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Effect of pre-treatment in the production of purple-fleshed sweet potato flour on cookies quality

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Abstract. The purpose of this research was to observe the effect of pre-treatment in the production of purple-fleshed sweet potato flour on cookies quality. There were four kinds of pre-treatment method (soaking in 2000 ppm sodium metabisulphite for 15 minutes, soaking in 2000 ppm sodium metabisulphite solution for 15 minutes followed by steam blanching for 5 minutes, steam blanching for 5 minutes and without pre-treatment as control). Data collected was analysed by using non factorial block design with 3 replicates. The results showed that the pre-treatment had highly significant effect on the colour, bulk density, moisture content and anthocyanin content of flour. The pre-treatment on flour processing had significant effect on cookies colour, volume expansion, hardness, moisture content, anthocyanin content, but had no significant effect on hedonic value of colour, aroma, taste, texture and overall acceptability of cookies. In conclusion, the best pre-treatment was soaking in 2000 ppm sodium metabisulphite solution for 15 minutes.

1. Introduction

In Indonesia, sweet potato is known as an edible tuber. Its young leaves and stems are often used as vegetables. The white or yellow fleshed sweet potato had a sweeter taste than red, purple, or orange fleshed [1]. Sweet potatoes hold the first rank in nutrition among vegetables [2]. The purple-fleshed sweet potato had the higher anthocyanins content. Anthocyanins are the most basic type of flavonoids from fruits and vegetables [3] and they are responsible for the variety of colours from orange to purple [4]. The range of colours they produce can be used as a natural dyes [5]. Anthocyanins are very reactive toward free radicals present in the body due to their particular chemical structure which have an electron deficiency [6], consequently enabling them become the source of antioxidants, has the ability as antimutagenic and anticarcinogenic, prevent disruption of liver function, anti-hypertension, antihyperglycemic and the ability to enhance memory [6-9].

The utilization of sweet potatoes in Indonesia is still limited to foodstuffs and raw materials for food industry. The limited shelf life of sweet potato due to its perishability [10] become a constraint in the processing. Sweet potato can be processed into flour, which is less bulky, more stable [10] and can be used as one way to increase national food security and diversification, lead to the reducing our dependency on the importing of wheat flour. The main problem in the processing of sweet potato flour is browning resulting from non-enzymatic (Maillard) reactions, caused mainly by reaction of reducing



sugars and amino acids at high temperature and also enzymatic browning caused by oxidation of phenols by polyphenol oxidase and peroxidase [11]. Blanching and soaking in sodium metabisulphite solution of sweet potato tubers or chips can reduce the deterioration during processing and improve acceptability of flour [11-12]. Therefore, the objective of this research was to study the effect of pre-treatment methods on the quality of flour and the made cookies from purple-fleshed sweet potato.

2. Materials and methods

The deep purple-fleshed sweet potato (PFSP) local varieties were purchased from farmers at Saree village, district Leumbah Seulawah, Aceh Besar, Indonesia. Other ingredients, such as margarine, eggs, salt, sugar and baking powder were purchased from a market in Medan, Indonesia.

2.1. Sample preparation and treatment

The clean tubers were peeled manually using stainless steel kitchen knife and sliced into 2 mm-thickness by using the slicer electric machine. The chips were divided into four different pre-treatment samples; (1) soaked in 2000 ppm sodium metabisulphite solution for 14 minutes (SM), (2) soaked in 2000 ppm sodium metabisulphite solution for 15 minutes followed by steam blanching for 5 minutes (SMB), (3) steam blanching for 5 minutes (B) and (3) without pretreatment or control (C).

2.2. Preparation of PFSP flour

Each pretreated sample was dried using cabinet dryer at a temperature of 55°C for about 20 hours. The dehydrated chips were milled in a disc mill to produce flour which passed through an 80 mesh sieve. The sweet potato flour obtained was packaged on a polyethylene plastic bag and stored at room temperature (28±2°C) for further analysis.

2.3. Analysis of the physical, chemical and sensory properties of PFSP flour samples

The colour of PFSP flour samples were measured using Hunter colour lab system (L*, a* and b* value) with Chroma meter CR-400 (Minolta Camera Co. Ltd., Tokyo, Japan). The colour of sample was calculated as $^{\circ}\text{Hue} = \tan^{-1} (b/a)$ [13]. The bulk density and browning index of flour was determined by using the method described by Youn and Choun [14] and Okaka and Potter [15] respectively. Moisture content of flour was analysed by using AOAC [16]. The total anthocyanin content of flour was analysed by spectroscopy method [17]. The hedonic test by 25 non-trained panellist was used to determine the sensory characteristics of flour and 9 point hedonic scale (9 = extremely like and 1 = extremely dislike) was used.

2.4. Cookies production

The formulation and process of cookies production was referred to Singh *et al.* [18] with a minor modification. PFSP flour (100 g), margarine (45 g), eggs (56 g), salt (1 g), sugar (30 g), baking powder (0.5 g) and water (depends on the consistency of the dough, until moldable dough was obtained). Margarine and sugar were mixed with a hand mixer at high speed for 3 minutes until it forms a smooth cream. Whole eggs were added and beaten for 3 minutes. Then, the PFSP flour, baking powder and cream and salt were added to the dough, stirred manually using a wooden spoon until all were completely blended. The dough was shaped using sheet roller until the dough thickness about 5 mm, then cut with a cookies cutter (mold) to obtain the uniform size, i.e. 50 mm. Pieces of cookies were placed on a baking sheet and baked using an oven toaster at approximate temperature of 180 °C for 35 minutes. The finished cookies were taken out, cooled and packaged in polyethylene plastic packaging, then kept in a plastic jar and stored at room temperature for 1 day prior to analysis. Cookies made of 100% wheat flour were used as a control.

2.5. Analysis of cookies quality

The physical, chemical and sensory quality of the cookies samples were determined. The colour of cookies was determined by using a Minolta Chroma Meter CR-400 (Minolta Camera Co., Ltd, Tokyo,

Japan) and the colour was expressed by L* value (lightness) and hue angle ($\tan^{-1} b/a$) [13]. Cookies hardness was determined using a Texture Analyser (TA-XT2, Stable Micro System) according to AACC Method [19]. Spread factor of cookies were found by measuring the cookies width and thickness according to the AACC method [19]. The specific volume was determined by the displacement seed method and calculated according to AACC method [19]. Moisture and anthocyanin content of cookies were determined according to the AOAC method [16] and Giusti and Wrolstad method [17] respectively. Cookies samples were organoleptically evaluated for their sensory characteristics. Hedonic score with 9 point (9=extremely like and 1= extremely dislike) was used for the colour, aroma, taste, texture, crispiness and overall acceptability of cookies.

2.6. Data analysis

Data using a randomized block design were analysed using SPSS ver.22 for windows. The data reported in all Tables are average of triplicate observations subjected to one-way analysis of variance (ANOVA). Differences among the ranges of the properties were determined using the method of Least Significant Ranges (LSR) tests at 95% confidence ($P < 0.05$).

3. Results and Discussions

3.1. Effect of pre-treatment on physical, chemical and sensory properties of PFSP flour

Table 1 shows a significant difference at 5% level in the value of °Hue, L*, a*, b* and bulk density, but there was no significant difference in the browning index. PFSP flour made from pre-treatment by soaking chips in sodium metabisulphite solution had higher L* (lightness) value and lower °Hue, browning index and bulk density. This implies that the sodium metabisulphite pretreatment results in prevention of enzymatic browning of the flour [12]. The reduced °Hue value from 22.61 in control to a range of 13.55 – 19.13 on the pretreated flour samples were obtained. It was influenced by the stability of the anthocyanin pigment (cyanidin and peonidin) which contributed in the formation of blue or purple hue on PFSP [20]. The sodium metabisulphite pretreated PFSP flour recorded the lowest b* value among the pretreatment methods. This result shows that the sodium metabisulphite pre-treated PFSP flour was less yellow than the other samples. The positive a* values obtained from all of flour samples indicated that the colour of flour is more red.

Table 1. The effects of pre-treatment on physical properties of PFSP flour¹⁾

Parameter	Pre-treatment			
	SM	SMB	B	C
Colour (°Hue)	13.55±1.03 ^c	17.78±0.50 ^b	19.13±0.95 ^b	22.62±1.77 ^a
L* value	54.68±0.49 ^a	52.21±0.98 ^b	48.25±1.19 ^c	50.14±0.72 ^c
a* value	10.96±0.20 ^a	11.16±0.15 ^a	9.22±0.36 ^b	10.00±0.58 ^b
b* value	2.64±0.18 ^d	3.21±0.10 ^b	3.19±0.05 ^c	4.16±0.28 ^a
Browning index	0.54±0.02	0.61±0.03	0.60±0.02	0.61±0.04
Bulk density (g/mL)	0.59±0.01 ^b	0.69±0.00 ^a	0.70±0.03 ^a	0.63±0.04 ^b

¹⁾ SM= soaking in 2000 ppm sodium metabisulphite solution for 15 minutes. SMB = soaking in 2000 ppm sodium metabisulphite solution for 15 minutes followed by steam blanching for 5 minute. B = steam blanching for 5 minutes. C = without pre-treatment (control).

The values are expressed as the mean of three replicates.

A number followed by different letters in a row show significantly different ($P < 0.05$) with LSR test.

Table 2 shows a significant difference ($P < 0.05$) in the lowest moisture content of flour was found in the blanching pretreated sample, but the higher anthocyanin content was found in sodium metabisulphite pretreated PFSP flour. Blanching has been reported to improve the drying rates of

green peppers [21]. Blanching can increase the cell walls permeability and faster the water migration to the surface for removal [22]. Sulphur content in sodium metabisulphite can both maintain the stability of anthocyanin and also the colour value. This happens because sodium metabisulphite protects the colour compounds from materials [23].

Table 2. Effect of pre-treatment methods on chemical properties of PFSP flour¹⁾

Pre-treatment	Parameters	
	Moisture content (% wb)	Anthocyanins content (mg/L)
SM	6.15±0.11 ^{ab}	387.42±9.72 ^a
SMB	5.76±0.26 ^b	237.92±7.87 ^b
B	4.93±0.80 ^c	162.30±6.98 ^c
C	6.85±0.11 ^a	231.52±8.78 ^b

¹⁾ SM= soaking in 2000 ppm sodium metabisulphite solution for 15 minutes. SMB = soaking in 2000 ppm sodium metabisulphite solution for 15 minutes followed by steam blanching for 5 minute. B = steam blanching for 5 minutes. C = without pre-treatment (control).

The values are expressed as the mean of three replicates.

A number followed by different letters in a row show significantly different (P <0.05) with LSR test.

Table 3 shows that there is no significant difference in hedonic values of colour and aroma among the flour samples. The sensory of colour and aroma for all sweet potato flour were liked slightly – moderately.

Table 3. The effects of pre-treatment methods on sensory properties of PFSP flour¹⁾

Pre-treatment methods	Hedonic values	
	Colour	Aroma
SM	5.97±0.12	5.20±0.16
SMB	5.51±0.58	4.60±0.28
B	5.27±0.19	4.73±0.15
C	5.32±0.18	4.88±0.24

¹⁾ SM= soaking in 2000 ppm sodium metabisulphite solution for 15 minutes. SMB = soaking in 2000 ppm sodium metabisulphite solution for 15 minutes followed by steam blanching for 5 minute. B = steam blanching for 5 minutes. C = without pre-treatment (control).

The values are expressed as the mean of three replicates.

3.2. Quality of cookies from the pre-treated PFSP flour

There were significant differences (P<0.05) on all parameters of physical characteristics of cookies except spread factor (Table 4). Cookies of PFSP flour made from steam blanching treatment chips (B) had higher °Hue value. Cookies of PFSP flour made from chips soaking in sodium metabisulphite solution (SM) had higher value of L*, a*, b* and hardness. Cookies of PFSP flour made from chips soaking in sodium metabisulphite solution followed by steam blanching (SMB) had higher specific volume. The differences of the cookies colour were due to the differences in PFSP flour colour and also Maillard reactions and caramelization during baking. Maillard tanning was due to the reaction of carbonyl compounds derived from the breakdown of carbohydrates or fats with amino compounds in the material. The caramelization occurred because the material was heated at high temperature [24]. Anthocyanins were positively associated with redness [25]. The specific volume of PFSP cookies was influenced by the fibre content of sweet potato flour [18] [26].

Table 4. The effect of pre-treatment on physical quality of cookies from the pre-treated PFSP flour¹⁾

Parameter	Pre-treatment			
	SM	SMB	B	C
Colour (°Hue)	28.94±2.28 ^b	34.22±2.66 ^a	36.39±2.11 ^a	29.21±0.77 ^b
L* value	26.35±1.23 ^a	23.70±0.37 ^b	24.08±0.34 ^b	24.34±1.14 ^b
a* value	4.29±0.29 ^a	3.62±0.08 ^b	2.67±0.28 ^c	3.47±0.12 ^b
b* value	2.37±0.08 ^a	2.47±0.23 ^a	1.96±0.19 ^b	1.94±0.07 ^b
Specific Volume (cm ³ /g)	58.02±0.26 ^b	62.11±1.52 ^a	52.87±0.35 ^c	59.14±0.65 ^b
Spread factor	7.17±0.34	7.08±0.31	7.16±0.48	6.91±0.54
Hardness	3994.00±93.98 ^a	3132.50±289.68 ^b	2578.42±151.71 ^{bc}	2526.24±359.84 ^c

¹⁾ SM= soaking in 2000 ppm sodium metabisulphite solution for 15 minutes. SMB = soaking in 2000 ppm sodium metabisulphite solution for 15 minutes followed by steam blanching for 5 minute. B = steam blanching for 5 minutes. C = without pre-treatment (control).

The values are expressed as the mean of three replicates.

A number followed by different letters in a row show significantly different (P <0.05) with LSR test.

Table 5. The effects of pre-treatment on chemical quality of cookies from the pre-treated PFSP flour¹⁾

Pre- treatment	Parameter	
	Moisture content (% wb)	Anthocyanins(mg/L)
SM	4.34±0.37 ^b	138,45±3,02 ^a
SMB	3.79±0.24 ^c	58,75±7,05 ^c
B	3.58±0.08 ^c	34,32±1,01 ^d
C	4.76±0.18 ^a	117,51±5,33 ^b

¹⁾ SM= soaking in 2000 ppm sodium metabisulphite solution for 15 minutes. SMB = soaking in 2000 ppm sodium metabisulphite solution for 15 minutes followed by steam blanching for 5 minute. B = steam blanching for 5 minutes. C = without pre-treatment (control).

The values are expressed as the mean of three replicates.

A number followed by different letters in a row show significantly different (P <0.05) with LSR test

Table 6. The effect of pre-treatment on sensory quality of cookies from pre-treated PFSP flour¹⁾

Parameter	Pre-treatment			
	SM	SMB	B	C
Hedonic values				
Colour	5.83±0.30	5.81±0.16	5.84±0.17	5.95±0.16
Aroma	4.93±0.28	5.08±0.37	5.01±0.25	5.17±0.06
Taste	4.97±0.22	5.12±0.26	4.93±0.22	5.00±0.17
Texture	5.69±0.06	5.49±0.57	5.92±0.11	5.31±0.47
Crispiness	5.77±0.12	5.69±0.64	6.28±0.28	5.55±0.47
Overall acceptability	5.77±0.02	5.67±0.35	6.08±0.14	5.56±0.32

¹⁾ SM= soaking in 2000 ppm sodium metabisulphite solution for 15 minutes. SMB = soaking in 2000 ppm sodium metabisulphite solution for 15 minutes followed by steam blanching for 5 minute. B = steam blanching for 5 minutes. C = without pre-treatment (control).

The values are expressed as the mean of three replicates.

Table 5 shows a significant difference (P<0.05) on moisture and anthocyanins content of cookies. The cookies of PFSP flour from chips steam blanching (B) produced lower moisture content. Moisture content in cookies was influenced by PFSP flour moisture content. Therefore, the lower moisture

content of the cookies was due to the lowest moisture content of PFSP flour with steam blanching pre-treatment. In contrast, the cookies of PFSP flour from chips soaking in sodium metabisulphite solution (SM) produced higher anthocyanins.

Table 6 shows no significant difference ($P > 0.05$) on hedonic values of colour, aroma, taste, texture, crispiness and overall acceptability of cookies from pre-treated PFSP flour. In general, cookies made from PFSP treated flour can be accepted by panellist (liked slightly – moderately).

4. Conclusion

The study indicates that pre-treatment affects resulted PFSP flour and also the quality of cookies. PFSP cookies were made from PFSP flour pretreated by soaking in 2000 ppm sodium metabisulphite for 15 minutes is more acceptable according to its sensorial characteristics and had adequate content of anthocyanin. Purple-fleshed sweet potato is an acceptable and an alternative crop that could be used in the production of cookies.

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