

Modification of Biscuits for Children under Five Years Old with *Spirulina* Fortification as a Complementary Food during Disaster Response

Sasanti Ayu Ningrum⁺, Riana Harumi Putri, Iftita Rakhma Ikrima and Monika Nanda G.W.

Students of Department of Nutritional Science, University of Indonesia

Abstract. This study finds out about the best formula of *Spirulina* biscuits that meets the characteristics and Recommended Daily Allowances of children 1-5 years old to help meeting their nutrition requirements, thus improving children's nutritional status and preventing diseases in disaster response. The formula selection considered the biscuit's chemical component analysis, organoleptic, difference, and hedonic test. The total of 44 panelists participated in the first and second tests. Using Kruskal-Wallis nonparametric analysis, the result showed that the fat ingredients (100% unsalted butter or 50% unsalted butter-50% margarine) and the amount of *Spirulina* addition (10g, 15g, or 20g) gives no significant difference in biscuits appearance, taste, texture, color, flavor, and aroma ($P>0.05$). Hence, combined with the result of chemical component analysis of biscuits, we concluded that the composition of 50%:50% unsalted butter-margarine and addition of 15g *Spirulina* is the most ideal formula as it meets the RDA and preferred by panelists.

Keywords: biscuits, children 1-5 years old, formula, Recommended Dietary Allowance, *Spirulina*.

1. Introduction

Indonesia, geographically and demographically, is prone to both natural and man-made disasters. Statistics has recorded that the total of 211 disasters occurred during 2011 with more than 15000 casualties. Generally, the physical harms of disaster are infrastructural, which causes a great deal of loss. However, the more fundamental impacts than the destructions lies on health and nutrition-related problems that occurs due to the disrupted food distribution channels, destruction of health care, limited food availability, as well as bad sanitation and water supply. Numerous health problems such as infectious diseases and under-nutrition come off after food insecurity in refugee camps. Food insecurity causes starvation, nutrition deficiency, weakening immunity that put the refugees at risk of diseases. [1]

Children are at higher risk of the health problems. Research has shown that in refugee camps, the death of children under five years old is 2-3 times bigger than those of the other age groups. Therefore, nutrition care for this age group becomes more crucial. [1] Breastmilk is compulsory for 0-6 month old baby, while those older than 6 months old shall be given complementary foods to fulfil daily nutrition requirements. It is important to design complementary food that is practical, durable, and dense in energy, protein, and micronutrients.

The form of biscuits is chosen because it has longer shelf life, practically consumed, less hazardous in its preparation than other forms of foods such as liquid, powder, or canned. The biscuits are fortified with *Spirulina* powder, the species of Cyanophyta (green-blue algae) which is widely consumed as food sources or supplements. *Spirulina* is rich in amino acids (62% of *Spirulina*), vitamins, minerals, and carotenoids. A number of animal and test tube studies suggest that it improves immunity and helps ward off infection and chronic illnesses, as well as protects against allergic reactions. [2] Furthermore, to optimize its nutritional

⁺ Corresponding author.

E-mail address: sasantiayuningrum@gmail.com

value, the biscuits formula is designed based on Dietary Reference Intake (Angka Kecukupan Gizi (AKG) 2013) and The Decree of Complementary Food Requirements by Indonesian Ministry of Health. According to The Decree of Complementary Food Requirements, complementary food should meet 10% of total Recommended Dietary Allowance. [3]

The aim of this study is to design formula of *Spirulina* biscuits that is long-durable, practical, and nutritionally suitable for children 1-5 years old, especially in the situation of disaster response. Although can be consumed for all ages as well, the *Spirulina* biscuits are expected to help meeting 1-5 year old children's Recommended Dietary Allowance, thus improving their nutritional status and preventing diseases.

2. Methods

2.1. Description of Study

The study was conducted in Depok and Bogor, West Java, Indonesia, during February-June 2014. This experimental study involved primary and secondary data analysis. Primary data was obtained from recipe formulation, chemical compounds test, storability test, as well as panellists' acceptability acquired from organoleptic test, difference test, and hedonic test. The data were collected from questionnaire and test results. The results of organoleptic, difference, and hedonic tests was analysed based on Mann Whitney and Kruskal Wallis nonparametric tests to find out whether the samples tested have the same mean population. [4] All the obtained data was processed by using software Statistical Package for Social Sciences (SPSS) 16.0.

2.2. Methodology

The study began with the formulation of control biscuits with no addition of *Spirulina*. The formula was designed based on The Decree of Complementary Food Requirements issued by Indonesian Ministry of Health, 2007, and Dietary Reference Intake to make it nutritionally suitable for the target group. The shape, size, and texture of the biscuits were also accustomed for children consumption. Considering the nutritional value of the biscuits, we produced several types of biscuits made of varying composition. Then, they were sent to the Integrated Laboratory of Bogor Agricultural Institute for chemical content analysis. At the same time, the sample of *Spirulina* powder was also analysed in laboratory.

The best type of biscuits was chosen based on the result of chemical content analysis, as well as consumer's judgment measured by simple organoleptic test, difference test, and hedonic test. Simple organoleptic test was conducted to determine the panellist's preference for each sample biscuits. Difference test aims to determine the level of difference among each biscuits, while hedonic test aims to determine the level of panellist's preference based on parameters appearance, texture, colour, flavour, and aroma. [5] The scoring was five-ranked score, for example ranging from "really dislike" to "really like".

Spirulina biscuits were basically made of the chosen formula of control biscuits added with *Spirulina* powder. To determine the amount of *Spirulina* addition, the result of control biscuit's chemical analysis was compared to 10% of children's Recommended Dietary Allowance and was compared to the nutritional value of *Spirulina* from laboratory test. Three formulas of *Spirulina* biscuits were generated with the different amount of *Spirulina* fortification (F1:10 gr, F2:15 gr, and F3:20 gr). The three types of biscuits were then tested with simple organoleptic test, difference test, and hedonic test to determine the best formula with the most preferred taste. After the final formula was determined, the *Spirulina* biscuits started to be produced. They were once again sent to the laboratory to test the nutritional value for nutrition facts label.

2.3. Biscuits Manufacturing

The materials needed to produce the biscuits include ingredients, baking tools, and the other standard equipment for food handlers according to HACCP principal.

The *Spirulina* biscuits are made by mixing together unsalted butter, margarine, and extra fine granulated sugar with a mixer. Once mixed well, wheat flour, milk flour, and *Spirulina* powder are added little by little to the dough, stir it, and then knead it until the dough becomes satin smooth. Press the dough and shape it round with a diameter of 4 cm. Put them into the oven for 20 minutes at 180°C.

3. Results and Discussions

In the process, we made two kinds of biscuits; control biscuits, the basic biscuit with no addition of *Spirulina*, and *Spirulina* biscuits. The biscuits are designed in such a way to make the biscuits suitable for children 1-5 years old. The biscuits specifications are as follows; (a.) size and shape: 4 cm diameter round; (b.) weight: 15 gr; (c.) flavor: medium sweet; (d.) texture: crunchy, rather melt in the mouth; (e.) colour: golden brown (control biscuits) and green (*Spirulina* biscuits); (f.) serving size: 2 biscuits (30 gr).

First of all, we made the control biscuits with no addition of *Spirulina*. After several trials, two formulas, which had the best taste, texture, and colour, were acquired (Table 1). We made some samples of biscuits using both formula and labelled them as Control Biscuits A and Control Biscuits B afterwards. The only difference between both types is their fat ingredients; biscuits A use 100% unsalted butter, while biscuits B use 50% unsalted butter and 50% margarine. Each formula of biscuits generated 15 biscuits. The two sets of biscuits samples were then chemically analysed in laboratory to find out their chemical composition (Table 2).

Table 1: Control biscuits formulation

Ingredients	Amount (gr)	
	Control Biscuits A	Control biscuits B
<i>Spirulina</i> powder	-	-
Unsalted butter	60	30
Margarine	-	30
Extra fine granulated sugar	25	25
Low protein wheat flour	75	75
Milk powder	10	10

Table 2: The chemical content of control biscuits

Parameter	Results		Unit	Analyzing Methods
	Biscuits A	Biscuits B		
Calorie	5970	5826	kal/g	Bomb Calorie
Carbohydrate	55.42	57.07	% w/w	Phenol Sulfat (Spektrofotometry)
Fat	33.35	31.62	% w/w	Soxhlet
Protein	4.54	4.8	% w/w	Kjeldhal (Titrimetry)
Iron (Fe)	20.06	35.21	mg/kg	AAS
Sodium (Na)	109.32	1324.73	mg/kg	AAS
Calcium (Ca)	119.92	134.18	mg/kg	AAS
Zinc (Zn)	18.43	21.71	mg/kg	AAS

Table 3: The scoring result of hedonic, difference, and organoleptic test questionnaire

		251	374
Hedonic test	Appearance	3.31	3.31
	Texture	3.58	3.69
	Colour	2.81	2.69
	Flavour	3.46	3.85
	Aroma	3.27	3.31
Difference test	Sweetness	2.54	2.62
	Crunchiness	3.04	3.31
Organoleptic test	Level of preference	3.69	3.31

According to the result of chemical content analysis, biscuits B clearly dominated biscuits A in the content of carbohydrate, protein, iron, calcium, and zinc. However, the selection of control biscuits also

considered consumer's judgment, which was measured by conducting organoleptic, difference, and hedonic test between two biscuits. Thirteen panellists participated in the tests. Control biscuits A was randomly labelled as 251 and control biscuits B as 374. The scoring was based on Mann Whitney and Kruskall Wallis nonparametric tests, analysed by using software Statistical Package for Social Sciences (SPSS) 16.0 (Table 3).

The result of organoleptic test showed that panellists' preference of biscuits 251 ranged from "dislike" to "neutral", while the preference of biscuits 374 ranged from "neutral" to "like". The difference test showed that there is no significant difference between both biscuits ($P > 0.05$). The result of hedonic test showed that panellists prefer biscuits 374 in texture, flavour, and aroma. In colour, biscuit 251 is more desirable, whereas in appearance, both biscuits are tie. Based on all the analysis, control biscuit B (374) was chosen as it won over biscuits A in both nutritional value and consumer's judgment.

Using the chosen control biscuits B formula, we then started to produce the *Spirulina* biscuits. Since complementary food should at least meet 10% of total Recommended Dietary Allowance, to determine the amount of *Spirulina* addition, the result of control biscuit B chemical analysis was compared to 10% of children's Recommended Dietary Allowance (Table 4) as well as to the nutritional value of *Spirulina* (Table 5). We made estimations of nutritional value for each 5 gr of *Spirulina* addition (5 gr, 10 gr, 15 gr, and 20 gr) to one formula of biscuits (Table 6) After that, we compared the estimations to the 10% of total Recommended Dietary Allowance, and then chose the biscuits that best meet the requirements.

Table 4: Indonesian Recommended Dietary Allowance (Angka Kecukupan Gizi (AKG) 2013) [6]

Parameter	1-3 years old (13 kg, 91 cm)		4-6 years old (19 kg, 112 cm)	
	RDA	10% RDA	RDA	10% RDA
	Calorie (kkal)	1125	112.5	1600
Carbohydrate (gr)	115	11.5	220	22
Fat (gr)	44	4.4	62	6.2
Protein (gr)	26	2.6	35	3.5
Fe (mg)	8	0.8	9	0.9
Na (mg)	1000	100	1200	120
Ca (mg)	650	65	1000	100
Zn (mg)	4	0.4	5	0.5

Table 5: The chemical content of *Spirulina*

Parameter	Results	Unit	Analyzing Methods
Calorie	3606	Kkal/kg	Manual
Carbohydrate	20.74	% w/w	Phenol Sulfat (Spektotometry)
Fat	1.36	% w/w	Soxhlet
Protein	66.35	% w/w	Kjeldhal (Titrimetry)
Iron (Fe)	599.09	mg/kg	AAS
Sodium (Na)	5727.59	mg/kg	AAS
Calcium (Ca)	798.90	mg/kg	AAS
Zinc (Zn)	14.82	mg/kg	AAS

Table 6: Estimation of nutritional value for 5 gr, 10 gr, 15 gr, and 20 gr *Spirulina* addition

Para-meter	+5 gr <i>Spirulina</i>		+10 gr <i>Spirulina</i>		+15 gr <i>Spirulina</i>		+20 gr <i>Spirulina</i>	
	Per formula	Per Serving Size (30 gr)	Per formula	Per Serving Size (30 gr)	Per formula	Per Serving Size (30 gr)	Per formula	Per Serving Size (30 gr)
Calorie (kkal)	862.8	172.56	880.83	170.48	898.86	168.54	916.89	166.71
Carbohydrate (gr)	83.79	16.76	84.83	16.42	85.86	16.1	86.9	15.8
Fat (gr)	45.92	9.18	45.99	8.9	46.05	8.63	46.12	8.39
Protein (gr)	10.28	2.06	13.6	2.63	16.91	3.17	20.23	3.68
Fe (mg)	8.1	1.62	11.1	2.15	14.09	2.64	17.09	3.11
Na (mg)	220.72	44.14	249.36	48.26	278	52.12	306.64	55.75
Ca (mg)	23.45	4.69	27.45	5.31	31.44	5.89	35.43	6.44
Zn (mg)	3.22	0.64	3.3	0.64	3.37	0.63	3.44	0.63

From the Table 6, we found out that to meet the Recommended Dietary Allowance of 1-5 years old children, the *Spirulina* addition should be at least 10 gr. Therefore, the results generated in the amount of *Spirulina* additions of 10 gr, 15 gr, and 20 gr to one formula of Control Biscuits B. Later, we made some samples of biscuits using each of the three formulas and labelled them as F1 (10 gr), F2 (15 gr), and F3 (20 gr).

Similar in choosing the control biscuits, consumer's judgment of biscuits F1, F2, and F3 was determined by organoleptic, difference, and hedonic test. Three samples of *Spirulina* biscuits were given to 31 panellists and they were required to fill in the questionnaire. To blind the test, F1 was randomly labelled as 329, F2 as 802, and F3 as 417. The scoring was based on Mann Whitney and Kruskal Wallis nonparametric tests by using software Statistical Package for Social Sciences (SPSS) 16.0 (Table 7).

Table 7: The scoring result of hedonic, difference, and organoleptic test questionnaire

		329	802	417
Hedonic test	Appearance	3.16	3.09	3.03
	Texture	3.28	3.38	3.25
	Colour	2.97	2.75	2.69
	Flavour	3.75	3.31	3.25
	Aroma	3.59	3.06	3.34
Difference test	Sweetness	3.22	3.09	2.72
	Crunchiness	3	3.09	3.19
Organoleptic test	Level of preference	3.56	3.41	3.31

Table 8: Nutrition Facts of *Spirulina* Biscuits

NUTRITION FACTS	
Serving size	2 pieces (30 g)
Serving per pack	2
Amount per serving	
Total calories	160 kkal (kcal)
Total fat	10 g
Protein	3 g
Total carbohydrate	16 g
Sodium	65 g
%RDA / %DV	
Protein	11
Calcium	2
Iron	35
Zinc	15
Magnesium	40

The Kruskal-Wallis analysis of hedonic test showed that the difference in *Spirulina* addition gives the same impressions in all parameters of biscuits ($P > 0.05$); in the other words, there is no significant difference of all biscuits in appearance, texture, colour, flavour, and aroma. The difference test showed that there is no significant difference between 329 and 802, and 329 and 417, while there is significant difference between 802 and 417. The result of simple organoleptic test showed that the level of panellist's preference of all biscuits ranges from "dislike" to "like" and there is no significant difference of preference level of three biscuits.

Based on all the analysis, we can conclude that panellists preferred biscuits 329 the most, followed by biscuits 802. In the other words, while the more *Spirulina* added, the better nutritional value the biscuits have, but according to the test, the more *Spirulina* added, the less preferred the biscuits are. However, we should note that there is no significant difference in panellists' preference of biscuits 329, 802, and 417. Therefore, the addition of 15 gr *Spirulina* (802) was chosen considering 802 is the most ideal since it meets the Recommended Dietary Allowance and also preferred.

The final *Spirulina* biscuits were sent to the laboratory for chemical content analysis. From the result, we acquired the nutrition facts for the food label (Table 8).

The packaging process was done at SEAFast Center, Bogor Agricultural Institute, using Vacuum Packing Machine at the pressure of -0.06 mpa. We chose vacuum as packaging methods because as it removes air from the pouch or plastic container, it protects the product from dehydration, barriers against dust, air, or moisture, as well as giving compressed packaging. [7] Vacuum packing gives maximum protection for the product, make the biscuit's shelf-life longer and, thus, appropriate for consumption in disaster response. The packing container used was aluminium plastic. There are four pieces of *Spirulina*

biscuits (two serving size) in one pack. Sticker label containing product information was attached on the front and back of the pack.

4. Acknowledgements

We would like to thank the Directorate General of Higher Education, Indonesian Ministry of Education for financially supporting the research of this paper. In developing the project, we also received helpful input from Dr. Ir. Diah Mulyawati Utari, M.Kes.and Department of Nutritional Science, University of Indonesia, and the team of examiners from DIKTI during the Student Creativity Program 2014.

5. References

- [1] Indonesian Ministry of Health. Nutrition Guidelines for Disaster Response. 2012, pp. 12-13. 613.2Ind p.
- [2] University of Maryland Medical Center. Spirulina. 2011, umm.edu/health/medical/altmed/supplement/Spirulina. Retrieved February 14, 2015.
- [3] The Decree of Indonesian Minister of Health No: 224/Menkes/SK/II/2007 about Technical Specification of Breastmilk Complementary Foods. Indonesian Ministry of Health, 2007.
- [4] Harinaldi. Statistical Principles for Engineering and Science. Jakarta: Erlangga, 2005.
- [5] S. Dwi, A. Apriyantono, M.P. Sari. Sensory Analysis for Industry and Agro. Bogor: IPB Press, 2010.
- [6] Hardinsyah, et al. Recommended Dietary Allowance 2013. Association of Nutrition and Food Specialist Indonesia, 2013.
- [7] National Geophysical Data Center. Packaging as it Relates to Core Storage and Preservation. *Curator meeting presentations*. 2007.