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The effect of different types and concentrations of hydrocolloids towards non-gluten sponge cake's chemical quality and organoleptic

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ABSTRACT

The number of people with autism and celiac disease keeps increasing. One of the efforts to assist the healing process naturally is through food consumption that is healthy, safe, and not carelessly, such as providing non-gluten food. The most favoured non-gluten product alternatives are the sponge cake. To produce a soft and elastic non-gluten sponge cake, then hydrocolloid is required. On the other side, the types and amounts of hydrocolloid are varied, depending on the product's types and ingredients.
This research aims to determine the correct type and concentration of hydrocolloid (xanthan gum and guar gum) towards chemical quality and organoleptic of the non-gluten sponge cake from the best cowpea. This research would also help fulfil food availability and diversity for the increasing number of people with autism and celiac disease, reduce the consumption of wheat flour as the gluten source that is now still imported, and utilise and increase consumption of cowpea locally-sourced food.
This research employs Randomised Block Design method consists of two factors: hydrocolloid type factor, which consists of two levels (xanthan gum and guar gum) and hydrocolloid concentration type factor, which consists of three levels (1 gr, 2 gr, and 3 gr). The chemical test parameters involve protein, water, and ash content. The organoleptic test parameters involve colour, aroma, flavour, and texture.
This research resulted in the best treatment of the cowpea sponge cake is at the usage of xanthan gum type on the 2 grams concentration (HIK2) with the highest Result Value of 0.78, with research criteria scores as follows: flavour = 5.7 (like); texture = 5.6 (like); water content = 9.535%; protein content = 4.354%; colour = 5.4 (rather like); and ash content = 1.622%.

Keywords: sponge cake; non-gluten; cowpea; hydrocolloid; autism

INTRODUCTION

In 2012, CDC showed that 1 out of 88 children in the United States are with autism. In 2014, it increased 30% to 1 out of 68. In Indonesia, there are no detailed data. However, based on Incidence dan Prevalence ASD (*Autism Spectrum Disorder*), there are two new cases per 1,000 people per year and ten cases per 1,000 people. Considering the Indonesian population is 237.5 million people with 1.14% population growth, it is estimated that 2.4 million Indonesians are with ASD, with new people with ASD as many as 500 people per year (RI, 2018). One of the efforts to assist the healing process naturally is through food consumption that is healthy, safe, and not carelessly, such as providing non-gluten food. The types of food mentioned are food that contains folic acid, omega-3 fat, pre-biotic, pro-biotic, non-casein protein, carbohydrate, and gluten-free (Lesmana, 2019).

Besides, some people cannot consume gluten for several reasons, such as celiac disease, a genetic disease in which a person cannot tolerate gluten (Uche-Anya et al., 2021). This disease changes the small intestine and causes nutrition absorption disturbance, which leads to several malfunctions in the body (Banjar et al., 2021). Therefore, innovation is needed to produce non-gluten food such as non-gluten sponge cake.

Sponge cake is one of the products expected to have a fluffy and smooth texture when eaten. Sponge cake is one of the bakery products made out of dough of flour, sugar, eggs, fat, and leavening agent baked in an oven (Hartati, 2016). Flour usually used in the making is wheat flour (Reza Rizkia Ningsih, Fadjar Kurnia Hartati, 2020), because it consists of gluten that produces a dough that able to contain gas and elastically expand when the gas evaporates during the baking process and its characteristics that are hydrated and expand when the flour is mixed with water (Li, Qu, Feng, & Chen, 2020). Until now, wheat flour as a gluten source is

still an imported commodity. Even Indonesia is one of the world's largest wheat importers (APTINDO, 2014).

Based on the issues above, this research aims to produce a non-gluten sponge cake for food availability for people with autism and celiac disease and reduce wheat flour consumption so it can decrease dependency on wheat. The ingredient's replacement will utilise the local commodities that are easy to get, inexpensive, and contains high nutritional content. One of the alternatives is the cowpeas. Cowpea is one of the nuts that become a plant-based protein source. This nut even contains the second-highest protein content after soybeans (Ismayanti & Harijono, 2015). Safitri, Ningsih, Ismail, & Waluyo (2016) said that cowpea contains much nutritional content. One hundred grams of cowpea even contains 24.4 grams of protein, 56.6 grams of carbohydrate, 1.9 grams of fat, 481 mg of calcium, 399 mg of phosphor, and 2.68 grams of phytic acid. Cowpea also has other benefits, such as having low-fat content, to minimise the negative effect of the use of fatty food products (Hargo Saputro, Andriani, & Siswanti, 2015).

However, cowpea does not contain gluten (Lestari, Yusasrini, & Wiadnyani, 2019), so hydrocolloid needs to be added as a replacement for gluten in the making of sponge cake. Hydrocolloids often used in the making of non-gluten cakes are such as HPMC (Hydroxypropyl methylcellulose), CMC (Carboxyl Methyl Cellulose), guar gum, xanthan gum, locust bean gum, Carrageenans, and Konjac Glucomannan (Naghavi, Dehghannya, & Ghanbarzadeh, 2018). Dewi (2017) explained that bread made from the mix of sweet potato and sago starch with the proportion of 80% sweet potato flour and 20% sago starch, with an addition of 0.5-3% xanthan gum, gives significant influence towards flour's and product's characteristics. Higher xantham gum content can increase inflating capabilities, peak viscosity, final viscosity, and gelatinisation time and temperature from the composite flour. The increased concentration of xanthan gum also can increase bread's fluffiness, rising ratio, and specific volume. Sasaki (2018) stated that bread made from the mix of rice flour and wheat flour with the addition of xanthan gum and guar gum on the 0.5%, 1%, and 2% concentration shows insignificant difference towards water content, but significant difference towards bread's volume.

Based on the findings above, research is required to determine the right type and concentration of hydrocolloid towards chemical quality and organoleptic of sponge cake made from cowpea/best non-gluten sponge cake.

METHODS

Ingredients and Tools

The main ingredients used in the making of gluten-free sponge cake are Orlife brand guar gum and Angeltata brand xanthan gum. The secondary ingredients are Palmboon brand margarine, Gulaku brand sugar, Koepoe-koepoe brand baking powder, Toffieco brand vanilla, and eggs. Materials used for chemical analysis are 0.32 N of H_2SO_4, 1.25 N of NaOH, and Ethanol 95%.

Tools used in making gluten-free sponge cake are scales, washbasin, spoon, mixen, electric oven, baking paper, cake pan, tissue, and scissors. Tools used for the chemical analysis are oven, porcelain cup, desiccator, cup tongs, analytical balance, Erlenmeyer flask, autoclave, filter paper, soxhlet extraction, fat flask, and kiln.

Research Design

This research employs Randomised Block Design, which stacked in a factorial way and consists of two factors: Factor 1: hydrocolloid type (H), consists of two levels: H1 (guar gum) and H2 (xanthan gum), and Factor 2: hydrocolloid concentration (K), consists of three levels: K1 = 1 gr, K2 = 2 gr, and K3 = 3 gr. Each treatment of combination is repeated three times (Hanafiah, 2014; Nugroho, 2008).

Research Procedures

This research consists of two stages: research on the making of cowpea flour (Figure 1) and non-gluten sponge cake (Figure 2).

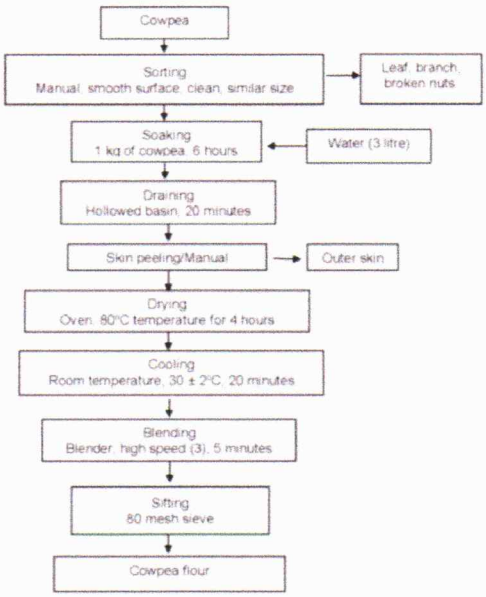

Figure 1. Flowchart of cowpea flour making (Ferdiansyah, 2015)

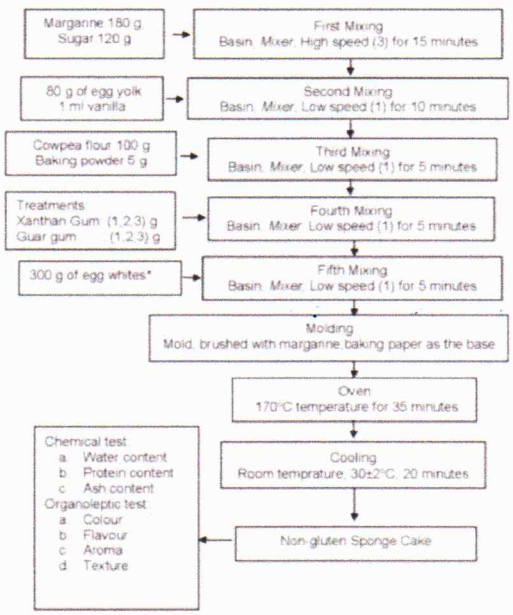

Figure 2. Flowchart of the Non-gluten sponge cake making (Imami & Sutrisno, 2018)

Observation Parameters

Parameters observed in this research encompasses chemical and organoleptic test. Chemical test parameters observe the determination of protein content using the Biuret method and water and ash content using the Gravimetric method (AOAC, 2016).Organoleptic test parameters use the Hedonic test, which involves flavour, aroma, and colour. This Hedonic test employs at least 25 panellists using the likeability scale as follows: 1 = really dislike, 2 = dislike, 3 = rather dislike, 4 = neutral, 5 = rather like, 6 = like, 7 = really like (Diwangkari, Rahmawati, & Safitri, 2016; Murekezi, Oparinde, & Birol, 2017).

Data Analysis

Parametric data of protein, water, and ash contents are analysed using Analysis of Variance (ANOVA). If the result shows a significant difference ($p < 0.05$), a further Fisher's LSD Test/Tukey's HSD Test/Duncan Test is subjected on the confidence level of $\alpha = 5\%$, depends on the Correlation Coeffience (KK) value. If KK is under 5% under the Fisher's LSD Test, between 5-10% under the Tukey's HSD Test, and above 10% under the Duncan Test (Diwangkari et al., 2016).

The non-parametric data is the organoleptic score that encompasses flavour, aroma, and colour analysed using hedonic/likeability average and later continued to Kruskal Wallis Test to determine the difference between treatments (Junaidi, 2015). The determination of the best treatment from all research parameters is conducted through Effectivity Test (De Garmo, E. D, 1998).

RESULT AND DISCUSSIONS

1. *Chemical Test*
   a. *Protein content*

ANOVA test result on the protein content of the non-gluten sponge cake shows that the different types of hydrocolloid have no significant difference towards the protein content in the sponge cake, the different concentration of the hydrocolloid has no significant difference towards the protein content, and interaction between types and concentration of different hydrocolloid also has no significant difference towards the protein content of the sponge cake. The average protein content in the non-gluten sponge cake is explained in Table 1.

Table 1. The difference of average protein content in the non-gluten sponge cake

Treatment Code	Hydrocolloid Concentration	Protein Content Average (%)
H1K1	1 gram	4,094[a]
H1K2	2 gram	4,354[a]
H1K3	3 gram	4,259[a]
H2K1	1 gram	4,215[a]
H2K2	2 gram	4,548[a]
H2K3	3 gram	4,488[a]
	KK = 5 % (Duncan)	

Note : Letters behind the number that has the same notation with the average shows no difference on the 5% Duncan Test

Table 1 above shows that the types of hydrocolloid, different hydrocolloid concentrations, and interaction between hydrocolloid types and concentrations have no significance in the protein content of the non-gluten sponge cake. Hydrocolloid itself is not a protein source but a polysaccharide functions as a thickener and gel former (Widyaningtyas & Susanto, 2015).

The H2K2 treatment has the highest protein content of 4.548%, and the H1K1 treatment has the lowest protein content of 4.094. The result is due to the protein content from the used ingredients (cowpea and eggs), so the sponge cake has a high protein content. The protein content of the cowpea itself is 22.3% (I.I. Khalid, 2012). Cornelia, Suada, & Rudyanto (2014) stated that the protein content of fresh eggs is between 12.8% - 13.4%. Egg protein decreased

with the length of storage time, which reached 9.85% - 10.4% after 28 days of storage (Lestari et al., 2019). Eggs stored in a cooler will decrease egg's quality but not as significant as storing at room temperature (Almeida, Schneider, Yuri, Machado, & Gewehr, 2015).The conclusion is that the difference in egg's storage place and duration can influence its protein content inside. Therefore, protein content on each treatment is caused by the different protein content on each egg.

b. Water content

ANOVA test result on the water content of the non-gluten sponge cake shows that the different types of hydrocolloid have highly significant difference towards the protein content in the sponge cake, the different concentration of the hydrocolloid also has highly significant difference towards the protein content, and interaction between types and concentration of different hydrocolloid has significant difference towards the protein content of the sponge cake. The average water content in the non-gluten sponge cake is explained in Table 2.

Table 2: The difference of average water content in the non-gluten sponge cake

Treatment Code	Hydrocolloid Concentration	Water Content Average (%)
H1K1	1 gram	11,206^{c}
H1K2	2 grams	9,535^{b}
H1K3	3 grams	8,260^{a}
H2K1	1 gram	13,535^{d}
H2K2	2 grams	11,342^{c}
H2K3	3 grams	9,236^{ab}
	KK = 5 % (Duncan)	

Note : Letters behind the number that has the same notation with the average shows no difference on the 5% Duncan Test

Table 2 above shows that the types of hydrocolloid and different hydrocolloid concentrations influences the water content of the non-gluten sponge cake, so it shows difference influence between the treatment. It is seen on the H2K1 treatment (1-gram concentration of guar gum), which has the highest water content of 13.353%, and this show different outcomes compared to the H1K3 treatment (3 grams concentration of xanthan gum), which resulted in 8,260%. Less added hydrocolloid leads to higher water content. In contrast, with more hydrocolloids added, the sponge cake will have lower water content.

c. Ash Content

ANOVA test result on the ash content of the non-gluten sponge cake shows that the different types of hydrocolloid have significant difference towards the ash content in the sponge cake, the different concentration of the hydrocolloid also has significant difference towards the ash content, and interaction between types and concentration of different hydrocolloid has significant difference towards the ash content of the sponge cake. The average ash content in the non-gluten sponge cake is explained in Table 3.

Ash content means the amount of organic matter that is ashed during the ashing process. The amount of ashed content will determine the ash content's amount. Less ashed matter means a lower ash content value. In opposite, more matter being ashed means higher ash content resulted. The H1K1 treatment (1 gram of xanthan gum) showed the highest ash content (1.753%). It is different from the H2K3 treatment (3 grams of guar gum), resulting in the lowest ash content (1.581%). Cornelia et al., (2014) explains that ash content is the remain of organic matter that still retained during the ashing process, and the content amount depends on how much organic matter is contained in the ingredients.

Table 3: The difference of average water content in the non-gluten sponge cake on the different hydrocolloid concentration

Treatment Code	Hydrocolloid Concentration	Average Ash Content (%)
H1K1	1 gram	1,753[b]
H1K2	2 gram	1,622[a]
H1K3	3 gram	1,610[a]
H2K1	1 gram	1,614[a]
H2K2	2 gram	1,634[a]
H2K3	3 gram	1,581[a]
KK = 5 % (Duncan)		

Note : Letters behind the number that has the same notation with the average shows no difference on the 5% Duncan Test

2. Organoleptic test

a. Colour

The average score of likeability towards the non-gluten sponge cake colour shows that the different hydrocolloid concentration gives a score of 5.1-5.4 on the likeability score. This means the panellists rather liked the colour of the sponge cake. The scoring average of the non-gluten sponge cake is illustrated in Table 4.

Table 4. Average score of colour aspect of the non-gluten sponge cake

Treatment Code	Treatment	Colour Average
H1K1	Xanthan Gum with 1-gram concentration	5,1
H1K2	Xanthan Gum with 2 grams concentration Xanthan	5,4
H1K3	Gum with 3 grams concentration	5,5
H2K1	Guar Gum with 1-gram concentration	5,1
H2K2	Guar Gum with 2 grams concentration	5,2
H2K3	Guar Gum with 3 grams concentration	5,3

The non-gluten sponge cake colour, either from xanthan gum or guar gum hydrocolloid, has a relatively similar colour, brownish-yellow. However, 3 grams of concentration has a higher colour score than the 1-gram concentration. This score difference is due to different hydrocolloid concentrations that can influence non-gluten sponge cake colour. A higher concentration will result in a yellow-brownish/light brown colour. The colour scored the highest (5.5), which means rather liked by the panellists. In contrast, lower hydrocolloid concentration resulted in brown non-gluten sponge cake and has a score of 5.1. Based the analysis result of Kruskal Wallis test towards the non-gluten sponge cake colour, it is known that there is a significant difference from all forms of treatments ($p = 0,043 > \alpha = 0,05$), which means different types and concentration of the hydrocolloid shows highly significant difference towards the panellists' acceptance towards the non-gluten sponge cake colour.

b. Flavour

The average score of likeability towards the non-gluten sponge cake flavour shows that the different hydrocolloid concentration gives a score of 5.0-5.7 on the likeability score. This means the panellists rather liked and liked the flavour of the sponge cake. The scoring average of the non-gluten sponge cake flavour is illustrated in Table 5.

Table 5. Average score of flavour aspect of the non-gluten sponge cake

Treatment Code	Treatment	Flavour Average
H1K1	Xanthan Gum with 1-gram concentration	5,2
H1K2	Xanthan Gum with 2 grams concentration Xanthan	5,7
H1K3	Gum with 3 grams concentration	5,1
H2K1	Guar Gum with 1-gram concentration	5,1
H2K2	Guar Gum with 2 grams concentration	5,4
H2K3	Guar Gum with 3 grams concentration	5,0

Two grams concentration of xanthan gum hydrocolloid gives the higher flavour score compared to 3 grams of guar gum hydrocolloid. The score shows that the more balanced types and concentrations lead to a tastier non-gluten sponge cake flavour. Based on the analysis result of the Kruskal Wallis test towards the non-gluten sponge cake flavour (as shown in Appendix 12), it is known that there is a significant difference from all forms of treatments ($p = 0,008 > \alpha = 0,05$), which means different types and concentration of the hydrocolloid shows significant difference towards the panellists' acceptance towards the non-gluten sponge cake flavour.

c. Aroma

The average score of likeability towards the non-gluten sponge cake aroma shows that the different hydrocolloid concentration gives a score of 5.0-5.7 on the likeability score. This means the panellists rather liked and liked the flavour of the sponge cake. The scoring average of the non-gluten sponge cake aroma is illustrated in Table 6.

Table 6. Average score of aroma aspect of the non-gluten sponge cake

Treatment Code	Treatment	Aroma Average
H1K1	Xanthan Gum with 1-gram concentration	5,3
H1K2	Xanthan Gum with 2 grams concentration Xanthan	5,5
H1K3	Gum with 3 grams concentration	5,7
H2K1	Guar Gum with 1-gram concentration	5,0
H2K2	Guar Gum with 2 grams concentration	5,1
H2K3	Guar Gum with 3 grams concentration	5,2

Three grams concentration of xanthan gum hydrocolloid gives a higher aroma score compared to 1 gram of guar gum hydrocolloid. The difference shown is that the 3 grams of xanthan gum can influence the non-gluten sponge cake aroma, so this treatment is the most liked by panellists (scored 5.7, categorised as "like") its more distinctive aroma. In opposite, 1 gram of guar gum resulted in a weaker aroma and scored as rather liked by the panellists (scored 5.0). Besides, the aroma of any foodstuff always merges with flavour to shape the distinctive flavour of the food. Food with a high taste also delivers a high aroma.

Based on the analysis result of the Kruskal Wallis test towards the non-gluten sponge cake aroma, it is known that there is no significant difference from all forms of treatments ($p = 0,018 < \alpha = 0,05$), which means different types and concentration of the hydrocolloid shows significant difference towards the panellists' acceptance towards the non-gluten sponge cake aroma.

d. Texture

The average score of likeability towards the non-gluten sponge cake texture shows that the different types and concentrations of the hydrocolloid give a score between 5.0-5.6 on the likeability score. This means the panellists rather liked and liked the texture of the sponge cake. The scoring average of the non-gluten sponge cake texture is illustrated in Table 7.

Table 7. Average score of texture aspect of the non-gluten sponge cake

Treatment Code	Treatment	Fluffiness Average
H1K1	Xanthan Gum with 1-gram concentration	5,4
H1K2	Xanthan Gum with 2 grams concentration	5,6
H1K3	Xanthan Gum with 3 grams concentration	5,0
H2K1	Guar Gum with 1-gram concentration	5,2
H2K2	Guar Gum with 2 grams concentration	5,3
H2K3	Guar Gum with 3 grams concentration	5,0

Table 7 above shows two grams concentration of xanthan gum hydrocolloid gives a high texture score of 5.6, which means liked by the panellists. Meanwhile, three grams concentration of both xanthan and guar gum shows a low score of 5.0, which means rather liked by the panellists. The score shows that the more balanced types and concentrations lead to more balanced water content. Conversely, a low concentration of hydrocolloid leads to higher water content in non-gluten sponge cake, and high hydrocolloid concentration leads to much less water content in non-gluten sponge cake, making it less perfect. As information, non-gluten sponge cake contains 8.2% - 13.535% water, so the water content influences the final texture.

Based on the analysis result of the Kruskal Wallis test towards the non-gluten sponge cake texture, it is known that there is no significant difference from all forms of treatments ($p = 1,07 > \alpha = 0,05$), which means different types and concentrations of the hydrocolloid shows significant difference towards the panellists' acceptance towards the non-gluten sponge cake texture.

3. Effectivity Test

Effectivity Test is conducted to determine which are the best/liked treatment. Based on the effectivity test towards all test parameters encompassing chemical and organoleptic tests, H1K2 treatment, which contains 2 grams of xanthan gum, is the best treatment with the highest Result Value (NH). NH of the Effectivity Test for all treatments is illustrated in Table 8.

Table 8. Result Value (NH) of the effectivity test of non-gluten sponge cake

Parameters	Result Value (NH) of the concentration					
	H1K1	H1K2	H1K3	H2K1	H2K2	H2K3
Flavour	0,04	0,16	0,02	0,02	0,09	0
Texture	0,10	0,16	0	0,05	0,08	0
Water content	0,07	0,12	0,16	0	0,06	0,12
Protein content	0	0,07	0,05	0,03	0,14	0,12
Colour	0	0,10	0,14	0	0,03	0,07
Aroma	0,05	0,08	0,12	0	0,01	0,03
Ash content	0	0,09	0,09	0,09	0,08	0,12
Total	0,26	0,78*	0,58	0,19	0,49	0,46

Note : * Best treatment

Table 8 indicates that H1K2 treatment with 2 grams concentration of xanthan gum is the best treatment with the highest Result Value (NH) of 0.78 with research criteria scores as follows: flavour = 5.7 (like); texture = 5.6 (like); water content = 9.535%; protein content = 4.354%; colour = 5.4 (rather like); and ash content = 1.622%.

Conclusions

The fluffy and elastic non-gluten sponge cake can be made from cowpea flour with the addition of a hydrocolloid. The research result shows that the right hydrocolloid type to make the cowpea flour-based sponge cake is the xanthan gum with two grams of concentration.

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