

The formulation of alternative gluten-free mung bean biscuits

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Abstract. Biscuit is a popular snack which is consumed by people of various age. Biscuit is practical and has long storability span. The formula of mung bean biscuit contains 60% of mung bean, 20% of wheat flour, and 20% cornstarch with the roasting period of 17 minutes. The biscuit has 454 kcal, 7.95% protein, and 19.75 mg of iron. In this research, we propose to change 20% of wheat flour with gluten-free rice flour. This research aims to 1) unveil the influence of formula (rice flour, cornstarch, and eggwhite) towards the sensory quality of biscuit, and 2) to show the composition of energy and protein. This research optimizes biscuit quality by changing wheat flour with rice flour and lessen the use of cornstarch and eggwhite as the binding agent with the random group plan. The ratio between rice flour and cornstarch is in the range of 15% - 22.5% from the overall flour, with the gap of 2.5%, while the eggwhite is 21g (7%) and 30g (10%). This ratio is given to 8 different formulas. We validate the quality of the biscuit by scoring it to 8 trained panellists in a 9-scaled scoring. The method of measuring energy content in the biscuit used calorimetry, while the protein used micro Kjeldahl. This research analyzes of the influence from formula to the sensory quality with variance analysis, followed by the Duncan test. The result of the sensory test of 7 formula shows the score in the range of 6.9-7.2 or the good category. However, the scoring to the other one is in the range of 5.7-6.7 in the good and moderately good category. The sensory quality of the biscuit is in yellow, with an average of 4.0 while the texture is in the very good category with an average score of 7.5. The formula does not have a difference in all sensory quality aspects, except the yellow gold colour ($p = 0.000$), with a difference in between formula 1 and formula 3 along with formula 4. The best formula from all formulas is formula 5 (TB 20, TM 20, PT10). The content of energy in the biscuit is in the range of 390 – 420 kcal, while the protein is between 9.0 – 10.7 g. From the test and measurement, the gluten-free biscuit in this proposal is a proper healthy food which follows the regulation of Indonesian National Standard.

1. Introduction

Biscuit is a baked small, sweet, and cereal product [1]. Biscuit is popular because it has high nutrition, instant, and affordable. Biscuit is very popular for kids and eaten after milk [2]. The main composition of the biscuit is wheat flour which has high energy in low quality. To improve the quality of biscuit, a food manufacturer commonly uses protein, whether it is from animals or plants. Previous researches have shown numerous innovation to a biscuit. The increase of protein can happen through the mixture of soy flour or cassava flour [3], the use of catfish flour [4], and



spirulina powder [5]. Fathonah and Muvida (2015) [6] explain that the use of 35% butter contains 453 kcal of energy (11.3%) and 13.1% of fibre. The duration of roasting for mung bean biscuit in the research is 17 minutes. The composition of the biscuit is 60% mung bean, 20% wheat flour, and 20% cornstarch [7]. The biscuit contains the 454 kcal of energy, 7.95% protein, 1.94% fibre, and 19.75mg iron [8]. The high level of protein and iron makes biscuit a healthy snack for early children, pregnant women, and anemia survivor.

Mung bean biscuit has also been publicly produced in different areas and occasion. In Bendan Ngisor, Gunungpati, the integrated healthcare centre made mung bean biscuit as a snack for early childhoods in 2 early childhood education centre around Gunungpati, Semarang [9]. In 2018, the biscuit was distributed on a bigger scale under the funding of the *Program Kemitraan Masyarakat* (Community Partnership Program) of DRPM [7]. In 2019, the production is continued under the control of Campus Intellectual Product Development Program or *Program Pengembangan Usaha Produk Intelektual Kampus*. To enhance the quality of the biscuit, there should be research regarding the formula of it. This research proposes to change the gluten-contained wheat flour with cornstarch. In Indonesia, gluten-free food is needed for people who suffer from celiac or the intolerance to ataxia gluten, dermatitis herpetiformis, wheat, and non-celiac gluten [10, 11, 12, 13]. The only way to handle a celiac problem is a strict diet of non-gluten food for life [14 15 16]. Consuming gluten for celiac sufferer will make them getting anxious and exhaustion [15]. The interest of the market to gluten-free food is increasing [17, 18, 12]. The wheat flour in the biscuit can be changed with gluten-free cereals, like corn or rice [19]. In this research, we propose the use of rice flour and eggwhite to change the wheat flour.

This research aims to optimize the quality of mung bean by increasing the content of energy and protein. The aims specify to the: 1) influence of biscuit formula to the sensory quality of mung bean biscuit, and 2) content of energy and protein in all proposed recipes.

2. Methods

This research uses applied culinary approach. This research uses biscuit with the quality sensory element. This research used a random group framework with three times of repeat.

The subject of this research is the mung bean biscuit. The study aims to produce gluten-free mung bean biscuit. The proposed composition of the receipt mainly is in the use of cornstarch, rice flour, and eggwhite. The ratio between rice flour and cornstarch is varied in the range of 15%-22.5%, with a gap of 2.5 %. Meanwhile, the use of egg white is in the ratio of 21g (7%) and 30g (10%). The complete formula can be seen in table 1.

Table 1. The composition of mung bean biscuit

Composition of Biscuit	Formula							
	1	2	3	4	5	6	7	8
Mung bean flour	180	180	180	180	180	180	180	180
Rice flour	45	45	52.5	52.5	60	60	67.5	67.5
Cornstarch	75	75	67.5	67.5	60	60	52.5	52.5
Eggwhite	21	30	21	30	21	30	21	30
Margarine	125	125	125	125	125	125	125	125
Fine granulated sugar	125	125	125	125	125	125	125	125
Milk	30	30	30	30	30	30	30	30
Baking powder	3	3	3	3	3	3	3	3

The process of biscuit manufacturing follows the following sequences. The first step is to mix margarine and sugar in around four minutes. Next, we add egg white to the mixture and mix it in

four minutes. Afterwards, we add mung bean flour, wheat flour, cornstarch, and baking powder in the mix and mix it in three minutes. The dough is included into the biscuit mould based on the desired shape. Then, we heat the mould in the oven in 17 minutes under the temperature of 150° C and the minimum temperature of 130° C. In the following step, we chill the biscuit in 15 minutes and package the biscuit in an airtight sachet.

After producing the biscuits, we analyse the sensory quality with eight trained panellists in the age range of 40–60 years old. They validated the research in a 9-scaled scoring (1 is very poor, and 9 is high quality). We follow the standard procedure of validation [20]. The considered aspects for the analysis are the colour, texture, sweetness, aroma, and overall quality. The sensory analysis was done in three times, with the space of 30 minutes. After tasting the biscuit, the panellists were asked to neutralize their tongue with water [20, 21].

Table 2. Criteria for biscuit's sensory quality

No	Values of Interval	Sensory Quality
1.	1.0 – 1.8	Very Poor
2.	1.9 – 2.7	Fairly Poor
3.	2.8 – 3.6	Poor
4.	3.7 – 4.5	Moderately Poor
5.	4.6 – 5.4	Neutral
6.	5.5 – 6.3	Fairly Good
7.	6.4 – 7.2	Good
8.	7.3 – 8.1	Very Good
9.	8.2 – 9.0	High Quality

Then, we analysed the energy with the calorimetry and the protein with micro Kjeldahl [22]. The researchers used ANOVA analysis to measure the influence of the different biscuit formula on the sensory quality of the mung bean biscuits, followed by the Duncan test [23].

3. Results and discussion

3.1. Results

Table 3. The sensory quality of gluten-free mung bean biscuits

Sensory Quality	Mung Bean Biscuits							
	formul a 1	formul a 2	formul a 3	formul a 4	formul a 5	formul a 6	formul a 7	formul a 8
Colour*	5.1	4.3	3.0	3.3	3.2	3.3	6.2	4.0
Aroma	6.5	5.9	6.0	6.1	6.1	6.0	6.2	6.1
Crunchiness	7.4	7.4	7.4	7.5	7.5	7.5	7.6	7.4
Sweetness	7.4	6.0	5.8	5.9	6.2	6.0	5.8	5.8
Mung bean flavour	6.8	6.3	6.2	6.2	6.0	6.5	6.9	6.0
Overall	7.1	7.1	6.9	7.2	7.5	7.1	7.0	7.2
Sensory quality	6.6	6.0	5.7	5.8	5.8	5.9	6.5	5.9

The sensory quality of gluten-free mung bean biscuit in the eight types of formula (see table 3) is varied in the range of 3.0 – 7.6. The low quality is in the golden yellow colour with a score of 3.0 (poor or pale yellow) to 6.2 (moderately good or in the colour of golden yellow or brownish). The sensory quality aspect is high in the element of crunchiness with a range of 7.4 – 7.6, or very good.

Overall, the best biscuit is formula 5 (20% rice flour, 20% cornstarch, and 21 g (7 %) eggwhite). Meanwhile, from all aspects, the highest score is in formula 1 (15% rice flour, 25% cornstarch, and 7% eggwhite). The result of the ANOVA test showed different sensory quality in the aspect of colour, where the good one has a golden yellow colour. The visible difference of all formulas can be seen in table 4.

Table 4. Results of Duncan Test in the Golden Yellow Color

	FRML	N	Subset for alpha = 0.05				
			1	2	3	4	5
Duncan	3	24	3.00				
	4	24	3.48	3.48			
	5	24		4.04	4.04		
	6	24		4.09	4.09		
	2	24		4.29	4.29	4.29	
	8	24			4.56	4.56	
	1	24				5.15	
	7	24					6.17
	Sig.		0.324	0.128	0.327	0.093	1.000

Based on table 4, it is known that formula 3 and 4 have the same colour. However, these groups are different with formula 1, 2, 5, 6, 7, and 8. Formula 4, 5, 6, and 2 has the same colour, but they are different from formula 8, 1, and 7. Formula 2, 8, and 1 is identical, but they are different with the formula 7. In figure 1, the yellow-coloured aspect has a distant location with the other elements, except the sweetness of formula 1, which has a relatively big gap.

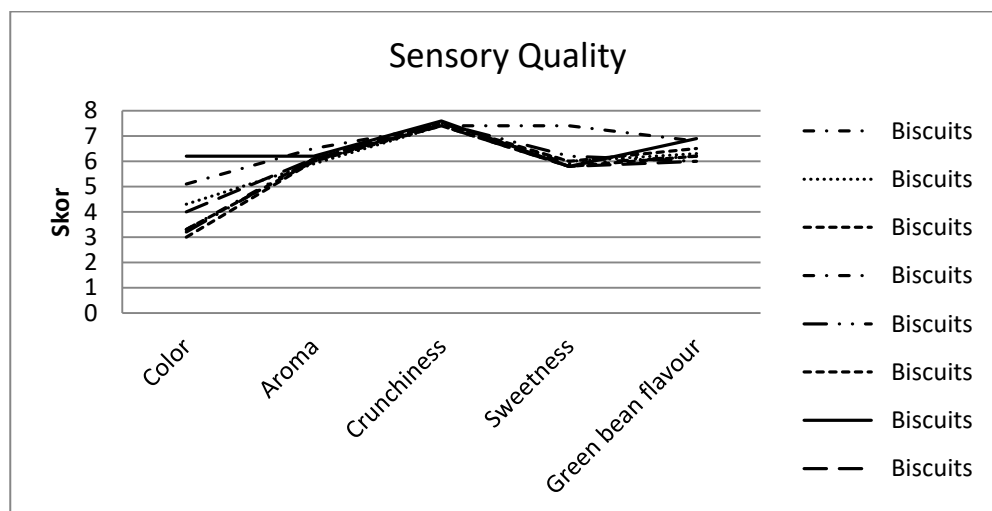


Figure 1. The sensory quality of gluten-free biscuit according to formulas

The result of the acceptance test shows a moderately higher result than the sensory quality. The acceptance rate of the biscuits is in the range of 6.5 – 7.4, in the category of favourable and very favourable. From the overall, acceptance rate, formula 3 is the most favourable one. The whole category is in the range of very favourable, and the acceptance rate is in the level of favourable.

The formulation of the gluten-free biscuit in 8 formulas does not have influential meaning. In figure 2, the difference between the formulas is visible from the colour of it. The formula 2, 4, and 6 have a pale yellow colour. Formula 1, 3, and 5 have a darker colour than formula 7 and 8.



Figure 2. The picture of 8 gluten-free mung bean biscuits formulas

The results of energy and protein test in the gluten-free mung bean biscuits showed that the energy in the biscuits is in the range of 390 – 420 kcal, while the protein is between 9.0 and 10.7g. The biscuit with most energy is in formula 1, while the most protein is in the biscuit 8. The various use of rice flour and cornstarch do not have a significant influence on the composition of energy and protein. However, the more use of eggwhite showed lower energy but higher protein. The formula of the biscuit is in line with the Indonesian National Standard of 01-2973-1992, except formula 6.

Table 5. The composition of energy and protein in the gluten-free mung bean biscuits

No.	Gluten-free mung bean biscuits	Energy (kcal)	Protein (g)
1.	Formula 1 (TB 15, TM 25, PT 7)	420	9.0
2.	Formula 2 (TB 15, TM 25, PT 10)	413	10.1
3.	Formula 3 (TB 17.5, TM 22.5, PT 7)	414	9.6
4.	Formula 4 (TB 17.5, TM 22.5, PT 10)	406	9.7
5.	Formula 5 (TB 20, TM 20, PT 7)	402	9.6
6.	Formula 6 (TB 20, TM 20, PT 10)	390	10.1
7.	Formula 7 (TB 22.5, TM 17.5, PT 7)	408	10.0
8.	Formula 8 (TB 22.5, TM 17.5, PT 10)	406	10.7
9.	Biscuits with Indonesian National Standards SNI 01-2973-1992	Min 400	Min 9.0

Notes : TB 15 = rice flour 15 %, TM 25 = cornstarch 25 %, and PT 7 = eggwhite 7 %

The composition of nutrition is portrayed in figure 3 and 4. The figures show contradicting phenomena. The energy decreases from formula 1 to 6 and an increase in formula 7 and 8. Meanwhile, the protein keeps rising from formula 1 to 8.

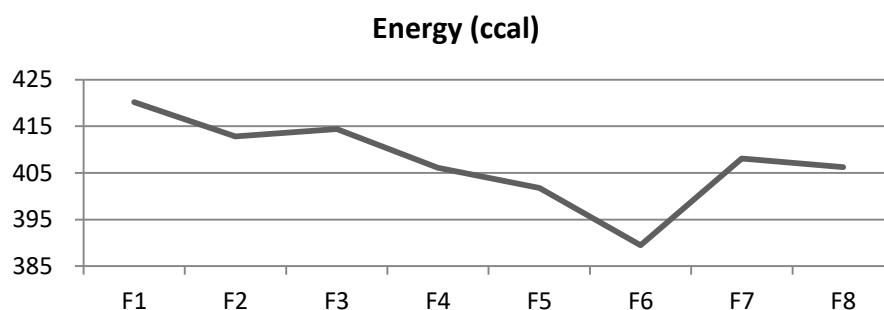


Figure 3. The graphic of energy composition

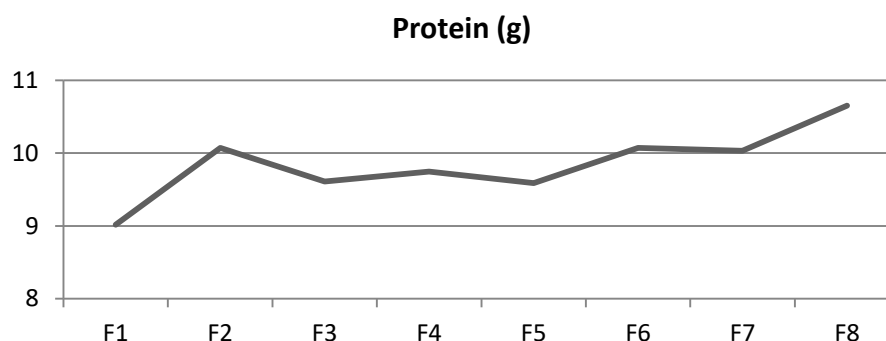


Figure 4. The graphic of protein composition

3.2. Discussion

Mung beans contain healthy nutrition for the human body, such as complex carbohydrate, high fibre, low fat, non-cholesterol, vitamins, mineral, and low sodium [24]. Mung bean flour is chosen as the main ingredients for business since it has a high level of protein [25]. Moreover, Lingga adds that mung bean contains energy, vitamin E, minerals, and acidic fat. Mung bean is a type of bean with excellent antioxidants like zinc, sulphur, Mangan, selenium, and ALA omega-3 [26]. The selenium in bean helps the people reduce anxiety, sensitivity, and depression. Mung bean is rich with niacin which allows the brain produces serotonin. Also, the mung bean has a high rate of iron which helps the control of the nervous system [27]. Besides, mung bean, rice flour, and cornstarch are non-gluten. Gluten is a protein which comes from wheat which controls gas, tolerate mixture, as well as maintain balance, extensibility, and crumb structure of a product [12]. Researches show that the interest towards gluten-free is rising [17, 18, 12]. In the same way, a biscuit is a popular food for kids and early childhood [2].

A gluten-free diet is needed for people who suffered from celiac (gluten intolerance). Those people get dermatitis herpetiformis, ataxia gluten, wheat allergy, and non-celiac gluten sensitivity [10, 11, 12, 13]. The only way to live healthily with gluten intolerance is by having a strict diet of gluten-free product for the whole life [14, 15, 16]. For these people, the consumption of gluten can increase anxiety and tiredness [15]. Research shows that the validation of immunochemistry in protein which is extracted from beans do not react to the wheat gliadin antibody. Hence, a bean is an alternative diet for people who are non-allergic and sensitive to gluten [28].

The change of wheat flour with rice flour can be done well in the creation of mung bean biscuits. The sensory quality of the biscuit is good. Moreover, the crunchiness of the biscuit is very good. The crunchiness is the central aspect which should be concerned in the biscuit. The process of biscuit roasting scan changes the sensory and texture of biscuits [29]. The fast heating can prevent biscuit from cracks, develop CO₂, and result in crunchy texture to a product [30]. The mung bean gluten-free biscuit (20% wheat flour) and gluten-free (20% rice flour) variance is received well by the consumers and can be an alternative to become a healthy snack [31].

From the sensory quality, formula 1 (15% rice flour, 25% cornstarch, and 21g eggwhite) has the best quality, yet from the overall aspects, formula 5 (20% rice flour, 20% cornstarch, and 21g (7%) eggwhite) is the best. The result shows that rice flour and cornstarch has a similar function to shape the structure of biscuits. The fraction of starch, amylose, and amylopectin in rice flour and cornstarch are in the separate order of 67.78%, 11.78%, 88.22%, 65.26%, 8.06%, and 9194% [32]. The change of wheat flour can also be done with gluten-free cereals, like corn and rice [19]. The research of gluten-free biscuits also includes red rice flour, cornstarch, potato flour, and bean flour in the percentage of 70%, 10%, 10%, 10% shows that there is a right receiving level in the sensory test (Schober et al., 2003). Rao et al. (2016) [33] observe that rough sorghum flour can produce a

cake with a lower level of hardness and acceptance. Mancebo et al. (2016) [34] report that rice can develop cookies with higher rates of spread and lower level of hardness.

The difference between biscuit formulas results in different biscuit colour. The different colour happened due to the Maillard reaction, which results in brown melanoidin. The higher number of protein and starch in the ingredients, the higher the chance for browning, which results in a brighter colour [35]. Maillard reaction produces the tone to brown with a unique aroma. The heat of the dough in high temperature and longer time will make biscuits have low moisture level and darker colour [36].

Based on figure 3 and 4, there is a contradicting phenomenon of energy and protein composition. From formula 1 to 8, the composition of the protein is increasing. The case happened due to the use of rice flour, cornstarch and egg white. Each ingredient has functions and nutritions. The visible change from the composition happens to the quality of biscuits [37, 38]. The composition of energy from rice flour, cornstarch, and eggwhite are 353, 341, and 50 kcal, and their compositions of protein are 7.0g, 0.3g, and 10.8g [39]. The physical characteristics of biscuits are strongly related to the organoleptic, physical form, texture, and crunchiness of biscuits [37]. The difference of calory between gluten-free and gluten products are 206 and 289 [40].

Gluten-free mung bean biscuits can be a healthy snack for the society which follows the National Standards of Indonesia. The product has a high level of energy, which is over 400 kcal [41], except in formula 6. The composition of energy is slightly higher than the previous research, which is 402-453 kcal for mung bean biscuits [6] and purple cassava biscuits 490-515 kcal [42]. In contrast, the composition of gluten-free protein in the mung bean biscuits (9.0–10.7), which is lower than mung bean biscuits mung bean with margarine 25–35% which is around 10.6 – 11.3 [6], and higher than purple cassava biscuits (5.8 – 6.0 g) [42] as well as corn biscuits (6.4 – 7.5 g) [7].

4. Conclusion

This research concerns with the formulation of biscuits with 60% of mung bean flour with the variation of a mixture containing rice flour and cornstarch around 15% - 22.5% and eggwhite in 7 % and 10 %. The eight formulas of mung bean biscuits do not have significant differences in sensory quality, except for the golden yellow colour ($p = 0.000$), with the difference between formula 1 and formula 3 and 4. The result of the sensory quality test to 7 formula is in the range of 6.9-7.2 in the good category, yet the scoring of each category is in the range of 5.7–6.7 or the category of moderately good and good. There is a lack of sensory quality, especially in the yellowish colour (average 4.0). The analysis also shows a very good texture of crunchiness (average score of 7.5). In the end, the researcher suggested the people do socialization to the society to produce and consume the gluten-free mung bean biscuits, especially formula 1 (highest for sensory quality) and formula 5 (best overall sensory quality). The biscuit in this research has a high level of energy, which is above 400 kcal (402–420 kcal), except formula 6 (TB 20, TM 20 and PT 10 %). Meanwhile, the biscuits have the composition of protein in the range of 9.6 – 10.7 g.

References

- [1] Rebbeca M 2016 *Encyclopedia of Food and Health: Biscuits, Cookies and Crackers: Nature of the Products*. (Oxford: Academic Press) 445-450
- [2] Rosidah S F and Sarwi 2014 *Greener J. Epid. Pub. Health* **2** 037
- [3] Akubor P I and Ukwuru M U 2003 *Plant Foods Hum. Nut.* **58** 1
- [4] Mervina, Clara M K and Sr A M 2012 *JTIP* **23(1)** 9-16
- [5] Parul S, Rakhi S, Alok J, Prasad R and Anuj K G 2015 *J. Food Sci. Tech.* **52** 1394
- [6] Siti F dan Fahriza A M 2015 *Proceeding of 1st ICRIC 2015* (Semarang, Indonesia: LP2M) 411
- [7] Siti F, Rosidah and Karsinah 2018 *JKT* **10** 12
- [8] Setyaningsih D N 2019 *My Food Res.* 779-780

- [9] Siti F, Dyah N S and Titin A 2016 *Peningkatan Ketrampilan pembuatan Biskuit Dengan Pangan Lokal Bagi Kader Posyandu Kelurahan Bendan Ngisor Semarang* Laporan Pengabdian kepada Masyarakat (Semarang: UNNES)
- [10] Sheila E C 2008 Celiac disease. In *Nutritional and Gastrointestinal Disease* (Totowa, NJ, USA: Human Press Inc) 123–147.
- [11] Maninde K, Kawiljit S S, Amitpal A and Aruna S 2015 *Food Sci.Tech.* **62** 628
- [12] Noemi F, R L, Domenico, Francesca R L, Bruno de C and Lucio C 2014 *Food Sci. Emerging Tech.*
- [13] Randi L W 2018 *Digestive Diseases and Sciences: Hypervigilance to a Gluten-Free Diet and Decreased Quality of Life in Teenagers and Adults with Celiac Disease.* Springer Science & Business Media
- [14] Tilman J S, Colm M O, Denise McC, Anja D and Elke K A 2003 *Eur. Food Res. Tech.* 216-369
- [15] Edurne S, Idoia L, Itziar C, Arrate L, María Á B, Virginia N, María del P F-G and J Miranda 2017 *Nutritional and Analytical Approaches of Gluten-Free Diet in Celiac Disease* (Springer)
- [16] Itziar C, Idoia Land Alate L 2017 *Gluten-Free Diet: Nutritional Status and Dietary Habits of Celiac Patients* Springer Briefs in Food, Health, and Nutrition (Springer) 79
- [17] Pamela C and Alessio F 2009 The increasing incidence of celiac disease and the range of gluten-free products in the marketplace. In: Gallagher E (ed) *Gluten-free food science and technology* (Oxford: Wiley Blackwell)
- [18] Andreas H, Agnes H and Thonmas B 2012 *Eur. Food Res. Technol.* **235** 195-121
- [19] Arrate L, Maria del P F, Maria Á B and Jonatan M 2017 *Nutritional and Sensorial Aspects of Gluten-Free Products.* Briefs in Food, Health, and Nutrition (Springer)
- [20] Meilgaard M, Civille G V and Thomas B 2007 *Sensory Evaluation Techniques: 2 nd ed.* CRC Press, Inc. London
- [21] Setyaningsih D, Apriyantono A dan Sari M P 2010 *Analisis Sensori untuk Industri Pangan dan Agro* (Bogor: IPB Press)
- [22] AOAC 1995 *Official Methods of Analysis Association of Official Analytical Chemists* (Washington D C)
- [23] Kadir 2015 *Statistika Terapan* (Jakarta: Raja Grafindo Persada)
- [24] Drummond K E and Brefere L S 2014 *Nutrition for Foodservice & Culinary Professionals.* 5th ed. (Canada: John Wiley & Sons)
- [25] Stauffer C E 1992 *Bakery Leavening Agents* in Y.H. Hui. *Encyclopedia of Food Science and Technology* (New York: John Wiley and Sons, Inc.)
- [26] Lanny L 2011 *The Healing Power of Antioxidant* (Jakarta: Gramedia)
- [27] Wied H A 2007 *Good Mood Food* (Jakarta: Gramedia Pustaka Utama)
- [28] Vasundhra, Barath K S, Vijaykrishnaraj M., and Prabhasankar P 2018 *J. Food Measur. Characterization* **12** 94-100
- [29] Karen E D and Lisa S B 2014 *Nutrition for Foodservice & Culinary Professionals* 5th ed (Canada: John Wiley & Sons)
- [30] Gary S T 2008 *Food Deterioration and Preservation* (Australia: Blackwell Publishing Profesional)
- [31] Siti, F, Rosidah, Octavianti P and Karsinah 2019 *Biskuit kacang hijau renfah gliten dan bebas gluten tinggi energi dan zat besi sebagai penganekaragaman jajanan sehat* (Yogyakarta : FTP UGM)
- [32] Nelis I 2012 *J. Nut. Food Res.* **35(1)** 13-22
- [33] Rao B D, Anis M, Kalpana K, Sunooj K V, Patil J V and Ganesh T 2016 *LWT- Food Sci. Tech.* **67** 8–13
- [34] Mancebo C M, Rodriguez P and Gómez M 2016 *LWT- Food Sci. Tech.* **67** 127–132
- [35] Engganeyski J C and Simon B W 2016 *JPA* **4** 391

- [36] Duncan M 2000 Technology of Biscuits, Crackers and Cookies Third Edition (England: Woodhead Publishing Limited)
- [37] Wenzhao L 2013 *J. Food Sci. Tech.* **5(6)** 682-687
- [38] Galyna D, Andrii P and Anna G 2014 *Ukr. Food J.* **3** 249
- [39] Direktorat Gizi Masyarakat. 2017. Tabel Komposisi Pangan Indonesia. Jakarta: Direktorat Gizi Masyarakat.
- [40] Miranda J, Lasa A, Bustamante M A, Churrua I, and Simon E 2014 *Plant Foods Hum. Nut.* **69(2)** 182 – 187
- [41] Made A 2009 Panduan Karbohidrat Terlengkap (Jakarta : Dian Rakyat)
- [42] Fathonah S and F Sari 2015 *ICGT* 28-32