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Development of Crackers Using Purple Yam Flour: Physicochemical and Sensory Characterization

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Abstract: Purple yam tuber is known to contain a lot of bioactive components useful for human health. This study was conducted to utilize the tuber in form of purple yam flour for crackers processing and to understand the effect of purple yam flour concentration on the characteristics of crackers. A completely randomized design was applied using several concentrations of purple yam flour (0, 10%, 20%, 30%, 40%, and 50%) and 3 replications. The concentration of purple yam flour affects volume expansion, color values (L*, a*, and b*) and anthocyanin content of the crackers, but did not affect its water content and texture. The higher concentration of purple yam flour decreased volume expansion, L*, b*, and overall acceptance of the crackers, but increased the anthocyanin content and a* values. This research proposes that 30% purple yam flour shall be applied to partly substitute wheat flour in crackers processing. At this concentration, crackers were accepted by the panelist (like it slightly) and has hardness value 287.2 gF, L* 70.35, a* 11.12, b* 20.18, 2.5% water, and anthocyanin content 179.6 mg cyanidin3-glucoside equivalent/g.

Keywords: Crackers; Physicochemical; Purple Yam Flour; Sensory

Introduction

Yam (*Dioscoreaalata*) is one of the potential natural resources of Jambi Province. Yam tubers are a carbohydrate-rich material and bioactive components that have the potential to be developed into functional food ingredient (Padhan et al., 2020; Shan et al., 2020; Ulyarti et al., 2021). Several studies on yam have revealed some basic characteristics of the tubers, including the chemical composition and the bioactive components (Padhan et al., 2020; Shan et al., 2020) and the nature of the starch granules of yam (Nadia et al., 2014; Ulyarti et al., 2021; Ulyarti et al., 2016). Further research on yam flour has only been limited to the manufacture of yam flour and optimization of its bioactive components (Imanningsih et al., 2013; Ulyarti & Fortuna, 2016; Ulyarti et al., 2016), the ability of yam flour to form a structure suitable for noodles (Lavlinesia et al., 2019), edible paper (Indrastuti et al., 2012) and bread (Amandikwa et al., 2015; Liu et al., 2019).

Crackers is a type of snacks with the fourth highest level of consumption after fried foods, cakes and sweet breads. According to the same source, stick crackers which are included in the fried snack category is in the first place of snack consumption in Indonesia in 2020. The high consumption of these types of snack provides opportunities for their development into functional foods that can have an impact on improving public health. Previous study on the inclusion of tef flours into crackers processing has shown that the inclusion reduced the available glucose and rapidly digestible starch (Rico et al., 2019).

Crackers are often consumed for their taste, long shelf life and relatively low price. Functional crackers began to be noticed with an increase in public awareness of the importance of consuming healthy food. Several studies on the development of functional crackers have been reported including crackers with the addition of lentil sprout extract (Polat et al., 2020), crackers from Hibiscus residue (Ahmed & Abozed, 2015) and gluten-

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free crackers from cactus mucilage and cladode flour (Dick et al., 2020). The characteristics of crackers products are strongly influenced by the ability of the ingredients to develop the dough (Nicole et al., 2021), therefore the formulation and processing techniques of crackers are very important in determining the quality of crackers.

The quality of crackers mainly lies in the characteristics of the main ingredients of the product. Wheat flour as the main ingredient for the product contains gluten which is important for the development of crackers. The absence of gluten in yam flour, can be overcome by adding protein isolate (Nicole et al., 2021) or protein extract (Polat et al., 2020) into crackers's dough, indeed could not replace gluten functionality. In addition, because the absorption capacity of yam flour is lower than that of wheat flour, the formulation of crackers must use the appropriate amount of water so that the dough can be formed well. One of the factors that determine the quality of the texture of crackers is the type and amount of fat sources used so that it needs to be considered in preparing the formulation (Espinosa-P´aez et al., 2021; Polat et al., 2020; Putri & Rahmawati, 2020). Based on these references, this study was performed to study the proposed formulation of crackers using several level of purple yam flour concentration and to understand the effect of the wheat substitution level on the characteristics of crackers.

Method

Material and Chemical

This research used purple yam tuber harvested at Jangkat, Bangko, Jambi Province, Indonesia. The chemicals used consisted of 95% methanol and HCl which were analytical grade. The instruments used in analysis consist of spectrophotometer, color reader Konica Minolta type CR-10 and Steven LFRA texture analyzer.

Research Design

This experiment was carried out using completely randomized design with 6 levels of wheat flour substitution and 4 replications. The levels of substitution were: P0= Purple yam flour 0% (control), P1= purple yam flour 10%, P2= Purple yam flour 20%, P3= Purple yam flour 30%, P4= Purple yam flour 40%, P5= Purple yam flour 50%.

Preparation of Yam Flour (Ulyarti et al., 2019)

Yam tubers were washed, peeled and sliced with a thickness of 0.5 cm. The slices were steamed at 100°C for 10 minutes, cooled, and dried in the oven at 50°C for 24 hours. The dried yam slices were ground and sieved using a 60 mesh sieves, packed in an air tight container, and stored at room temperature until further use.

Preparation of Crackers

First, the salt and water were placed in a bowl and stirred evenly using a spoon. In another bowl, the purple yam flour, wheat flour, yeast, powdered sugar, butter and margarine were mixed and stirred until homogeneous. The salt solution was added into the bowl, mixed and kneaded by hand until smooth. The dough was covered with a cloth to give chance for the dough underwent fermentation. The fermentation process was carried out for 30 minutes. The dough was further sheeted and cut into 5 cm x 3 cm length, 2 mm thick, and pricked to make small holes. The final step was the baking in the oven at 180°C for 30 minutes, cooling for 5 minutes at room temperature.

Hardness of Crackers

Crackers's hardnesswas measured using a Steven LFRATexture Analyzer. The instrument was set using"measure force in compression" mode, 3mm distance, and 0.5 mm/s speed. A cylindrical probe with a diameter of 2 mm and the auto type trigger wereused. The crackers was placed on the slab of the holding table and the start button was pressed. The probe was automatically search for the sample surface. The probe pressed the crackers and the hardness value was displayed on the tool display. Hardness values were expressed in units of gram force (gF).

Expansion Volume

The volume of raw crackers was obtained by measuring the length, width and height of the crackers (V1). The volume of baked crackers (V2) was obtained by calculating the difference between volume of flour in a measuring glass with and without crackers. The percentage of expansion volume of the crackers using the equation 1.

$$\text{Expansion Volume (\%)} = \frac{V2-V1}{V1} x100\% \quad (1)$$

Anthocyanin Content

Anthocyanin content was measured using a spectrophotometric method. A total of 1 gram of sample was extracted using 10 ml of methanol-acid solution prepared by mixing 95% methanol with 1 N HCl (85:15, v/v). The sample was streamed with nitrogen, shaken for 30 minutes and centrifuged at 3000g for 10 minutes. The supernatant was read at both 535 and 700 nm. The anthocyanin content was calculated using the Equation 2.

$C = \left\{\frac{A535\ nm - A700\ nm}{\varepsilon}\right\} x100$ x (total volume of methanolic extract) x MW x $\frac{1}{sample\ weight}$ (2)

where: C = Total anthocyanin content (mg cyanidin 3-glucoside equivalents/gram sample), ε = Molar absorptivity (for cyanidin 3-glucoside = 25.965/cm/M), MW = 449.2 g/mol.

Color Assessment

The assessment of color of the crackers was carried out using Konika Minolta CR-10 color reader. The reading of L*, a* and b* was taken 3 times and the average was reported as the value of the parameter.

Sensory Evaluation

The sensory properties were evaluated by 20 panelists using 5 scales of parameters including crunchiness, tastiness, and intensity of purple color. The panelists were given the sample of crackers and asked to give their impression after consumption on 5 scale sensory properties as seen in Table 1.

Table 1. The Sensory Scale

Scale	Crunchiness	Tastiness	Intensity of Purple Color
1	Very Crunchy	Very Tasty	Very Purple
2	Crunchy	Tasty	Purple
3	Slightly Crunchy	Slightly Tasty	Slightly Purple
4	Not Crunchy	Not Tasty	Not Purple
5	Very not Crunchy	Very Not Tasty	Very Not Purple

Data Analysis

The effect of the treatment on the parameters was determined using ANOVA. If the ANOVA showed a significant effect (p<5%), the data were further analyzed using DnMRT post-test.

Result and Discussion

The Physicochemical Properties

Crackers made by partial substitution of wheat using purple yam flour produced crackers with different physicochemical characteristics as shown in Table 2. The greater the substitution of wheat with purple yam flour, the lower the volume of expansion of the crackers. The level of substitution that can still be tolerated only reaches 10% when viewed from the main parameter, namely hardness. However, for the purposes of functionality, the level of substitution can still be made up to 30% (Giannoutsos et al., 2023). The increase in purple yam flour may cause the dough to be less compact leading to more brittle crackers. Need to analyze the cohesiveness of the crackers to confirm this. The hardness of the crackers depends on the viscoelasticity of the dough. The viscoelasticity of the dough is influenced by the dough formulation, type and amount of protein in particular (En Tay et al., 2022; Nicole et al., 2021).

The increase in purple yam flour substitution increased the anthocyanin content of the crackers. This bioactive component in crackers have been retained despite the high temperature in the baking process. Similar to this was also reported previously for bioactive in olive leaf flour (Faccioli et al., 2021).

The Color Properties

The most apparent effect of wheat substitution using purple yam flour in crackers was its color. The increase of purple yam flour reduced the lightness of the crackers produced as shown by its L* values (Table 3). The values of a* and b* were significantly affected by the concentration of purple yam flour in the dough formulation (Table 3). However, the color was not turn into purple but rather considered as brownish color. The change of color may be due to both oxidation of anthocyanin and Maillard reaction (Shen et al., 2018).

The Sensory Properties

The sensory properties of crackers were significantly affected by the concentration of purple yam flour (Table 4). The intensity of purple colour was increasing with the increasing amount of purple yam flour in the crackers. Relevant to the water content and the hardness values presented is presented in Table 2.

Table 2. The Physicochemical Properties

Purple Yam Flour (%)	Water content (%)^{ns}	Anthocyanin Content (mg cyaniding-3-glucoside/g)	Hardness (gF) ^{ns}	Expansion Volume (%)
0	2.51	0.23 ^{a}	536.10	1.82^{d}
10	2.51	51.32 ^{b}	484.90	1.43^{cd}
20	2.50	116.72 ^{c}	344.90	1.08^{bc}
30	2.50	179.58 ^{d}	287.20	0.84^{ab}
40	2.41	211.76 ^{e}	263.90	0.71 ^{ab}
50	2.39	253.04 ^{f}	259.70	0.51 ^{a}

NS = not significant (statistically, the treatment do not affect the parameter)
Numbers followed by the same superscript letter are not significantly different (p>5%) according to DnMRT

The increase in purple yam flour decreased the crunchiness of the crackers. Other author described the texture for crackers with term crispiness (Udomkun et al., 2020). The crispiness as described by the author may relate to the water content of the crackers. The crispy crackers were produced when moisture content reached 4%. The decrease in crunchiness of the crackers may be due to higher water absorption capacity of the purple yam flour when compared to wheat flour (Ulyarti et al., 2021) The presence of purple yam flour in the crackers formulation was not preferred by the panellist as shown by lower values of taste when compared to control (Table 4).

Table 3. The Color Properties of the Crackers

Purple Yam Flour (%)	*L**	*a**	*b**
0	66.10^{f}	8.23^{a}	31.78^{d}
10	55.40^{e}	10.82^{b}	22.52^{c}
20	50.40^{d}	11.01^{b}	21.33^{b}
30	47.35^{c}	11.12^{b}	20.18^{a}
40	45.73^{b}	11.18^{b}	20.14^{a}
50	43.10^{a}	11.18^{a}	20.09^{a}

Numbers followed by the same superscript letter are not significantly different (p>5%) according to DnMRT

Table 4. The Sensory Properties of the Crackers

Purple Yam Flour (%)	Intensity of purple color	Crunchiness	Taste
0	1.15^{a}	4.30^{c}	4.10^{b}
10	2.15^{b}	3.95^{bc}	3.65^{a}
20	2.90^{c}	3.75^{b}	3.65^{a}
30	3.50^{d}	3.65^{b}	3.80^{ab}
40	4.15^{e}	3.15^{a}	3.65^{a}
50	4.95^{f}	3.05^{a}	3.45^{a}

The numbers are following the scales in Table 1 Numbers followed by the same superscript letter are not significantly different (p>5%) according to DnMRT

Conclusion

Development of crackers using purple yam flour as a substitute for wheat flour should be done carefully as the concentration of purple yam flour affects volume expansion, color values and sensory properties of the crackers. The higher concentration of purple yam flour may increase the functionality of the product as its anthocyanin content is increased. This research suggests that maximum level of substitution for crackers is 30% purple yam flour.

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Author Contributions
This research was carried out in a team with specified contribution. Ulyarti for the conceptualization and methodology of the research, Septina Yuri Cahyati to handle the Laboratory work including formal analysis and investigation and original draft preparation, Dian Wulansari and Surhaini for project administration, Fitry Tafzi and YG Armando for the supervision, and Nazarudin for review and publication.

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Conflicts of Interest
Authors declare that no conflict of interest in the research.

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