The Development of gluten and eggs-free Cookies Enriched with Canna edulis flour rich in Resistant Starch Type 3 as a Functional

M Nugraheni\textsuperscript{1*}, Sutopo\textsuperscript{2}, S Purwanti\textsuperscript{1}, and THW Handayani\textsuperscript{1}

\textsuperscript{1}Department of Culinary Art Education, Yogyakarta State University, Depok Sleman, Yogyakarta, 55281
\textsuperscript{2}Department of Mechanical engineering Education, Yogyakarta State University, Depok, Sleman, Yogyakarta, 55281

Abstract. This research aims to determine the gluten and egg-free cookies enriched with Canna edulis flour rich in resistant starch type 3 based on sensory characteristics, chemical composition, and physical properties. The research method was done with cookies formulation based on the amount of Canna edulis flour rich in resistant starch type 3 and a control (wheat flour cookies). The selected cookies based on a hedonic test with 80 semi-trained panelists was Formula I. The value of sensory characteristics were: aroma 7.56 ± 0.65; color 7.56 ± 0.65; taste 7.56 ± 0.73; texture 7.75 ± 0.49; overall acceptance 7.63 ± 0.60. The chemical composition were: moisture content 3.69 ± 0.17%; ash 4.20 ± 0.53%; fat 32.67 ± 0.15%; protein 11.15 ± 0.13%; carbohydrate 28.36 ± 0.60%; soluble fiber 0.80 ± 0.01%; insoluble fiber 24.81 ± 0.10%; resistant starch 3.36 ± 0.08%; amylose 13.80 ± 0.03%; amylopectin 12.88 ± 0.34%; energy 452.07 ± 0.87 cal. The physical characteristics were: weight 1.11 ± 0.02 g; diameter 31.47 ± 0.20 mm; height 3.77 ± 0.09 mm; spread ratio 8.34 ± 0.22; hardness 8.41 ± 0.56 N/kg. The selected cookies can be used as a functional food for people who are sensitive to gluten and eggs.

1. Introduction
Indonesia has the potential advantage of vegetable food sources which can be used to make flour-based local potential, i.e. tubers, legumes, and cereals. The prominence of Indonesia in terms of vegetable food sources, not yet fully exploited with the optimum for product development, it appears on the data showed Indonesia became the second largest wheat flour importer in the world. Indonesia also has considerable potential related to the number of sufferers of diabetes mellitus, the World health organization predictions show that Indonesia can occupy ranking 4th in the world in 2025. So it needs to be a concerted effort to suppress the sufferers of diabetes mellitus at once create eating patterns of people who already suffer from diabetes mellitus. Food ingredients sourced from tubers, legumes, and cereals contain high carbohydrates, so needed the modification process to increase the levels of resistant starch. Resistant starch in some research can provide a positive impact on the management of the profile glucose and lipids in diabetics mellitus.

Cookies are a source of energy and is a product that is ready to consume. Moreover, cookies can also be produced in high numbers with a short time, and it is easy to be widely distributed [1]. According to SNI 01-2973-1992 cookies are one of the types of biscuits made from soft dough, containing high fat, relatively crisp when broken and densely textured. Fat in cookies serves as...
shortening and will affect the texture, flavor, tenderness, and mouthfeel [2]. The ingredients of making cookies consist of flour with protein, fat, sugar, and eggs.

Wheat flour commonly used in making cookies. The content of gluten in wheat flour has the functionality to make the dough becomes elastic and easy to set up. Gluten formed only serves to establish the characteristics of the cookies as desired, and this suggests that the role of gluten in the manufacture of tiny cookies so that substitution wheat flour with wheat flour is none could be developed. So the flour can be replaced with local food-based flour (gluten-free flour). Functional properties of an egg as power developers, emulsifier, coagulation, connective power, and water as well as the creation of the texture. However, some people cannot consume eggs and flour for various reasons, such as allergies and cholesterol. The eggs included eight major allergens on food [3]. Therefore need to deployment on modified materials as a substitute for eggs, e.g., flaxseed [4] and wheat flour substitute.

Wheat flour is known to cause allergies in some people such as celiac disease sufferers, allergy allergy-gluten wheat flour and non-celiac [5,6]. Gluten-free food products have benefits to minimize the risk and create a type 1 diabetes mellitus [7]. The existence of a modification of processing technology can change gluten-free flour being rich in resistant starch type 3 can also be developed to create a disease of diabetes mellitus type 2, as it can improve insulin sensitivity [8]. This research aims to determine the selected gluten and egg-free cookies enriched with resistant starch type 3 from Canna edulis flour based on chemical composition, physical properties and sensory tests.

2. Method
The design of this study is an experiment in the laboratorium with Canna edulis flour rich in RS3, wheat flour (as control), F1, F2, and F3. The experiment was conducted at the chemical laboratory of food engineering education Yogyakarta State University. Canna edulis Flour obtained from farmer in the Clereng Kulon Progo. Tapioca flour, Cornstarch, rice flour obtained from the bakery in Yogyakarta. Canna edulis and Coleus tuberosus flour rich in RS3 obtained from processing modifications 3-cycles autoclaving-cooling [9].

2.1. Formulation
Cookies recipe formulations referring to the Gisslen [10], with little modifications, by replacing the eggs become flaxseed. The formula used is in Table 1. Treatment factors used in this formulation is based on changes in the amount of Canna edulis flour rich in RS3 to the total flour gluten-free. FI using 10.5% (21 g), FII using 12.5% (25 g), 14.5% using FIII (29 g).

| Composition | Control (gram) | F I (gram) | F II (gram) | F III (gram) |
|-------------|----------------|------------|------------|-------------|
| Wheat flour | 200            | 200        | 200        | 200         |
| The composit gluten-free flour : rice flour, tapioca flour, Canna edulis flour rich in RS3, Coleus tuberosus flour rich in RS3, Corn starch, native canna edulis flour |
| Margarine   | 90             | 90         | 90         | 90          |
| Flaxseed    | 10             | 10         | 10         | 10          |
| Water       | 30             | 30         | 30         | 30          |
| Salt        | 2              | 2          | 2          | 2           |
| Cheese      | 50             | 50         | 50         | 50          |

Making cookies begins with the making of gel flaxseed, 10 grams flaxseed soaking with water 45 ml, stirred and the allow in the refrigerator for 15 minutes. Then margarine, sugar, blended until silky, then added flaxseed gell, mix well then add flour, cocoa powder, and cheese. The next process is forming. The next process is baking with a different temperature, 120°C for the upper and 110°C for bottom temperature, 40 minutes. Baking in the oven is cooking the dough stage and changes a dough
into a cookie. During the baking process occurs three main changes, i.e. increased thickness (development of the structure), increased color reddish brown on the surface of the product (based on the principle of reaction maillard), and decreased water levels significantly [11].

2.2. Chemical characteristics
Chemical analysis of the levels of water content, ash, fat, protein and dietary fiber using AOAC method [12]. Carbohydrate levels determined by difference and the calorie value is determined by calculation. Resistant starch levels determined following the methods developed [13].

2.3. Physical characteristics
Cookies are taken as a random, weighted using digital scales. Thickness (height) and the diameter was measured using vernier caliper (Trickle brand, Shanghai China). Measurement of the thickness and diameter of the cookies is done by taking three samples. Spread ratio is calculated using the formula: diameter cookies divided thick (high) cookies [14]. Physical characteristics measured using cookies Liyod universal testing machine type 1000 S within 24 hours after baking process.

2.4. Sensory evaluation
The sensory evaluation carried out by 80 semi-trained panelists (30 men, 50 women) of culinary art Engineering Education of Yogyakarta State University students. Evaluation based on the 9-point hedonic scale method: 9 (very, very well liked) and 1 (very, very not liked). Evaluation of the cookies is done 24 hours after baking process cookies. Sensory tests carried out on four types of cookies.

2.5. Data analysis
Statistical analysis was analyzed with SPSS version 11.0 (Illinois, USA) using the ANOVA of one line. A different test was done using Duncan Multiple Range test (DMRT).

3. Result and Discussion
3.1. Chemical analysis of control cookies, gluten and egg-free cookies
In this study, made four types of cookies, i.e. cookies control are made from 100% wheat flour and three types of gluten and egg-free cookies.

| Parameter (%) | Kind of cookies |
|---------------|----------------|
|               | Wheat cookies (control) | Gluten and egg-free cookies (F I) | Gluten and egg-free cookies (F II) | Gluten and egg-free cookies (F III) |
| Moisture content | 3.88 ± 0.07<sup>c</sup> | 3.69 ± 0.17<sup>b</sup> | 4.29 ± 0.03<sup>d</sup> | 3.14 ± 0.07<sup>a</sup> |
| Ash | 3.45 ± 0.07<sup>c</sup> | 4.20 ± 0.53<sup>b</sup> | 4.51 ± 0.06<sup>b</sup> | 4.22 ± 0.35<sup>b</sup> |
| Fat | 31.14 ± 0.13<sup>a</sup> | 32.67 ± 0.15<sup>b</sup> | 33.45 ± 0.19<sup>c</sup> | 33.47 ± 0.15<sup>c</sup> |
| Protein | 15.14 ± 0.05<sup>c</sup> | 11.15 ± 0.13<sup>b</sup> | 11.22 ± 0.06<sup>b</sup> | 10.52 ± 0.28<sup>a</sup> |
| Carbohydrate | 25.21 ± 0.11<sup>a</sup> | 28.36 ± 0.60<sup>b</sup> | 28.46 ± 0.22<sup>b</sup> | 30.47 ± 0.09<sup>c</sup> |
| Soluble dietary fiber | 0.54 ± 0.12<sup>a</sup> | 0.80 ± 0.01<sup>b</sup> | 0.81 ± 0.17<sup>b</sup> | 0.72 ± 0.20<sup>ab</sup> |
| Non soluble dietary fiber | 20.56 ± 0.16<sup>a</sup> | 24.81 ± 0.10<sup>d</sup> | 24.30 ± 0.05<sup>c</sup> | 23.64 ± 0.15<sup>b</sup> |
| Resistant starch | 2.18 ± 0.18<sup>a</sup> | 3.36 ± 0.08<sup>b</sup> | 3.51 ± 0.08<sup>c</sup> | 3.821 ± 0.18<sup>d</sup> |
| Amilosa | 13.52 ± 0.05<sup>a</sup> | 13.80 ± 0.03<sup>b</sup> | 13.76 ± 0.04<sup>a</sup> | 13.86 ± 0.03<sup>b</sup> |
| Amilopeptin | 17.86 ± 1.64<sup>d</sup> | 12.88 ± 0.34<sup>c</sup> | 8.36 ± 0.72<sup>b</sup> | 8.23 ± 0.43<sup>a</sup> |

Values are the Mean±SD from triplicate determinations, different superscripts in the same row are significantly different (p<0.05)

The role of the egg as the adhesive was replaced by flaxseed. The consistency of flaxseed gel is like the consistency of egg [4]. Flaxseed has several advantages including the content of lignans, fiber, and α-linolenic acid (ALA)[15]. Moisture content influence on shelf life, appearance, texture, and taste.
of the food. The results of the analysis of moisture content cookies range 3.24-4.29%, it does meet the standards of SNI 01-2973 2011 i.e. water content cookies under 5%. Moisture content is acceptable as the moisture content in the product is still new cookies that is under 5% [16, 17]. Low moisture content are expected to increase the shelf life of cookies.

The level of ash is a component that describes the mineral levels present in food. The higher the value of the levels of ash a material will be increasingly higher mineral content. The results of the analysis of grey levels of 3.45-4.51%. The levels of ash in wheat flour cookies and gluten-egg free cookies are high enough it is alleged to be caused by components constituting namely flaxseed (3.4%) [18], the levels of Coleus tuberosus flour (4.4%). Fat is a component of macronutrients that determine the quality of a food product. Based on the results of the analysis, it can be noted that the levels of fat gluten-egg free cookies higher than wheat cookies (as control). A reasonably high-fat content on cookies due to the contribution of fat margarine (17%) flaxseed and containing fats about 41% [18] and cheddar cheese. However, the fat content of cookies meet the qualified quality pastries (cookies) according to SNI 01-2973-2011, i.e. a minimum fat content of 9.50%.

Protein content in wheat flour cookies (control) was the highest. Wheat flour cookies (control): 15.14%, while gluten and egg-free cookies amounted to 10.52 – 11.22%. The protein content of gluten and egg-free cookies eligible quality egg pastries (cookies) according to SNI 01-29732011, i.e. minimum protein levels by 5%. The difference in protein content between wheat flour cookies and gluten and egg-free cookies caused by different types of an ingredient. The wheat flour as an ingredient of control cookies containing protein 10.5 – 11.5%

Levels of carbohydrate in wheat flour cookies (control) lower than three types of gluten and egg-free cookies (FI, FII, FIII). The difference in the levels of resistant starch on the FI, FII, FIII cookies resulted in increased levels of carbohydrates. The presence of the ddition of the levels of resistant starchy on FI (10.5%), FII (12.5%) FIII (14.5%) give an impact on increasing the levels of resistant starch on cookies. Dietary fiber levels on three types of gluten and egg-free cookies (FI, FII, FIII) higher than wheat flour cookies (control). The difference in levels of dietary fiber on gluten-egg free than wheat flour cookies (control) resulting from constituting components namely Canna edulis flour. The content of dietary fiber of Canna edulis ranged from 5.12 – 5.24%. The age harvest tubers influence the dietary fiber levels on flour, the older, the tuber starch levels will progressively decrease and will occur change from the starch into fiber [19].

Levels of amylose on gluten and egg-free cookies higher than wheat flour cookies. This is in line with the levels of resistant starch that increase with increasing levels of amylose on gluten and egg-free cookies (FI, FII, and FIII). The higher the amylose starch levels, the higher resistant starch levels [20].

### 3.2. Physical characteristics

Physical characteristics include weight (g), diameter (mm), height (mm), the spread ratio and hardness (N). Wheat flour cookies (control) have lower spread ratio than gluten and egg-free cookies (formulation I, II and III) (p<0.05).

**Table 3.** Physical characteristics of wheat flour cookies (control) and three types of gluten and egg-free cookies

| Determination    | Wheat flour cookies (control) | Gluten and egg-free cookies (FI) | Gluten and egg-free cookies (F II) | Gluten and egg-free cookies (F III) |
|------------------|-------------------------------|----------------------------------|-----------------------------------|-----------------------------------|
| Weight (g)       | 1.27 ± 0.02<sup>b</sup>       | 1.11 ± 0.02<sup>a</sup>         | 1.11 ± 0.02<sup>a</sup>          | 1.11 ± 0.02<sup>a</sup>          |
| Diameter (mm)    | 30.89 ± 0.13<sup>a</sup>      | 31.47 ± 0.20<sup>a</sup>        | 31.50 ± 0.25<sup>a</sup>         | 31.48 ± 0.21<sup>a</sup>         |
| Height (mm)      | 3.84 ± 0.03<sup>a</sup>       | 3.77 ± 0.09<sup>b</sup>         | 3.79 ± 0.07<sup>b</sup>          | 3.79 ± 0.09<sup>b</sup>          |
| Spread ratio     | 8.04 ± 0.09<sup>b</sup>       | 8.34 ± 0.22<sup>a</sup>         | 8.32 ± 0.18<sup>a</sup>          | 8.32 ± 0.24<sup>a</sup>          |
| Hardness (N)     | 12.24 ± 0.25<sup>c</sup>      | 8.41 ± 0.56<sup>a</sup>         | 8.84 ± 0.12<sup>b</sup>          | 9.07 ± 0.18<sup>b</sup>          |

Values are the Mean±SD from triplicate determinations, different superscripts in the same row are significantly different (p<0.05)
Based on Table 3, wheat flour cookies (control) has the smallest ratio spread. Spread ratio shows the capabilities of cookies to expand [21]. The lower the spread ratio then shows that the ability to inflate wheat flour cookies better than gluten and egg-free cookies. This expands the capabilities associated with high protein content in wheat flour cookies, will have an impact on their ability to bind water and so will limit the developing of cookies. Texture differs significantly between wheat flour cookies (control) with three types of gluten and egg-free cookies. The highest value for the texture of the cookies contained in wheat flour that is amounted to 12.24 N. It is associated with high protein content in wheat flour cookies than these three types of cookies to another. Flour containing high-protein requires more water to get the dough good cookies, and these cookies will have even greater the hardness.

3.3. Sensory test

Sensory Tests used in this test is a hedonic test. The test is to know the consumer acceptance of subjectivity and the Favorites on the product. Semi-trained panelists used as many as 80 people (30 men and 50 women).

| Characteristics | Wheat flour cookies (control) | Gluten and egg-free cookies (F I) | Gluten and egg-free cookies (F II) | Gluten and egg-free cookies (F III) |
|-----------------|-------------------------------|----------------------------------|----------------------------------|-----------------------------------|
| Aroma           | 8.01 ± 0.58<sup>c</sup>       | 7.56 ± 0.65<sup>b</sup>         | 7.25 ± 0.72<sup>a</sup>         | 7.12 ± 0.66<sup>a</sup>          |
| Color           | 7.93 ± 0.67<sup>c</sup>       | 7.56 ± 0.65<sup>b</sup>         | 7.16 ± 0.68<sup>a</sup>         | 7.01 ± 0.72<sup>a</sup>          |
| Taste           | 7.89 ± 0.50<sup>c</sup>       | 7.56 ± 0.73<sup>b</sup>         | 7.29 ± 0.78<sup>a</sup>         | 7.29 ± 0.78<sup>a</sup>          |
| Texture         | 7.82 ± 0.55<sup>b</sup>       | 7.75 ± 0.49<sup>c</sup>         | 7.16 ± 0.61<sup>a</sup>         | 7.01 ± 0.72<sup>a</sup>          |
| Overall acceptance | 7.90 ± 0.54<sup>c</sup>     | 7.63 ± 0.60<sup>b</sup>         | 7.16 ± 0.60<sup>a</sup>         | 7.09 ± 0.72<sup>a</sup>          |

Values are the Mean±SD, different superscripts in the same row are significantly different (p<0.05)

Based on sensory evaluation showed that wheat flour cookies (control) have the highest assessment score compared to the other three types of cookies on the categories aroma, color, taste, texture and overall acceptance. The gluten and egg-free cookies Formulation I had the highest score in comparison to the Formula II and III on the parameters of the aroma, color, flavor, texture and overall acceptance. Table Four shows that the addition of the percentage of *Canna edulis* flour rich in RS3 resulted in a decrease in the level of acceptance of the panelists. Some research also suggests the existence of a replacement of some parts of the wheat flour or gluten-free flour impact on decreasing by hedonic panelists valuations score against a product [22]. Determination of selected formulations based on a hedonic test on these three types of cookies. Based on the results of this research show that the gluten and egg-free cookies formula I most preferred by the panelists. So these cookies that will be developed for further testing and commercialization. Determination of a product favored by panelists very important related to new product development.

4. Conclusion

Gluten and egg-free cookies formulation selected was the formulation I (FI) use *Canna edulis* flour rich in RS3 as much as 10.5% has the highest acceptance in terms of semi-trained panelist. The chemical composition of the selected cookies were moisture content: 3.69 ± 0.17%; Abu: 4.20 ± 0.53% fat: 32.67 ± 0.15%; protein: 11.15 ± 0.13%; carbohydrate 28.36 ± 0.60%; soluble dietary fiber: 0.80 ± 0.01%; insoluble dietary fiber: 24.81 ± 0.10%; resistant starch: 3.36 ± 0.08%; amylose: 13.80 ± 0.03%; amylopectin: 12.88 ± 0.34%; energy: 452.07 ± 0.87 cal. The physical characteristics of the selected cookies, weight: 1.11 ± 0.02 g; diameter: 31.47 ± 0.20 mm; height: 3.77 ± 0.09 mm; spread ratio: 8.34 ± 0.22, hardness: 8.41 ± 0.56 N. Sensory characteristics were, aroma: 7.56 ± 0.65; color: 7.56 ± 0.65; Taste: 7.56 ± 0.73; texture: 7.75 ± 0.49; overall acceptance: 7.63 ± 0.60.
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