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Characteristics of gluten-free cookies from konjac, jack beans and dragon fruit (*Hylocereus undatus*)

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Abstract. The development of gluten-free cookies can be done using fiber-rich konjac flour. The addition of protein sources will reduce the GI of the ingredients so that the addition jack bean flour which is a local food is expected to increase its functional properties. To improve its appearance and functional properties, dragon fruit which is rich in anthocyanins is added as a functional component. The aim of the study was to determine the right formulation to produce gluten-free food from konjac tubers, jack bean and dragon fruit with good nutritional and sensory values and favored by panelists. The study used a factorial Completely Randomized Design with 2 factors. The first factor is the proportion of konjac flour: jack bean flour consists of 3 levels, namely 80:20, 70:30 and 60:40. The second factor was the proportion of dragon fruit consisting of 3 levels, namely 10, 20 and 30%. The variables studied at this stage are nutritional values including levels of total protein, fat, minerals, water, ash, yield, and carbohydrates as well as sensory properties including aroma, texture, taste, colour, aftertaste, flavour, and overall acceptability. The conclusion from this study is that the ratio of the use of konjac tuber flour and jack bean flour, as well as the proportion factor of the use of dragon fruit concentrate have an effect on moisture content, ash content, fat content, total protein content, carbohydrate content, and yield of the resulting cookies. In addition to the results of sensory analysis, the results showed a significant effect of the use of the ratio of flour and dragon fruit concentrate, on the attributes of color, aroma, taste, texture, flavour, aftertaste, and overall acceptance of cookies.

1. Introduction

Increased public awareness of health and the slogan “Food as medicine”, will increase the need for functional food, including for groups with special needs [1][2]. One group that requires special food is people with celiac disease who cannot consume gluten and casein [3][4]. According to Cairano et al. (2021) [5], gluten-free food is also related to its glycemic index. Therefore, controlling the glycemic index can be done by consuming gluten-free and low glycemic index foods [6]. Bakery products such as cookies and biscuits are snacks that are preferred, including by people with celiac disease, even though the gluten content and glycemic index are high [7].

Dietary fiber can lower the glycemic index of food. Konjac are local foods with high dietary fiber [8]. According Laignier *et al.* (2022) [9], the substitution of konjac flour in the manufacture of wheat biscuits will increase the fiber content of the food. Therefore, konjac are an alternative raw material for gluten-free food formulas with a low glycemic index. There has been research on processing konjac tubers into biscuits, but they still use wheat flour [10]. This gluten-free food from konjac is in the form



of cookies, because it is widely consumed, the shelf life is long and practical and the manufacturing process does not need gluten development from wheat flour [11][12]. However, the challenge faced in the manufacture of these cookies is to obtain high nutritional and functional values, in addition to the sensory characteristics (texture, aroma, appearance and taste) of cookies that are preferred.

Glycemic index control can be done by adding protein [3],[13]. The addition of nuts to konjac cookies can increase the protein content, and an alternative is jack bean. In addition to the high protein content (27.4%), jack bean also has 66.1% carbohydrate content and low fat (2.9%). Another advantage of the jack bean is that it is cheaper and easy to cultivate [14]. One of the simple preparations of jack bean flour to enrich the protein content in functional cookies. The addition of jack bean flour can replace cow's milk which contains casein, which patients with celiac disease should avoid [15]. Until now, there has been no research on making cookies from porang flour with the addition of jack bean flour.

Functional cookies are more attractive, especially in appearance with the addition of natural dyes. Red dragon fruit is an alternative natural dye for food products whose potential has not been fully utilized [16]. Compounds that contribute as natural dyes in red dragon fruit are anthocyanins, which also function as antioxidants [17]. The addition of fruit powder as a natural dye in breakfast cereals can make the appearance more attractive and increase its functional value [18]. Therefore, in the cookie formula, red dragon fruit will be added to get an attractive cookie appearance, while increasing its functional properties. The purpose of this study was to examine the formulation, physicochemical properties, and sensory functional cookies based on jackbeans, konjac tubers, and dragon fruit.

2. Materials and Methods

2.1. Ingredients

The materials used were jack bean flour (*Canavalia ensiformis*) (from Temanggung, Indonesia), konjac tuber (*Amorphophallus muelleri*) flour (from Malang, Indonesia), dragon fruit (*Hylocereus undatus*) (from Purwokerto, Indonesia), margarine, baking powder, powdered sugar, as well as analytical materials. The equipment used is a blender, kjeldahl flask, measuring flask (Pyrex), measuring cup (Pyrex), beaker (Pyrex), erlenmeyer (Herma), refrigerator, freezer, plastic container, spoon, stove, pan, electric oven (Miyako), sieve, filter cloth, cookie cutter, kiln, porcelain dish, soxhlet flask, burette, stand, clamp, dropper, measuring pipette, desiccator, spectrophotometer, cuvette, digital scale (Krisbow), water bath, test tube, analytical balance, bomb calorimeter, mortar and pestle.

2.2. Methods

2.2.1. Production of dragon fruit concentrate [19]. The process of making dragon fruit concentrate is done by weighing 100 grams of dragon fruit, then mixed using 1000 ml of distilled water (10% w/v). After the ingredients are mixed, then mashed using a blender until homogeneous. Then, the material is filtered using a filter cloth to be separated from the slurry and seeds. The results of the filtered material are then concentrated using an evaporator, with distilled water as a solvent, for 7 hours of evaporation. The concentrated sample results were then used for cookie supplementation.

2.2.2. Production of cookies. Cookie processing procedure refers to [11], starting with 30 grams of sugar, 25 grams of margarine using a hand mixer until a creaming process is formed. Then added dragon fruit concentrate according to the proportion of the research level, 10 grams of egg yolk, and 1 grams of baking powder into the first mixture. The dough is stirred again until homogeneous using a whisk. After homogeneous, added konjac flour and jack bean flour according to the ratio of the level of research factors. Then the dough is printed using a cookie cutter with a thickness of 0.5-0.7 mm and a diameter of 3.5 cm. The dough is then baked for 30 minutes at 120°C

2.3. Design experimental

The study used a completely randomized design. The factors used are the ratio of the use of konjac tuber flour and jackbean flour with levels of 80:20, 70:30, and 60:40, and the proportion factor of the use of red dragon fruit concentrate to 100% use of flour (N) with a level of 10%, 20%, and 30%. The design was repeated 3 times, so that 27 experimental units were obtained. The test results of chemical and sensory characteristics were then analyzed using Analysis of Variance (ANOVA), and if they had a significant effect, then continued using the Duncan's Multiple Range Test.

2.4. Variables

The variables observed were moisture content [20], ash content [20], protein content [20], fat content [20], and carbohydrate (by difference) [20]. Sensory testing is carried out using a scoring test with 30 trained panelists [21].

3. Results and Discussion

3.1. Raw material characteristics

The raw materials used in this study include konjac tuber flour, jack bean flour, and red pitaya concentrate. Based on the results of the analysis, it was found that konjac flour contains 86.877% crude fiber, 68.348% starch, 2.933% amylose, and 65.415% amylopectin. The results of this analysis, have differences from the research conducted by Laignier *et al.* (2022) [9], where the crude fiber of konjac flour was 4.18%. Differences were also according to Witoyo *et al.* [22] that found that the yellow konjac flour have 5.598% of starch and amylose 16.948% In the same study, the results of white konjac tuber were also obtained, where the starch obtained was 47.554%, amylose 17.536%, and amylopectin 30.018%. These results show differences, when compared with the results of the raw material analysis carried out in this study.

According to Abidin *et al.* (2020) [14], nuts are a good source of vegetable protein, fat, and fiber for the body. From this research, the protein content of jack bean flour was 32.178%, and crude fiber was 46.457%. According to Wei *et al.* (2020) [23] the protein content of jack bean flour was 37.61%, while the seeds were 21.7%. Another study conducted by Ochme *et al.* (2018) [24], showed that the total protein and crude fiber content of jack bean flour were 28.02% and 1.84%, respectively.

According to Mardiana *et al.* (2020) [16] anthocyanins and betacyanins are bioactive polyphenolic content that are commonly found in the flesh and skin of red dragon fruit. Based on this study, it was also explained that the flesh and skin of red dragon fruit contained a total anthocyanin content of 159.7 ± 8.9 and 135.4 ± 9.3 mg/g of dry sample, respectively. This value has a difference to the results of testing anthocyanin levels in this study. In this study, the anthocyanin content was found to be 2,933 mg/100gram. In addition to anthocyanin levels, in this study, the characteristics of the total sugar used in the red pitaya fruit were reviewed. Based on the results of the analysis, total sugar was found to be 3.4029%. Research conducted by Huan *et al.* (2020) [25], regarding the analysis of the content of red dragon fruit and white dragon fruit, it was found that red dragon fruit contains a total sugar value of 6 grams/100 grams of fresh fruit weight.

3.2. Sensory properties

The interaction between the ratio of konjac flour: jack bean flour with red dragon fruit concentrate supplementation has a significant effect on colour, beany aroma, texture, sweet taste, flavour, bitter aftertaste, and preference of cookies (Figure 1). Red dragon fruit is a potential source of various plants that produce dyes [16]. The dye produced from this dragon fruit is in the form of a pigment called betalain pigment. Betalain is a secondary metabolite in the form of pigment, soluble in water, contains a nitrogen group and plays a role in the appearance of red-purple (betacyanin) and yellow-orange (betaxanthin) colors. Betalains are water soluble nitrogen-containing pigments which can be divided into red-violet pigment called betacyanins and yellow pigment called betaxanthins. According to Costa *et al.* (2022) [19], betaxanthins are totally devoid in red pitaya and at least seven identified betacyanins

in the *Hylocereus* genus. These betacyanins identified are betanin, isobetanin, phyllocactin, isophyllocactin, betanidin, isobetanidin, and bougainvillein-R-1. Betacyanin pigment has antioxidant properties that exhibit health benefits hence making it a potential source as natural pigment and functional ingredient in food products. Thus, it contributes greatly to the formulation of cookies. In addition, the raw material used is konjac tuber flour. Konjac tuber flour, physically has a light brown color appearance. In addition, jackbean flour has a yellowish white color like wheat flour. Based on the results of the panelists responses, it was found that the greater the ratio of konjac tuber flour, which was used, the darker the color of the cookies produced. However, the greater the ratio of konjac tuber flour used, the lighter the color of the final cookie will be. This is in line with Yanuriati *et al.*[33], that in contrast to other types of local tubers, konjac tubers have orange and yellow-brown flesh fiber colors. This is what affects the appearance of functional cookies attributes.

Table 1. The sensory quality of *functional cookies*

Samples	Color	Beany aroma	Texture	Sweet taste	Flavour	Bitter after taste	Overall acceptability
T1N1	1.60a	4.36d	3.53de	3.10a	3.83a	4.16a	3.66a
T1N2	2.96d	4.10d	2.90ab	3.20ab	3.26b	4.13ab	3.1bc
T1N3	3.36e	3.66c	2.60a	3.56ab	3.16b	4.03bc	3.0c
T2N1	2.30b	4.30a	3.73ef	3.00bc	3.50b	3.96cd	3.16bc
T2N2	3.20de	3.96b	3.43de	3.10bc	3.10bc	3.93cd	2.8c
T2N3	3.53e	3.56b	3.24bc	3.16c	3.03b	3.90cd	2.9c
T3N1	2.63c	4.13a	3.90f	2.66bc	2.96c	3.66d	2.86c
T3N2	3.46e	3.73c	3.63ef	2.80c	2.96d	3.50d	2.43d
T3N3	4.20f	3.36d	3.26cd	2.83d	2.53b	3.26d	2.23d

Numbers followed by different letter superscripts indicate significant differences ($p < 0.05$)

T1 = ratio of konjac tuber flour : jackbean flour 80 : 20

T2 = ratio of konjac tuber flour : jackbean flour 70 : 30

T3 = ratio of konjac tuber flour : jackbean flour 60 : 40

N1 = 10% red pittaya concentrate

N2 = 20% red pittaya concentrate

N3 = 30% red pittaya concentrate

The interaction of flour ratio and proportion of red pittaya fruit concentrate supplementation, gave a significant effect on the value of the aroma attribute, especially beany aroma. The unpleasant aroma of cookies may comes from the jackbean flour. According to Li *et al.* (2017) [27], the unpleasant nature of legumes is produced by the lipoxygenase enzyme which hydrolyzes the fat of jack beans into compounds that cause unpleasant odors. The results of this reaction then form eight volatile compounds, one of which contributes the most to the unpleasant aroma is ethyl phenyl ketone [28]. The results obtained in this study are in line with the results of Ugwuona and Suwaba (2013) [29], regarding the production of butter cookies based on modified jack bean flour. The results of this study indicate that the greater the proportion of jack bean flour used, the panelists' preference for the assessment of aroma attributes, indicates that the panelists are more dominant in detecting the unpleasant aroma in the butter cookies product. In addition to the use of jack bean flour, the use of dragon fruit concentrate can affect changes in the aroma of functional cookie products. According to Huan *et al.* (2020) [25], it is explained that the factors that affect the aroma of red dragon fruit-based products include the presence of volatile content which is widely contained in red dragon fruit. In this study, the volatile content of red dragon fruit was detected using a machine instrument such as GC/MS. Some of the volatile compounds found were alcohols, ketones, aldehydes, esters, and terpenes. These compounds contribute to the unpleasant aroma of functional cookies.

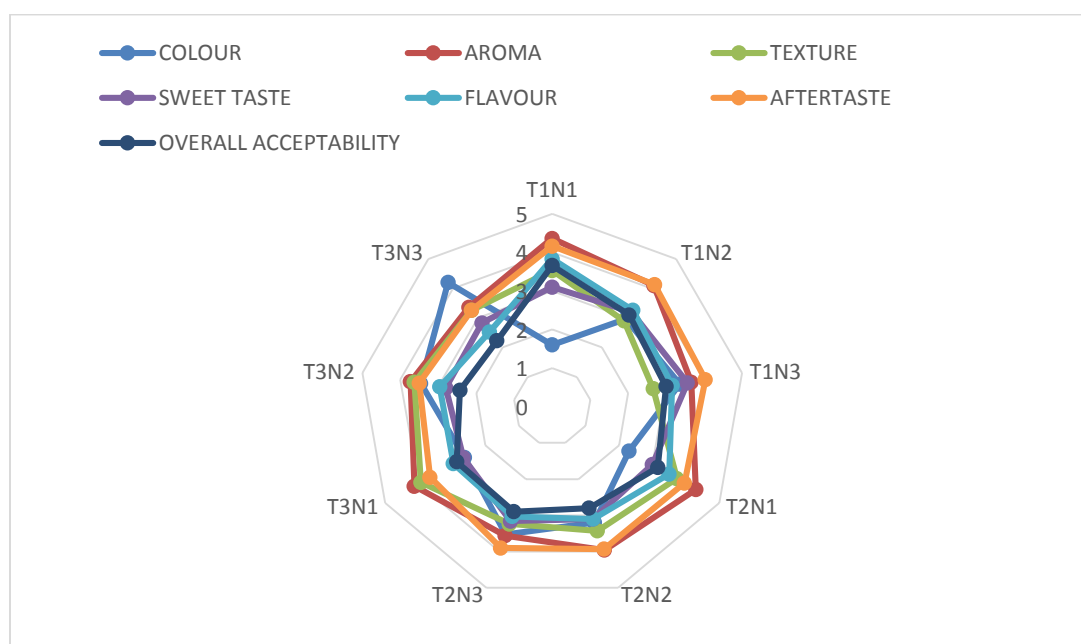


Figure 1. Sensory properties of cookie was affected by interaction of proportion between konjac flour and jackbean flour and supplementation of red dragon fruit concentrate

Variations in flour ratio and concentrate proportion have a significant effect on the texture of cookies. According to Witoyo *et al.* (2020) [22] the main content in konjac tubers is glucomanan. Glucomanan has special properties, such as being able to form a thick solution in water, being able to expand with great swelling power, being able to form a gel, being able to form a thin, impermeable layer of water with glycerin. In several studies, most of the konjac tubers are commonly used as formulations of edible films and edible coatings. This is because konjac tubers have the ability as a gelling agent, which can dissolve in water with very high viscosity [9]. Thus, in the formulation of functional cookie dough, the more proportion of konjac tuber flour is used, the resulting dough will be wetter, and sticky like a gel mixture. Based on the preferences of the panelists, it was found that the panelists' assessment of the higher proportion of konjac tuber flour in functional cookies resulted in less crumbly texture of cookies. This is supported by the use of dragon fruit concentrate in the formulation of functional cookies. According to Jagadiswaran *et al.* (2021) [30], regarding the production of cookies with the addition of dragon fruit juice, the research factor used is the proportion of dragon fruit juice with research levels of 10%, 20%, and 30% the use of red dragon fruit juice. Based on this research, that the highest water content was obtained from the use of dragon fruit juice by 30%, which was 10.6361%, which greatly affected the texture of the cookies to be softer and less crumbly. So that, the more concentrated dragon fruit, the texture of the resulting cookies will be softer, or less crunchy. The results obtained also showed that, the more proportion of jack bean flour, the crispier the cookies. According to Doss *et al.* (2011) [31], jack bean contain carbohydrates in the form of starch consisting of 31.12% amylose and 68.88% amylopectin. The high content of amylopectin in a material can affect the texture characteristics of the final product. In food products, amylopectin stimulates the puffing process. Therefore, food products made from starch with high amylopectin content will be light, porous, crisp and crunchy [32]. The results obtained are in line with Imawan *et al.* (2020) [33], regarding the formulation of crackers based on jack bean flour. The higher the use of the jack bean flour, it can increase the panelists' preference for the crispness of crackers.

Variations in flour ratio and concentrate proportion have a significant effect on the attribute value of the sweetness of cookies. The use of dragon fruit concentrate affects the level of sweetness of cookies because red dragon fruit has a high sugar content of 17.75%. This is in accordance with [19] which states that red dragon fruit has a higher level of sweetness than white dragon fruit, reaching 13-18%.

Thus, this can affect the sweetness of cookies. In addition to the attribute of the sweetness level of cookies, bitter aftertaste was also analyzed in this study. The results of the analysis of variance show that variations in flour ratio and concentrate proportion have a significant effect on the attribute value of the bitter aftertaste of cookies. According to Darini (2021) [15], jack bean have anti-nutritional compounds that can cause a bitter taste and aftertaste or a lingering taste on the tongue. This is caused by the presence of phytic acid in the jack bean. In line with regarding the production of pastries based on jack bean flour with a variety of baking methods using the oven and drying in the sun, it was found that the more proportion of jack bean flour used, the more bitter the final taste. Bitterness on the tongue. Another study conducted by Imawan et al. [34] regarding the production of crispy cookies based on jack bean flour, showed that the response of the panelists to the after taste of the cookies produced, it was assessed that the panelists detected a bitter, unpleasant, and sour aftertaste from the formulation of crispy cookies with the proportion of 100 % jack bean flour. 100 The sensory results were 8.96 for the bitter aftertaste, 10.41 for the sour aftertaste, and 10.51 for the unpleasant aftertaste. In this study, the lowest value of bitter aftertaste was obtained at a value of 3,26 for the use of 40% jack bean flour. In addition to the use of jack bean flour, although dragon fruit concentrate contributes to the sweet taste, the assessment in this study shows that there is an effect of using red dragon fruit concentrate on the bitter aftertaste of functional cookies. The greater the proportion of dragon fruit concentrate, the stronger the bitter aftertaste produced. In the same study, 3% treatment used red dragon fruit flour, panelists stated that there was a bitter taste, while in 6% and 9% treatment using dragon fruit flour, panelists detected a very strong bitter taste arising when consuming bakpia. Thus, it can be concluded that the use of dragon fruit in product formulations can increase the bitter aftertaste of cookies.

Flavor is a complex sensation of a food. It is described as the total sensory attributes of a food material. It is also represents the characteristics or properties of a food material which produce the flavor sensation [35]. Basically, the overall sensation of flavor is comprised of aroma, taste, texture and psychological perception. While the main factors affecting sensation are taste and aroma [29]. When a person ingests food, flavor involves not only the sensory quality, but also the receptor mechanism in both the oral and nasal cavities. Flavor is an important sensory aspect of the overall acceptability of food. Based on the study, it was found that the research factors used had a significant effect on the flavor attribute. The highest value of the flavor attribute assessment was 3,83 from the T1N1 experimental unit, and the lowest flavor was obtained from the T3N3 experimental unit. The combination of T1N1 treatment is the use of a ratio of konjac tuber flour and jack bean flour worth 80:20 and the proportion of dragon fruit concentrate is 10%, where the score falls into the category "a bit good taste". This is in line with the explanation of the unpleasant aroma and bitter aftertaste attributes of functional cookies in this study, because these two attributes are interpretations of the final flavor, which are the impressions of the panelists' assessment of the product being tested. Panelists do not like functional cookies products, because the ingredients used are ingredients that are not commonly used as formulations. The jack bean did not escape the aftertaste of bitter, bitter, and sour which influenced the panelists' preference for flavor cookies. Also, dragon fruit concentrate as a combination of cookies formulation, which is known as an ingredient that has an unpleasant aroma and bitter aftertaste [25]. Thus, the combination of aroma and aftertaste can affect the resulting flavor.

Another attribute that determines product acceptance, is when viewed from the perspective of overall acceptance. Food acceptability is affected by many factors, which may be related to the individual, the food, or the environment in which the food is consumed. Acceptability is a subjective measure based on hedonics (pleasure), which in turn is influenced by the sensory properties of the food, previous exposure to it and subsequent expectations, contextual factors, an individual's culture, physiological status (i.e., hunger, thirst, and presence/absence of illness), and many other variables [16]. The variation in the use of flour ratio and the proportion of dragon fruit concentrate can affect the overall acceptance of the functional cookie products tested. The highest score was obtained from the T1N1 treatment combination with an average score of 3.66, and the lowest score was obtained from the T3N3 treatment combination with an average score of 2.23 where the overall acceptance assessment was still in the range of "a bit like" and "like" description range.

3.3. Yield

There was an influence of the ratio of konjac tuber flour and jack bean flour to cookies (Figure 2), as well as the influence of the proportion of red dragon fruit concentrate (Figure 3). However, there was no significant effect of the interaction between factors.

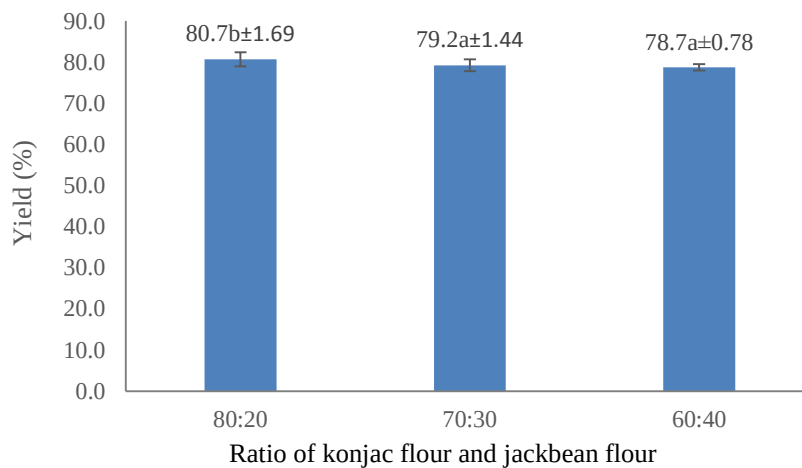


Figure 2. The yield of cookies was affected by on ratio of konjac flour and jack bean flour

Yield is the percentage of product weight that has been processed with ingredients prior to processing. The high yield of konjac tubers, the increase in the yield of cookies (Figure 2). It was caused by the presence of hydrocolloid in konjac flour, namely glucomannan which has the ability to absorb high water, causing the yield of cookies to increase at higher formulations of konjac tubers. In addition, konjac also can expand in water reaching 138-200 %.

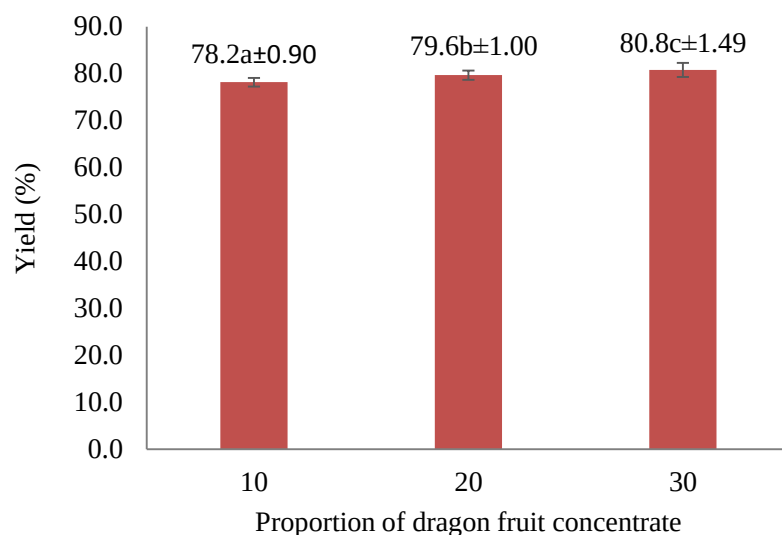


Figure 3. The yield of cookies was affected by proportion of dragon fruit concentrate

The greater the dragon fruit concentrate used, the higher the yield value produced (Fig. 3). This is in line with Harun et al. (2018) [36] regarding the formulation of marshmallow with the addition of dragon

fruit juice. In this study, it was found that the greater the dragon fruit juice used, the greater the yield. This is because the mixture contains more wet ingredients which are then bound to dry ingredients. So that when the product is cooked, the yield was lower.

3.4. Fat content

There was significant effect of the ratio of konjac tuber flour and jack bean flour, as well as the proportion of red dragon fruit concentrate on the fat content of cookies. However, there was no significant effect of the interaction between factors on the fat content (Figure 4).

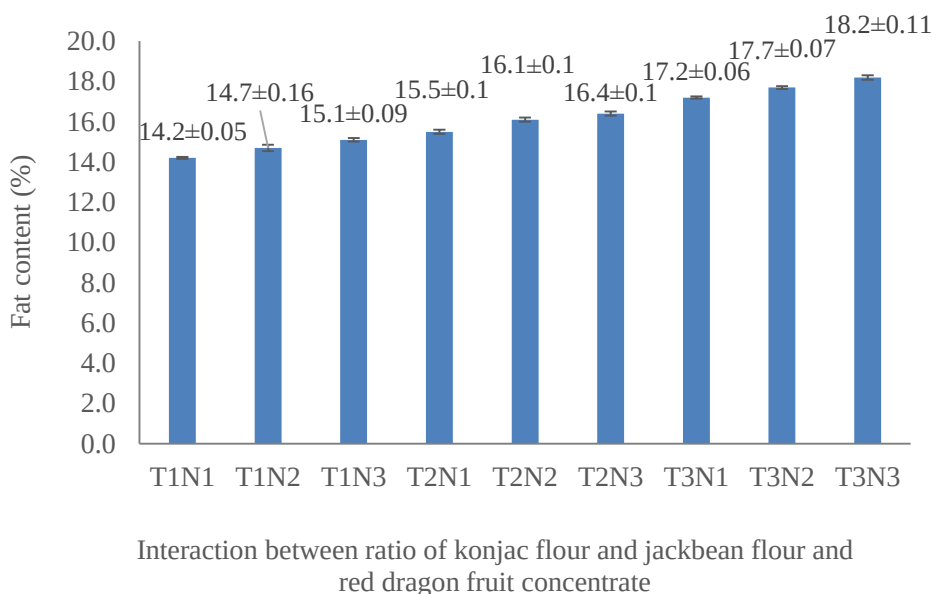


Figure 4. The effect of Interaction between ratio of konjac flour and jackbean flour and red dragon fruit concentrate to the fat content of cookie

Based on the regulation of the Indonesian National Standard (2018) [37] regarding pastries, it is explained that the minimum level of fat contained in pastries is 9.5%. Jack bean is a plant belonging to the family *Leguminoceae* which has high carbohydrate and protein content and lower fat than other nuts [15]. In 100 grams of jack bean contain 389 kcal of energy, and 2.9% fat. The fat content of konjac tuber flour is 2.98%, which is classified as having a much lower value than the fat content of jack bean flour. Thus, the ratio of jack bean flour has an effect on increasing the fat content of cookies. The more jack bean flour, the more fat content of the cookies. This is in line with Cheng et al. (2016) [38], that the more proportion of jack bean flour, the fatter content of cookies. The use of dragon fruit concentrate also influences increasing the fat content of the functional cookies produced. The fat content of red dragon fruit has 0.61 grams [25]. Although the fat content is classified as very low compared to other ingredients, based on the analysis of variance, it has an influence on the fat content, due to differences in the proportions. The high fat content of cookies is supported by the presence of raw materials for cookies that are rich in fat, such as margarine and egg yolks as binding ingredients.

3.5. Ash content

There was an influence of the ratio of the use of konjac tuber flour and jack bean flour, as well as the the proportion of red dragon fruit concentrate on the ash content of cookies. However, there is no significant effect of the interaction between factors on the ash content (Fig 5).

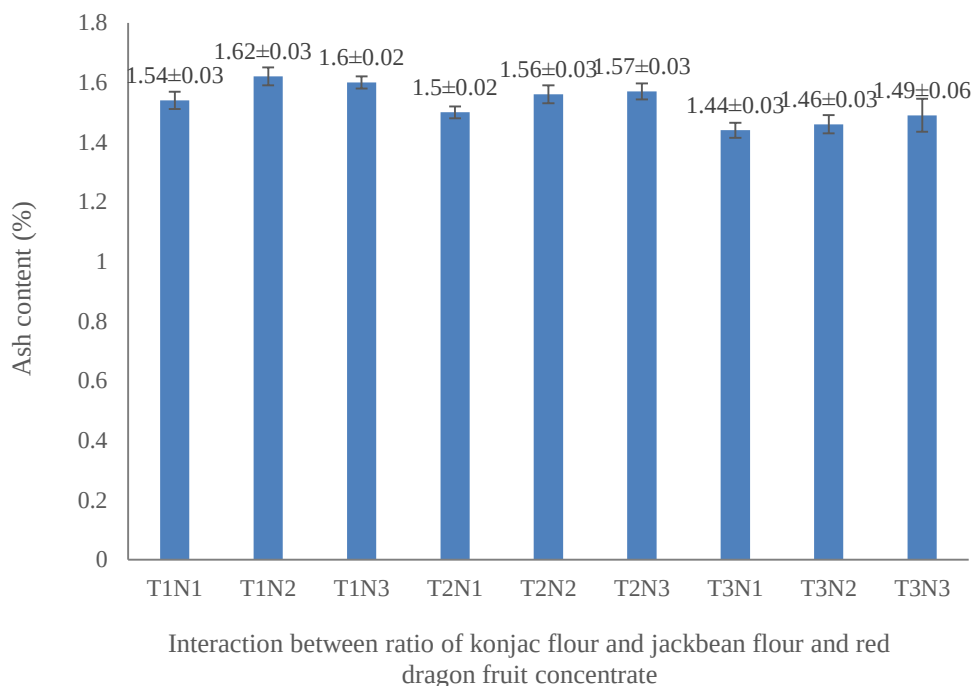


Figure 5. The effect of interaction between ratio of konjac flour and jack bean flour and red dragon fruit concentrate to the ash content of cookie

The ash content of a product shows the mineral content contained in the material, the purity, and cleanliness of the product. The highest ash content was obtained from a combination of treatments with the use of 80% konjac tuber flour, with a dragon fruit concentrate of 20-30%. The Indonesian National Standard 2973-2018 [37] regarding the quality requirements of biscuits, states that the maximum ash content of a biscuit product is 1.6%. The ash content of this cookies showed that the highest ash content value was obtained from the T1N2 treatment combination of 1.62%, and the lowest ash content was obtained from the T3N1 treatment combination of 1.44%. The combination of T1N2 and T1N3 treatments had 1.62% and 1.60% ash content, respectively. These results slightly exceed the maximum determination of the quality requirements of biscuits based on [37]. The ash content of konjac tubers was 9.261% which was quite high [39]. The high ash content is due to the fact that during the processing of konjac tuber flour, there is a boiling stage using NaCl solution where NaCl is an inorganic substance in the form of salt so it is suspected to be the cause of the high ash content. High ash content indicates that the minerals contained in the sample are high and the high minerals in food make it difficult for the digestive system to digest. Another ingredient that can affect the high ash content, is the use of jack bean. The ash content of jack bean flour was 2.74% [15]. Even though the ash content detected was not as large as that of konjac tuber flour, this matter still had an effect because the jack bean contained various types of minerals. In addition, the use of the proportion of dragon fruit concentrate can also affect the ash content of cookie products. Dragon fruit has an ash content of 0.70 grams. The mineral content in dragon fruit were calcium (5.70 mg), phosphorus (23.0 mg), magnesium (28.30 mg), sodium (50.15 mg), potassium (56.96 mg), iron (3.40 mg), zinc (13.87 mg) and copper (0.031 mg) [17].

3.6. Moisture content

There was an influence of the ratio of using konjac tuber flour and jack bean flour, as well as the influence of factors using the proportion of red dragon fruit concentrate on the moisture content of cookies. In addition, there is a significant effect of the interaction between factors, on the moisture content.

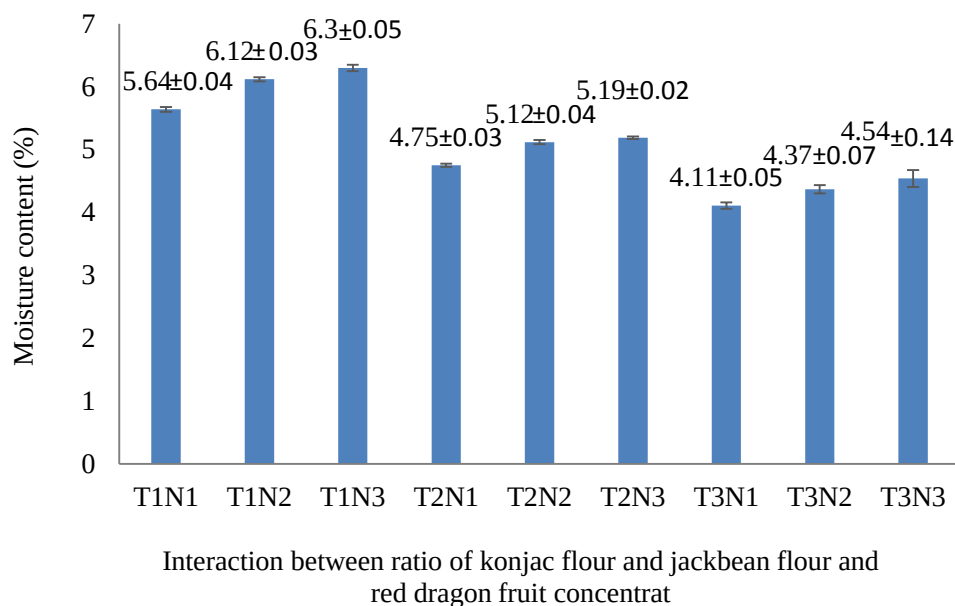


Figure 6. The effect of interaction between ratio of konjac flour and jackbean flour and red dragon fruit concentrate to the moisture content of cookie

Moisture content is one of the most important characteristics of food, because water can determine the freshness and durability of these foodstuffs. The lower the moisture content, the slower the growth of microorganisms so that the food can last longer. The higher the moisture content, the faster the microorganism's growth, so the decay process will be faster. The highest moisture content of the cookies was obtained in the T1N3 of 6.30%, while the lowest was the T3N1 of 4.11%. Based on the SNI 2973-2018 [37], the maximum moisture content in the biscuits was 5%. The combination of treatments T1N1, T1N2, T1N3, T2N2, and T2N3 has a moisture content range in the range of 5% to 6%. These results exceed the provisions of the biscuit quality requirements. This is related to the water content of the raw materials used. The moisture content of konjac tuber flour was 12.965%. According to da Silve et al. (2016) [40] the increase in water content is thought to be caused by konjac flour, because konjac flour contains glucomannan. Glucomannan is a hydrocolloid polysaccharide consisting of D-Glucose and D-Mannose residues which are bound together in -1,4 glycosides and -1,6 glycosides bonds, these compounds can bind water. In addition, the proportion of red dragon fruit concentrate use can also affect the moisture content of cookies. In line with [34] regarding the production of mocaf cookies with the addition of dragon fruit juice, it was found that cookies that had the highest water content were found in the addition of 30% red dragon fruit juice. Thus, the more konjac tuber flour content and the proportion of dragon fruit concentrate used, the wetter the dough and.

3.7. Protein content

There was an influence of the factor of using the ratio of konjac tuber flour and jack bean flour, as well as the influence of the factor of using the proportion of red dragon fruit concentrate on the total protein content of cookies. However, there was no significant effect of the interaction between factors on the total protein content.

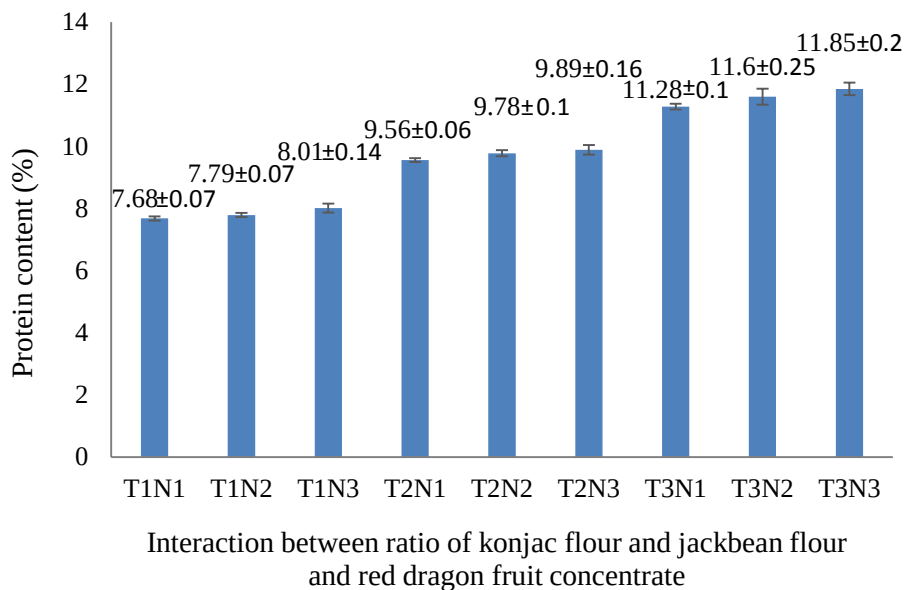


Figure 7. The effect of interaction between ratio of konjac flour and jackbean flour and red dragon fruit concentrate to the protein content of cookie

The protein content value increased, along with the increase in the amount of jack bean flour. The total protein content in has a close relationship with the amount of jack bean flour, considering that the use of jack bean juice in the formulation of this study serves as a protein source. The highest protein content was obtained from the T3N3 of 11.85%, while the lowest value was obtained from the T1N1 of 7.68% (Fig 7). The results are in accordance with the quality requirements of biscuits based on SNI [37], where the minimum protein content of a biscuit product is 5%. Protein content of jack bean was 32.178%, whereas the high nutritional composition of the jack bean is one of the new opportunities as ingredient for protein rich products. Jack bean flour does not have gluten protein as in wheat flour, has the potential to substitute wheat flour in cookies that does not require too much development and can be used as a food source for people who are intolerant to gluten protein or celiac disease. In addition, the use of dragon fruit concentrate influences the protein content of the functional cookies produced. The protein content of red dragon fruit has a value of 0.66 grams. The higher the proportion of dragon fruit juice used, the higher the protein detected. In addition, the study showed that cookies that had the highest protein content were cookies with the addition of 20% red dragon fruit juice.

3.8. Carbohydrate content

There was an effect of the factor of using the ratio of konjac tuber flour and jack bean flour, as well as the influence of the factor of using the proportion of red dragon fruit concentrate on the carbohydrate content of cookies. However, there was no significant effect of the interaction between factors, on the levels of carbohydrates produced.

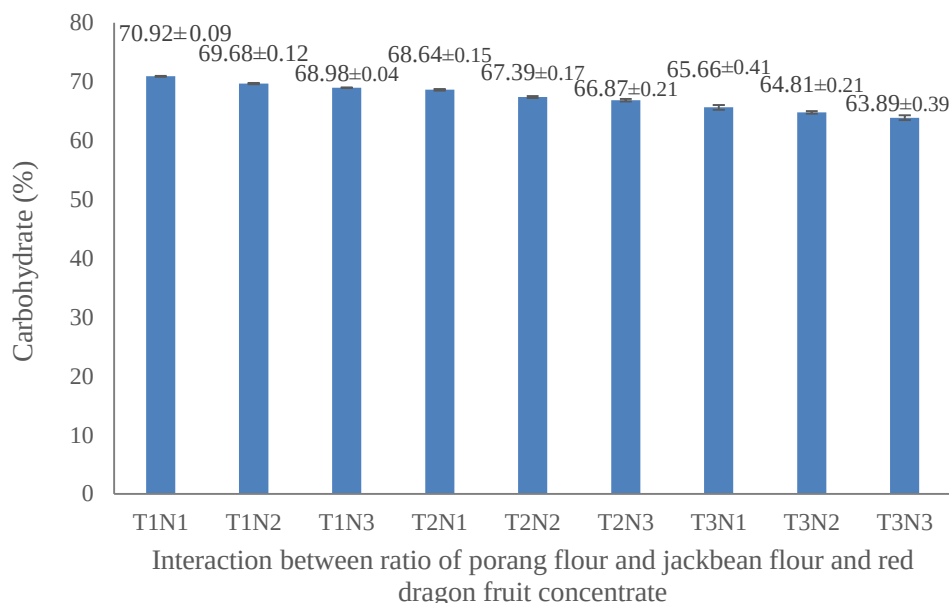


Figure 8. The effect of interaction between ratio of konjac flour and jackbean flour and red dragon fruit concentrate to the carbohydrate content of cookie

The more konjac flour will increase the carbohydrate content produced in the cookies. The combination of treatments with the highest carbohydrate value was obtained from sample T1N1 in which the combination of treatments used a ratio of using konjac tuber flour and jack bean flour of 80:20. Meanwhile, the lowest value was obtained from the T3N3 sample with the use of a ratio of konjac tuber flour and jack bean flour of 60:40. According to Laignier et al. (2022) [9], carbohydrate content of konjac tuber flour was 43.38%. Glucomannan is a type of complex carbohydrate that is superior to konjac tubers. Carbohydrates in konjac consist of starch, glucomannan, crude fiber, and reducing sugar. The more the ratio of konjac tuber flour is used, the higher the carbohydrate value produced will be. In addition to the use of konjac tuber flour, the proportion of dragon fruit concentrate also affects the carbohydrate content of functional cookies, though based on analysis of varians, the supplementation of concentrate didn't make the cookies have a higher carbohydrate. According to Ismail et al. (2012) [41] the carbohydrate content of red dragon fruit has a value of 1.48 grams.

3.9. The Best Cookies Formulation

The best treatment combinations were selected using effectiveness index analysis to obtain the best one sample, and the results was T1N1. The T1N1 sample consisted of the use of konjac flour and jack bean flour as much as 80:20, and dragon fruit concentrate of 10%. This product has a moisture content than the provision of biscuit quality [37], which is 5.64%, but the others parameters were fulfil.

Table 2. The results of index effectiveness

Parameter	Component alternative scores								
	T1N1	T1N2	T1N3	T2N1	T2N2	T2N3	T3N1	T3N2	T3N3
Water content	0,30	0,08	0,00	0,71	0,54	0,51	1,00	0,88	0,80
Ash content	0,44	0,00	0,11	0,67	0,33	0,28	1,00	0,89	0,72
Crude protein	0,00	0,03	0,08	0,45	0,50	0,53	0,86	0,94	1,00
Crude fat	1,00	0,88	0,78	0,68	0,52	0,45	0,25	0,13	0,00
Carbohydrate	1,00	0,82	0,72	0,68	0,50	0,42	0,25	0,13	0,00
Yield	0,21	0,65	1,00	0,00	0,27	0,63	0,00	0,27	0,29
Color	0,00	0,52	0,68	0,27	0,62	0,74	0,40	0,72	1,00

Parameter	Component alternative scores								
	T1N1	T1N2	T1N3	T2N1	T2N2	T2N3	T3N1	T3N2	T3N3
Aroma	1,00	0,74	0,30	0,94	0,60	0,20	0,77	0,37	0,00
Texture	0,69	0,19	0,00	0,84	0,61	0,46	1,00	0,76	0,47
Taste	0,49	0,60	1,00	0,38	0,49	0,56	0,00	0,16	0,19
Flavour	1,00	0,56	0,48	0,75	0,44	0,38	0,33	0,33	0,00
Aftertaste	1,00	0,97	0,86	0,78	0,74	0,71	0,44	0,27	0,00
Overall acceptability	1,00	0,61	0,54	0,65	0,40	0,47	0,44	0,14	0,00
Total Skor	9,38	7,85	7,61	8,75	7,49	7,22	7,30	6,31	4,48

By the sensory attributes, the color detected by the T1N1 sample tends to have a low value of 1.6 with a dark brown description. However, based on other sensory attributes, the panelists assessed that there was a good reception of T1N1. This is due to the low formulation jack bean flour as the cause of the unpleasant aroma, and gives a bitter aftertaste. Thus, after analyzing the effectiveness index, the best value was obtained from the T1N1 treatment combination.

4. Conclusions

The ratio of the use of konjac tuber flour and jack bean flour, as well as the proportion factor of the use of dragon fruit concentrate can have an effect on moisture content, ash content, fat content, total protein content, carbohydrate content, and yield of the resulting cookies. In addition to the results of sensory analysis, the results showed a significant effect of the use of the ratio of flour and dragon fruit concentrate, on the attributes of color, aroma, taste, texture, flavour, aftertaste, and overall acceptance of cookies.

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