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The Characteristics of *Kerupuk Gembus*

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Abstract. *Kerupuk gembus* or soy pulp crackers is an innovated snack product made from tapioca flour combined with *gembus*, solid waste of tofu production. *Gembus* contains high fiber and protein useful for enhance the fiber and protein content of foods. The aim of the experiment was to determine the suitable composition of *kerupuk gembus* and the use of additives in the *kerupuk* production. Formulation used were modified on the *gembus* ratio and the additives use. In the physical characteristics of *kerupuk gembus*, it showed significant difference in hardness and swelling ability between all formulations. The proximate results showed that *kerupuk gembus* contains high fiber ranged between 38.1 to 67.4%. From the sensory evaluation and triangle test, it showed that the *kerupuk gembus* quite liked by the panelists were *kerupuk* with *gembus* and tapioca flour 1:1 ratio with Sodium Tripolyphosphate (STPP) 0.5%w (A1), *kerupuk* with *gembus* and tapioca flour 1:1 ratio without any additives (A3), and *kerupuk* with *gembus* and tapioca flour 2:1 ratio without any additives (B3). Author suggested the best formulation for consumption was *kerupuk* with *gembus* and tapioca flour 2:1 ratio without any additives.

Keywords: *kerupuk gembus*, soy pulp cracker, high fiber snack

1. Introduction

There are 84,000 unit of tofu industry in Indonesia with the production capacity 2.56 million ton/years, which is 80% of them located in the Java Island[1]. They use soy bean as their main ingredients and release about 20 million m³/year of liquid waste and 1,024 million tons of solid waste[2]. The solid waste of tofu production (known as soy pulp, *gembus*, okara) were about 40% of the total capacity of 100 kg soybean[3]. Tofu waste still contains high nutrient values, however, most of its organoleptic properties are less preferred [4,5]. It contains about 20.93% protein, 21.43 fiber, 20.31 crude fat, 0.72% calcium, 0.55% phosphor and 36.69% other compounds[6].

Gembus is a solid waste of tofu production. It is used as the ingredients of tempe *gembus* (fermented soybean cake), stock feeds and fertilizer or just dumped in the landfill. Previous work indicates that *gembus* were shown having proteolytic, fibrinolytic, antioxidant and antimicrobial activities may provide a significant opportunity for health [7,8,9,10,11]. In Randudongkal, the dumped *gembus* polluting the environment because of its smells, and bothers the community. This condition has to be changed so it



could be beneficial for all. The authors proposed to make use of *gembus* as the additional ingredients in the *kerupuk* production, so it will be utilized effectively[12].

Kerupuk, Indonesian crackers, is a food which is widely consumed by Indonesian people. It is popular in South-East Asian countries, it is called “*kaogrieb*” in Thailand, “*keropok*” in Malaysia, and “*bánh phồng tôm*” in Vietnam[13]. It usually consumed as snacks or together with main course. *Kerupuk* composed by tapioca flour, garlic, salt, and pepper. There are also *kerupuk* combined with fish fillets or prawn to enhance the flavor[14]. Improving nutritional value of *kerupuk* is needed to make *kerupuk* as a healthy snack.

Based on many research about *gembus* composition, it is recommended to use *gembus* as ingredient in biscuits and snack to increase the dietary fiber and reduce the calorie intake[14]. It could be used as dietary supplement to prevent diabetes, obesity, hyperlipidemia and cardiovascular diseases [15,17,18,19]. Soy food products also has low cost in production, so it is suitable for ingredients in *kerupuk* production[5,19]. This research purposes were to analyze the nutritional composition of *kerupuk gembus* and determine the acceptable composition of the *kerupuk* for general consumption.

2. Material and Methods

2.1. Raw Material

Gembus was obtained from soy milk production waste product. Soy bean was soaked in water for 4-6 hours at ambient temperature so the husk were peeled off. It was boiled for 45 minutes until the soy beans are tender and all of the remaining husk exfoliated. The soy bean separated and grinded in blender with water (1,200 ml per 100 g soybean). The soy milk was filtered and the resulting *gembus* was ready for the *kerupuk* ingredient.

2.2. Kerupuk Preparation

For *kerupuk* production, the *gembus* was mixed with tapioca flour (extracted of cassava root), salt, pepper, garlic, and dried shrimp. Six formulation were developed: *kerupuk* with *gembus* and tapioca flour 1:1 ratio with Sodium Tripolyphosphate (STPP) 0.5%w (A1), *kerupuk* with *gembus* and tapioca flour 1:1 ratio with baking soda (Sodium Bicarbonate, NaHCO₃) 0.5%w (A2), *kerupuk* with *gembus* and tapioca flour 1:1 ratio without any additives (A3), *kerupuk* with *gembus* and tapioca flour 2:1 ratio with Sodium Tripolyphosphate (STPP) 0.5%w (B1), *kerupuk* with *gembus* and tapioca flour 2:1 ratio with baking soda (Sodium Bicarbonate, NaHCO₃) 0.5%w (B2), and *kerupuk* with *gembus* and tapioca flour 2:1 ratio without any additives (B3).

The ingredients were kneaded, shaped into cylindrical shape, and wrapped using banana leaves. It was steamed at 100°C for 45 min to 1 h and dried at the room temperature. The cylinders were sliced using knife manually into 2-3 mm thickness and dried under the sun until became hard raw *kerupuk*. The raw *kerupuk* were fried in hot cooking oil for 15-30 s.

2.3. Physical Characteristics

2.3.1. Texture Analysis

The textural characteristics of *kerupuk gembus* analyzed were the hardness, determined using Texture Profile Analysis method (TPA). Test performed on a Brookfield CT3 Texture Analyzer[20].

2.3.2. Swelling Analysis

The swelling ability were measured using *kerupuk* surface area before and after frying process. It was measured with millimeter blocks paper using five different samples and the average was calculated for each group. In order to determine the swelling ability, the surface area was calculated using following equation :

$$\text{Swelling ability} = \frac{\text{surface area after frying}}{\text{surface area before frying}} \times 100\%$$

2.4. Proximate Composition

The proximate test was done at Integrated Laboratory for Food Technology in Diponegoro University. Bradford methods of analysis were used to determine protein content, analyzing methods from SNI 01-2891-1992 were used to determine the water, fiber, and fat content[21]. The total carbohydrate content obtained were using *by different* analysis.

2.5. Sensory Evaluation

The organoleptic test was held in campus laboratory after lunch break. Panelist were the same for triangle test and hedonic test. They were 30 semi-trained panelists who did not have any oral disease that would impair taste on the day of the experiment (flu, cold, etc).

Prior to the testing, each *kerupuk* sample was individually sealed in a pouch and coded with a three-digit number. Drinking water was provided for mouth rinsing between samples.

2.5.1. Triangle test

Triangle test was used to determine the difference between the additives added group and without additives. The panelists were asked to choose the most different samples according to color, flavor, texture, and taste parameter.

2.5.2. Hedonic test

Hedonic test was used to determine the most panelists liked formulation for the *kerupuk gembus* according to color, flavor, texture, and taste parameter. Panelists were evaluate the parameters using 5-point hedonic scale (1=like, 5=dislike). The results were categorized into ≤ 1.5 liked, 1.6-2.5 quite liked, 2.6-3.5 neutral, 3.6-4.5 quite disliked, and ≥ 4.5 disliked.

2.6. Statistical Analysis

Result are presented using means and standard deviation of analysis performed in duplicate. One way anova and continued by post hoc test were used to determine the significance of difference within each samples physical characteristics at $p < 0.05$. The hedonic tests were analyzed using Friedman test.

3. Results and Discussion

3.1. Physical Characteristics

Physical character of the *kerupuk gembus* were determined using the hardness and swelling ability of the *kerupuk*.

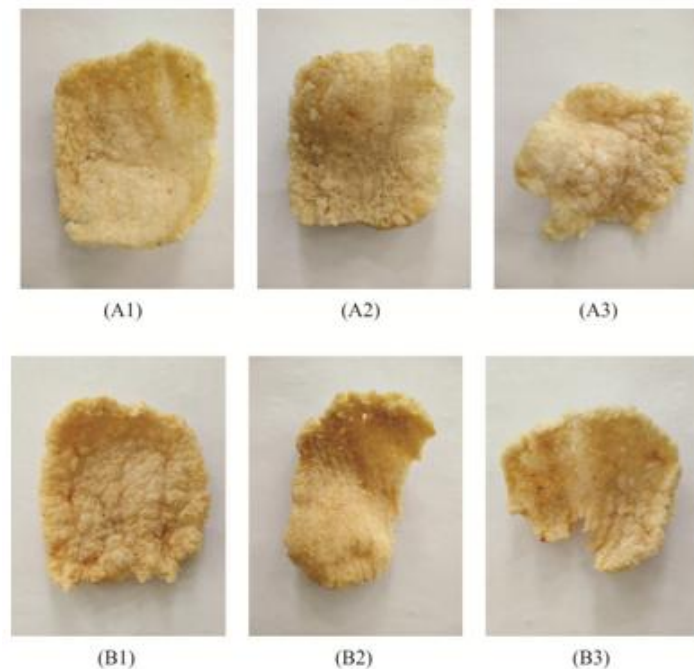


Figure 1. Photograph of *kerupuk gembus* with different formulation. A1, A2, A3 for 1:1 *gembus* and tapioca flour ratio. B1, B2, B3 for 2:1 *gembus* and tapioca flour ratio.

3.1.1. Hardness characteristics

Texture analysis were determined the hardness of each samples. Table 1 shows that there was significant difference in hardness of the *kerupuk gembus* ($p < 0.05$). A2 *kerupuk* was the hardest *kerupuk* followed by B1 and A3. Harder the *kerupuk* the greater force needed to deform it.

Table 1. Hardness characteristics of *kerupuk gembus*

<i>Kerupuk gembus</i>	Force (N)			<i>p</i>
	Min	Max	Mean \pm SD	
A1	13.57	29.38	18.88 \pm 9.09 ^{ab}	0.017
A2	25.78	33.18	29.82 \pm 3.74 ^c	
A3	22.96	31.86	27.46 \pm 4.45 ^{bc}	
B1	24.25	33.04	28.47 \pm 4.40 ^{bc}	
B2	11.80	19.55	15.88 \pm 3.89 ^a	
B3	15.21	21.05	17.43 \pm 3.16 ^a	

Different letter within the same column differ significantly from each other ($p < 0.05$)

Research conducted by Resiandini, showed that *kerupuk* with higher proportion in tapioca flour will increase the crispness/hardness of the *kerupuk*. It is because of the amylopectin content of the tapioca flour[22]. Result of this research on hardness test were not correspond with the Resiandini research. The data does not different between 1:1 ratio (group A) and 2:1 ratio (group B).

Other than that, the thickness of the sliced *kerupuk* also affect the hardness[23]. The silindrycal shape of *kerupuk* (after steamed) should be hard and solid in order to ease the slicing process so the thickness will be uniformed (2-3 mm). The uniform thickness of raw *kerupuk* will improve the crispness of the *kerupuk* after frying[24].

3.1.2. Swelling ability

Table 2 showed that there was significant difference in swelling ability of *kerupuk gembus* ($p < 0.05$). A3 has the biggest swelling, followed by B3, B2, and A2.

Table 2. Swelling ability of *kerupuk gembus*

<i>Kerupuk gembus</i>	Min	Max	Mean \pm SD	<i>p</i>
	%	%	%	
A1	71.80	115.60	84.90 \pm 17.90 ^{ab}	.001
A2	92.80	139.40	114.74 \pm 17.93 ^{bc}	
A3	111.90	181.30	131.12 \pm 28.97 ^c	
B1	56.00	113.50	75.78 \pm 22.48 ^a	
B2	101.80	134.00	113.02 \pm 12.86 ^{abc}	
B3	91.30	124.10	113.66 \pm 13.13 ^{abc}	

Different letter within the same column differ significantly from each other ($p < 0.05$)

In the experiment done by Taewee said that the use of tapioca flour for *kerupuk* ingredients shows better swelling ability compared to other flour *kerupuk* (sago, rice, corn, wheat flour). It will form the crispness and the hardness of the *kerupuk*[25].

The amylopectin content of *kerupuk gembus* also affect the swelling ability. The *higher* amylopectin content the bigger percentage of swelling ability[25,26]. Data on the table 2 does not support this theory because there were no significant different in group A (1:1) and group B (2:1) swelling ability.

The addition of baking soda (A2 and B2) also affects the swelling ability of *kerupuk gembus*. It will produces CO₂ during the cooking process, so the *kerupuk* were swollen[27,28]. But the statistical result does not show significant difference between A2 and other formulation in A group, B2 and other formulation in B group.

Slicing thickness of the raw *kerupuk* will affect the swelling ability, the thicker *kerupuk* the smaller percentage of the swelling ability of it[23]. In the production process of the raw *kerupuk* the slicing process were done manually using kitchen knife. This may cause the different thickness of the raw *kerupuk gembus* and the different swelling ability of the *kerupuk*.

3.2. Proximate Composition

Table 3 shows the results of *kerupuk gembus* nutrition composition, with the greatest incorporation of *gembus* there were increase in fiber content.

The water content, fat, and carbohydrate were almost the same in all formulation. The water content ranged between 1.99 and 3.00%. Water content of *kerupuk gembus* were affected by the gelatinization process, the higher tapioca flour added the higher water concentration in the *kerupuk*[29,30]. Tapioca binds water in the gelatinization process[31]. Other research also showed that the reduced water composition in *kerupuk* also related to the addition of protein, ash, and fat[30].

Fat content in *kerupuk gembus* ranged between 11.8 and 16.8%. The fat content may depend on the amount of ingredients added, and increase because of oil absorption during frying process[30].

Table 3. Composition of *kerupuk gembus*

<i>Kerupuk gembus</i>	Water %	Protein %	Fat %	Carbohydrate %	Fiber %
A1	2.6338 ±0.8644	0.651 ±0.0255	14.4165 ±0.2831	44.178	38.1205 ±0.8951
A2	3.0037 ±0.1701	0.538 ±0.0354	11.8188 ±0.3894	38.577	46.0620 ±0.8661
A3	1.9982 ±0.1565	0.298 ±0.0247	13.9677 ±0.5172	41.777	41.9582 ±0.7383
B1	2.3723 ±0.4606	0.584 ±0.1697	13.0716 ±0.1729	18.901	65.0711 ±0.4343
B2	2.1682 ±0.2862	0.841 ±0.0544	16.8670 ±0.0441	25.706	54.4165 ±0.1523
B3	2.0505 ±0.4824	0.326 ±0.036	15.1214 ±0.8838	15.056	67.4453 ±0.1481

Kerupuk gembus with additives (A1, A2, B1, B2) shows higher protein content compared to *kerupuk gembus* without additives. The protein content in *kerupuk gembus* mainly composed by *gembus* protein, it has 7.72-4.8% protein composition in wet *gembus*[31,32]. The amino acid content of *gembus* were almost complete, it is a potential protein source of low cost vegetable protein for consumption[33]. In this case, *gembus* ratio in the *kerupuk gembus* formulation does not show any correlation in protein content.

Fiber content of *kerupuk gembus* in this experiment ranged between 38.1 and 67.4% and showed higher number on the 2:1 *gembus* and tapioca flour ratio. Many research showed that *gembus* has high fiber composition and used to improve the fiber content of foods so consumers has higher fiber consumption[15,19]. *Gembus* contains soluble fiber in digestive tract has anti-inflammatory and anti-carcinogenic effects, also insoluble fiber which increases faecal bulk and reduce gastrointestinal transit time good for treating diarrhea and constipation [34].

3.3. Sensory Evaluation

3.3.1. Color

The color analysis result (Table 4) of *kerupuk gembus* showed that there was significant difference within groups ($p < 0.05$). The *Kerupuk gembus* color were bright and dull broken white. The dull-colored *kerupuk*, B2, were quite disliked by the panelist.

Table 4. Color analysis of *kerupuk gembus*

<i>Kerupuk gembus</i>	Mean ± SD	Category
A1	1.50 ± 0.73 ^a	liked
A2	2.97 ± 1.29 ^c	Neutral
A3	1.87 ± 0.86 ^{ab}	Quite liked
B1	2.43 ± 0.85 ^{bc}	Quite liked
B2	3.70 ± 0.95 ^d	Quite Disliked
B3	2.33 ± 0.92 ^{bc}	Neutral

$p = 0.000$

Different letter within the same column differ significantly from each other ($p < 0.05$)

Color of the *kerupuk* were composed by the ingredients namely tapioca flour, *gembus*, and the additives. Tapioca flour is a white colored product while the *gembus* color is yellowish white, it makes the fried *kerupuk gembus* has broken white color. *Kerupuk* with sodium bicarbonate additives has darker color compared to the others.

Sodium bicarbonates or baking soda used as food additives to improve the crispness of the *kerupuk* (leavening agent). It has basic (high) pH, if not neutralized by an acid, enhances browning by Maillard reaction [35]. This reaction responsible for the darker color in the A2 and B2 *kerupuk gembus*.

3.3.2. Flavor

Table 5 shows that there was no significant difference within groups in the flavor parameter ($p < 0.05$). The flavor was not quite strong for all *kerupuk*, rather like fried tofu flavor, based on the panelists description.

Table 5. Flavor analysis of *kerupuk gembus*

<i>Kerupuk gembus</i>	Mean \pm SD	Category
A1	2.33 \pm 1.03	Quite liked
A2	2.53 \pm 0.90	Quite liked
A3	2.37 \pm 0.93	Quite liked
B1	2.37 \pm 0.96	Quite liked
B2	2.40 \pm 1.04	Quite liked
B3	2.60 \pm 1.04	Neutral
$p = 0.894$		

Flavor of *kerupuk gembus* were quite liked by the panelists. It has high level of acceptance according to the hedonic result. Flavor of the *kerupuk* derived from the volatile substance from the dried shrimp and the *gembus*. The higher shrimp and *gembus* concentration stronger the flavor produced [36,37].

3.3.3. Texture

There were various texture characteristics described by the panelists, such as hard, crispy, and grainy texture. Table 6 shows that there was no significant difference within groups in the texture parameter ($p < 0.05$).

Table 6. Texture analysis of *kerupuk gembus*

<i>Kerupuk gembus</i>	Mean \pm SD	Category
A1	2.30 \pm 1.39	Quite liked
A2	2.30 \pm 1.21	Quite liked
A3	2.30 \pm 1.18	Quite liked
B1	2.83 \pm 1.23	Neutral
B2	2.87 \pm 1.19	Neutral
B3	2.30 \pm 1.18	Quite liked
$p = 0.164$		

Texture of the *kerupuk gembus* were determined from the flour properties. Tapioca flour contains starch which expands after the heating process. The starch gelatinization affects *kerupuk* swelling ability and also the *kerupuk* texture. Research in various kind of flour for making *kerupuk* shown better expansion result in the sago and cassava *kerupuk*, it makes better texture of the *kerupuk* (more crunchy) [25].

3.3.4. Taste

Taste of the *kerupuk gembus* were combination between salt, pepper, and garlic so the taste were rather savory, salty or spicy. From table 7, we could see that there was no significant difference in taste parameter for each *kerupuk gembus* formulation (Table 7).

Table 7. Taste analysis of *kerupuk gembus*

<i>Kerupuk gembus</i>	Mean \pm SD	Category
A1	2.43 \pm 1.04	Quite liked
A2	2.57 \pm 1.07	Neutral
A3	2.47 \pm 1.25	Quite liked
B1	2.63 \pm 1.22	Neutral
B2	1.90 \pm 0.96	Quite Liked
B3	2.70 \pm 1.12	Neutral
$p = 0.089$		

Taste of the *kerupuk gembus* produced were quite liked by the panelists. There are no different in taste between A group and B group (higher *gembus* composition).

The *gembus* used in the production process have bland taste, the added salt, pepper and garlic will form the taste of this *kerupuk* [38]. The taste of *gembus* in the various dishes has been known and familiar among Japanese and Chinese people. They often consume soy products foods for their daily meals [38,39].

3.3.5. Sensory Evaluation Result

Table 8. Sensory evaluation of *kerupuk gembus*

<i>Kerupuk gembus</i>	Mean \pm SD	Category
A1	2.14 \pm 0.43	quite liked
A2	2.59 \pm 0.27	neutral
A3	2.25 \pm 0.26	quite liked
B1	2.56 \pm 0.21	neutral
B2	2.72 \pm 0.76	neutral
B3	2.48 \pm 0.19	quite liked

$p = 0.368$

There was no significant difference in the sensory evaluation of all *kerupuk gembus* formulation according to all aspects. The result showed that A1, A3, and B3 *kerupuk gembus* were quite liked by the panelists.

3.3.6. Triangle test result

The triangle test was used to determine whether A3 *kerupuk* different compared to A1 and A2, also B3 different compared to B1 and B2 according to the parameters (color, flavor, texture, taste).

Table 9. Triangle test result for *kerupuk* A1, A2, and A3

Answer	Color n (%)	Flavor n (%)	Texture n (%)	Taste n (%)	Total n (%)
A1	8 (27)	10 (33)	9 (30)	12 (40)	39 (33)
A2	18 (60)	12 (40)	16 (53)	11 (37)	57 (48)
A3	4 (13)	8 (27)	5 (17)	7 (23)	24 (20)
Total	30 (100)	30 (100)	30 (100)	30 (100)	120 (100)

Table 9 shows the most different *kerupuk gembus* formulation in 1:1 ratio of *gembus* and tapioca flour. From the color, flavor, and texture parameter, the most different *kerupuk* were A2 (60%, 40%, 53%). For the taste parameter, the most different *kerupuk* was A1 (40%). At the total, the A2 *kerupuk* was the most different *kerupuk* in the group (48%). This results showed that addition of STPP in A1 (33%) does not make any different compared to the A3 (20%) formulation.

Table 10. Triangle test result for *kerupuk* B1, B2, and B3

Answer	Color n (%)	Flavor n (%)	Texture n (%)	Taste n (%)	Total n (%)
B1	8 (27)	7 (23)	11 (37)	6 (20)	32 (27)
B2	19 (63)	14 (47)	13 (43)	13 (43)	59 (49)
B3	3 (10)	9 (30)	6 (20)	11 (37)	29 (24)
Total	30 (100)	30 (100)	30 (100)	30 (100)	120 (100)

Table 10 presents the most different *kerupuk gembus* formulation in 2:1 ratio of *gembus* and tapioca flour. According to all parameter, the most different *kerupuk* were B2. This results showed that addition of STPP in B1 (27%) does not make any different compared to the B3 (24%) formulation.

From the triangle test result we can concludes that there were no different between *kerupuk* without STPP and *kerupuk* with STPP. In the experiment done by Sukjuntra, *kerupuk* with STPP (0.4%) as the additives has the highest quality indicated by the highest moisture, textural characteristics and sensory scores[40].

STPP used as preservatives for seafood, meat, poultry, and animal feed[41]. In Indonesia, STPP known as food additives for substituting borax in *kerupuk* production. Borax are banned food additives by the government because of its dangerous effects for health in the long term consumption. STPP has improving quality ability in the *kerupuk* production because of its properties. It can increase the water absorbing, water binding and water holding capacity[42].

In this experiment the use of additives could be avoided, *kerupuk gembus* without additives has same sensory properties compared to the *kerupuk* with STPP and Sodium bicarbonate addition. Other than that, *kerupuk* without additives also has high acceptance by the panelists.

4. Conclusion

Kerupuk gembus contains high fiber in the 2:1 formulation (54.4-67.4%). The formulations quite liked by the panelists were *kerupuk* with *gembus* and tapioca flour 1:1 ratio with Sodium Tripolyphosphate (STPP) 0.5%w (A1), *kerupuk* with *gembus* and tapioca flour 1:1 ratio without any additives (A3), and *kerupuk* with *gembus* and tapioca flour 2:1 ratio without any additives (B3). Considered the results from the triangle test, author suggested the best formulation for consumption was *kerupuk* with *gembus* and tapioca flour 2:1 ratio without any additives.

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