of the product added. Some types of minerals can cause changes in unexpected characteristics such as changes in color, texture and stability by increasing interaction with other ingredients and components added.

High-protein biscuits can be designed with the use of macronutrients such as carbohydrates, proteins and fats in recommended amounts [4]. Whey protein can be used as a source of protein components used in the formulation of high protein biscuit products as emergency food. Hey is a liquid substance obtained from the process of separating coagulum (aggregated casein) in milk or cream in cheese making (Code of Federal Regulation). There are various types of whey protein, one of which is whey protein concentrate. According to Council (2006) the protein contained in whey protein concentrate reaches 34–80% per serving [5]. The formulation of high-protein foods can cause the main problems in terms of texture, which is a hard texture due to the presence of high-concentration proteins. These problems can have an impact on the stability and power of receiving products for consumers. The use of whey protein in some foods produces characteristics that are less preferred. Whey protein which contains many native proteins tends to produce a hard texture. This can be overcome by modifying natural whey protein to change its conformation. One of them is by way of protein denaturation which can result in the loss of the functional properties of whey so that the texture of the product added to whey protein can be controlled.

The characteristics of high protein biscuits made from whey protein with the addition of mineral can also be influenced by other ingredients. In order to meet the nutritional content according to emergency food criteria, emergency food products can add a source of carbohydrates from local food ingredients.

Sweet potatoes are one of the local food ingredients that contain high nutrient content so that they can meet the needs of carbohydrates in the emergency food composition. The use of sweet potatoes in food products can be added in the form of puree or flour which is processed using high temperatures. Utilization of sweet potatoes and whey protein as a macronutrient source can produce emergency food products that have high carbohydrate and protein content. Texture parameters are essential for consumers, who either purchase or select to consume food products, including biscuits. High-protein biscuits can be an alternative food as an effort to fulfill the nutritional intake of toddlers who are victims of disasters. In addition, emergency food biscuit formulations with added flavor favored by children such as chocolate flavor will increase the palatability of emergency food biscuits.

2. Materials and methods
The raw materials used were 10–15% of denaturated whey protein concentrate powder, 2–3.5% of mineral (magnesium supplement and KCl), sugar, skim milk powder, egg yolk, cocoa powder, margarine, all purposed flour, and sweet potato flour.
2.1. Formulation of biscuit

The amount of denatured whey protein was varied on each sample prepared, meanwhile other ingredients were fixed. Formulation of biscuits used in the current study showed as follow:

### Table 1. Formulation of high protein biscuit.

| Ingredient               | A, B, C, D, I | E   | F   | G   | H   | J   | K   | L   | M   |
|--------------------------|---------------|------|------|------|------|------|------|------|------|
| Denaturated WPC          | 29            | 58.45| 29.6 | 9.2  | 50   | 9.2  | 29.6 | 0.75 | 50   |
| Mineral                  |               | 8    | 8    | 10   | 5    | 5    | 3    | 8    | 10   |
| Sugar                    |               | 70   | 70   | 70   | 70   | 70   | 70   | 70   | 70   |
| Baking Powder            |               | 2    | 2    | 2    | 2    | 2    | 2    | 2    | 2    |
| Skim Milk Powder         |               | 50   | 50   | 50   | 50   | 50   | 50   | 50   | 50   |
| Egg yolk                |               | 60   | 60   | 60   | 60   | 60   | 60   | 60   | 60   |
| Cocoa Powder            |               | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    |
| Margarine               |               | 80   | 80   | 80   | 80   | 80   | 80   | 80   | 80   |
| Water                   |               | 5    | 5    | 5    | 5    | 5    | 5    | 5    | 5    |
| All Purposed            |               | 80   | 80   | 80   | 80   | 80   | 80   | 80   | 80   |
| Flour                   |               | 18.4 | 6.45 | 22.4 | 40.8 | 5    | 45.8 | 27.4 | 45   |
| Sweet Potato Flour      |               | 408  | 408  | 408  | 408  | 408  | 408  | 408  | 408  |
| Total Mass              |               | 408  | 408  | 408  | 408  | 408  | 408  | 408  | 408  |

2.2. Baking procedure

The biscuit was baked using the straight dough method described by [9] Chauhan et al [6]. Margarine and the sugar were mixed thoroughly; until both formed a homogenous mixture (fluffy). All the other ingredients were properly mixed in separate bowls. The mixed margarine and sugar were added to the ingredients and mixed thoroughly to form dough and kneaded. They were rolled out thinly on a cutting board and cut out into and placed in a baking tray. The cut dough was baked at a temperature of 180 °C for 15 minutes. The baked biscuits were allowed to cool at room temperature, and then packaged in an air tight container.

2.3. Textural property

The textural property of the biscuits were measured using a texture analyzer. The hardness of the freshly baked biscuits was measured by the biscuit bending model, using a small three-point bending test rig with a P/6 probe. The first peak force was recorded as the hardness force.

2.4. Optimization

Numerical optimization technique of the Design Expert (10.0.) software was used for optimization responses using Response Surface Methods (RSM) with Central Composite Design model. The desired goal for each of the protein, mineral and texture was chosen. Protein and mineral concentration were maximized and the texture hardness was minimized. The solution of the optimization with the highest desirability was chosen.

2.5. Sensory evaluation

Fifteen semi-trained panelists from Department of Food Industrial Technology, Padjajaran University were used to carry out the sensory evaluation of the samples using 7 points hedonic scale to evaluate color, flavor, taste, and texture. All panelists were regular consumer of biscuits. They were asked to detect or state their degree of like or dislike.
3. Result and discussion

The result of texture property which is hardness obtained from Texture Analyzer are presented in the table 2. Biscuits with the addition of denatured whey protein concentrate and mineral were slightly harder than biscuits with smaller amount of whey protein concentrate and mineral. Therefore, the amount of protein addition seemed to be important to the texture [7]. The addition of denatured whey protein concentrate and mineral at different levels changed the quality of the product in terms of the texture parameters. Formulation A, B, C, D and E shows different value of hardness. The cause of this inconsistency could be because of different level of the thickness of the biscuit. The number

| Sample | Protein (%) | Mineral (%) | Hardness (gF) |
|--------|-------------|-------------|---------------|
| A      | 12.5        | 2.75        | 5375.24       |
| B      | 12.5        | 2.75        | 5217.85       |
| C      | 12.5        | 2.75        | 5432.17       |
| D      | 12.5        | 2.75        | 5597.64       |
| E      | 10.73       | 3.28        | 5130.08       |
| F      | 10.73       | 2.22        | 5135.05       |
| G      | 15          | 2.75        | 6266.63       |
| H      | 12.5        | 3.5         | 6101.88       |
| I      | 12.5        | 2.75        | 5648.72       |
| J      | 14.27       | 3.28        | 6301.36       |
| K      | 14.27       | 2.22        | 6011.97       |
| L      | 12.5        | 2           | 5216.93       |
| M      | 10          | 2.75        | 4030.54       |

3.1. Optimization

After simultaneously maximizing the variables concentration and targeting minimize the texture response, optimization suggested that biscuits made with 12.49% protein and 3.28% mineral achieved the best solution for this combination of variables. The value of desirability result for this solution is 0.51. This suggestion further was produced and evaluated by sensory evaluation.

3.2. Sensory evaluation

The results of the analysis of optimized formula (Table 3.) showed that the products were quite acceptable to consumers. Color parameters are essential for consumers, who either purchase or select to consume food products, including biscuits, on the basis of their color [7]. Almost every food product
has an acceptable color range, which depends on a variety of factors including the variability between consumers, their age and ethnic origin and the physical nature of the environment when giving opinions [8]. However the value was showing average number but mean value for odor was higher compared to the other parameters. This result indicated that producing biscuit from optimized formulations will give products with good textural acceptability as judged by assessors to be above average.

| Table 3. Mean value of the sensory evaluation of biscuits. |
|---------------------------------------------------------|
| Optimized formulation | color | texture | Odor | taste |
|------------------------|-------|---------|------|-------|
|                        | 4.5   | 4.8     | 6.1  | 4.8   |

### 4. Conclusion
Addition of denaturated whey protein concentrate, sweet potato flour and mineral enriched its nutritional value by increasing protein and total mineral contents as well as total calories. However, the textural property increased by bigger amount of denaturated whey protein concentrate and mineral added in formulation. Moreover, the optimized formulation of the biscuit were quite acceptable to consumers and indicated that producing biscuit from optimized formulations will give products with good textural acceptability as judged by assessors to be above average.

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