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Effect of pre-treatment in the making of purple-fleshed sweet potato flour towards cake characteristics

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Abstract. The purpose of this research was to find the effect of pre-treatment in the making of purple flesh sweet potato flour on cakes quality. The research was using factorial randomized block design with one factor, the methods of pre-treatment namely (P): (blanching, 2000 ppm soaking in sodium metabisulphite, soaking in 2000 ppm sodium metabisulphite followed by blanching and control). The results showed that the pre-treatment had highly significant effect on the colour value L, a, b and °hue, browning index, water content and organoleptic test value of colour and had no significant effect on bulk density and organoleptic test value of aroma of the purple-fleshed sweet potato flour. The best cake was the cake made with purple-fleshed sweet potato flour with pre-treatment of blanching with 495.62 mg/L anthocyanin content, 274.08 µg/ml antioxidant activity (IC₅₀), 22.9% moisture content and accepted organoleptic values. The result finding suggests that purple-fleshed sweet potato flour is recommended as alternative flour in producing cakes.

1. Introduction

Sweet potato is a staple food in many of the developing countries. It is consumed both fresh and in the processed forms [1]. It is a potential food commodity in improving food security in Indonesia. It does not require high levels of inputs, yet it contains high amount of dry matter and it is able to grow in a wide range of agro-climates and farming systems [2]. Sweet potato plant is quite resistant, therefore application of herbicides, insecticides and fungicides are often not necessary [1].

Sweet potato has high nutrients and tastes slightly sweeter than wheat flour. In every 100 g of sweet potato contains 46 mg Ca, 25 mg Mg, 50 mg P, 337 mg K, 0.3 mg Zn, 0.8 mg Fe, 0.8 mg ascorbic acid, 24 mg niacin, 0.8 mg pantothenic acid and 11 µg folic acid. The fresh sweet potato contains up to 27.9% carbohydrate and 68.5% moisture content and its flour contains up to 85,26% carbohydrate and 7% moisture content. Compared to wheat flour, sweet potato flour has more fibre and ash content [3]. Fresh sweet potato has low protein content but the average protein production/ha from sweet potato is same that of cereals, beans and chickpeas [1].

PFSP (Purples-fleshed sweet potato) is considered a healthy food due to its anthocyanin accumulation. Purple-fleshed potato has high antioxidant activity due to anthocyanin [4]. Anthocyanin is claimed to have many health benefits such as anti-carcinogen, anti-inflammation, anti-bacteria, anti-virus, anti-allergy, anti-thrombotic and antioxidant [5].



Processing sweet potato into flour is done to enhance its storage quality due to drying process. In addition to that, flour can be combined with other flours (composite flour) to create a flour with desired nutritional value. However, the nutritional values in sweet potato decrease as sweet potato undergo processing. Therefore, pre-treatments such as blanching, soaking in sodium metabisulphite or both combined are expected to maintain the effect of processing towards nutritional value of purple-fleshed sweet potato at minimal.

Produced purple-fleshed sweet potato flour is made into a cake to see how pre-treatments in the making of the flour affect physical, chemical and sensory property of the cake. Cake is chosen as the final product of this research because it is a popular dessert favourable by many of any ages. It is often served in many community and social events. Cake made from purple-fleshed potato flour is an innovation in an effort to improve the utilisation of purple-fleshed sweet potato.

2. Materials and methods

2.1. Materials

Purple-fleshed sweet potato was purchased from farmers in Berastagi, North Sumatra Province, Indonesia. Ingredients in the making of cake, such as eggs, sugar, skimmed milk, margarine, vanilla flavouring, baking powder, were purchased from a local market in Medan.

2.2. Sample preparation and treatments

The roots were washed from dirt and manually peeled with a stainless steel peeler. The peeled roots were sliced using mechanical root slicer into chips. Chips were divided into four portions, three of which are to undergo pre-treatments which are: 5-minute steam blanching, soaking in aqueous 2000 ppm sodium metabisulphite for 15 minutes, soaking in aqueous 2000 ppm sodium metabisulphite for 15 minutes followed by 5-minute steam blanching, a portion is for control (without pre-treatment).

2.3. Preparation of purple-fleshed sweet potato

The treated chips were dried in a drying oven at 55°C for 12 hours. Dried chips were milled using a disc mill and sieved manually using 80-mesh sieve. The flours were then packaged in sealed polyethylene bags and stored at room temperature ($28 \pm 2^\circ\text{C}$).

2.4. Analyses of purple-fleshed sweet potato flours

There were analyses of physical, chemical and sensory properties. Physical properties analyses were L, a, b, $^{\circ}\text{hue}$ colour, browning index and bulk density. L, a, b colour was determined using Minolta Chroma meter Cr-400. Browning index was determined using the method described by Youn and Choi [6]. Bulk density was determined using the method described by Okaka and Potter [7]. Chemical properties analyses were moisture content and anthocyanin content. Moisture content was determined using the method described in [8]. Anthocyanin content was determined using the method described by [9]. Sensory properties analysis was organoleptic test of colour, aroma, taste, texture and overall acceptability. The organoleptic test was undertaken with 25 panellists (students of University of Sumatra Utara) with hedonic scale ranging from 1-9 (1 = very very dislike, 9 = very very like).

2.5. Cakes production

Each pre-treated purple-fleshed sweet potato flour was made into cakes according to formula by [10]. The ingredients were 100 g of sweet potato flour, 3 g of baking powder, 125 g of eggs, 100 g of sugar, 50 g of skimmed milk, 10 g of margarine, 2 g of vanilla flavouring [10]. Each cake was made using the same method. The first mixture was manually blended flour and baking powder. The second mixture was the mixture of egg, sugar, skimmed milk, margarine and vanilla which were mixed using hand mixer at high speed for 6 minutes. The first mixture was then gradually added to the second mixture and mixed at low speed for 3 minutes. The dough was then poured into baking pan and baked

in an oven at 180 °C for 35 minutes. The cakes were allowed to cool at room temperature for 30 minutes.

2.6. Analyses of purple-fleshed sweet potato cake

There were analyses of physical, chemical and sensory properties. Physical properties analyses were L, a, b, °hue colour of crumb and crust, specific volume and texture profile analyses: hardness, cohesiveness, chewiness, springiness and %deformation. L, a, b colour was determined using Minolta Chroma meter Cr-400. Specific volume was determined using modified rapeseed displacement test in [11], the modification was that rapeseed was replaced with sesame. Texture profile of the cakes was determined using Brookfield AMETEK CT-3 Texture Analyser. Chemical properties analyses were moisture content and anthocyanin content. Sensory properties analysis was organoleptic test of colour, aroma, taste, texture and overall acceptability. The organoleptic test was undertaken with 25 panellists (students of University of Sumatra Utara) with hedonic scale ranging from 1-9 (1 = very very dislike, 9 = very very like). Antioxidant activity of the best cake was analysed using the method described by [12]. The best cake was determined using effectivity index [13].

2.7. Data analyses

Obtained data were analysed using one-way ANOVA (Randomized Blocks Design) with IBM SPSS Statistics 23 for Windows. The data shown in tables were the average of triplicate observations. Statistically significant differences in ANOVA result will be analysed further using Least Significant Range (LSR) test at 95% ($P < 0.05$) and 99% ($P < 0.01$) confidence level.

3. Results and discussions

3.1. Effect of pre-treatment on physical properties of PFSP flour

Table 1 shows that there was a significant difference at 95% ($P < 0.05$) and 99% ($P < 0.01$) in L (lightness), a, b, °hue and browning index, but show no significant difference in bulk density.

Table 1. Effect of pre-treatment on physical properties of PFSP flours

Physical properties	Pre-treated Flours			
	P ₁	P ₂	P ₃	P ₄
L	39.89±0.16 ^{b,B}	42.51±1.28 ^{a,A}	39.92±0.33 ^{b,B}	42.04±0.61 ^{a,A}
A	6.82±0.24 ^{bc,B}	7.08±0.38 ^{b,B}	8.85±0.9 ^{a,A}	5.98±0.12 ^{c,B}
B	2.67±0.17 ^{a,A}	1.64±0.06 ^{b,B}	1.47±0.17 ^{b,B}	2.82±0.18 ^{a,A}
°Hue	21.43±1.45 ^{c,B}	13.06±0.36 ^{b,A}	9.48±1.19 ^{a,A}	25.27±1.49 ^{d,C}
Bulk density (g/ml)	0.78± 0.03	0.74± 0.03	0.81±0.01	0.78±0.03
Browning index	0.71±0.02 ^{a,A}	0.62±0.04 ^{b,AB}	0.58±0.06 ^{b,B}	0.73±0.07 ^{a,A}

Note: Data shown are the average of triplicate observations and ± shows standard deviation. Superscript letters in the table show significant difference at 95% confidence level (lower case letter) and 99% confidence level (upper case letter) of LSR test.

P₁ = steam blanching

P₂ = soaking in aqueous 2000 ppm sodium metabisulphite

P₃ = soaking in aqueous 2000 ppm sodium metabisulphite followed by steam blanching

P₄ = control

The significant difference of L value at each pre-treatment was probably due to heat involvement in steam blanching pre-treatment which caused caramelisation or pigment degrading resulting in darker colour [14]. P₃ treatment had the highest a (redness index), lowest b (yellowness index) value and

lowest browning index value which was probably due to the combined pre-treatment of steam blanching and sodium metabisulphite soaking that was capable of maintaining anthocyanin pigment and reducing browning process in PFSP flour [15-16].

3.2. Effect of pre-treatment on chemical properties of PFSP flours

Table 2 shows that there was a significant difference at 95% ($P < 0.05$) and 99% ($P < 0.01$) in moisture content and anthocyanin content. P_3 had the highest anthocyanin content whereas P_4 had the lowest anthocyanin content. This was probably due to the combined pre-treatment of steam blanching and sodium metabisulphite soaking that was capable of maintaining anthocyanin pigment [15-16]. Anthocyanin content in P_3 was related to and positively affected a (redness index) value.

Table 2. Effect of pre-treatment on chemical properties of PFSP flours

Pre-treated flours	Chemical properties	
	Moisture content (%)	Anthocyanin content(mg/L)
P_1	$6.33 \pm 0.42^{a,A}$	$839.1233 \pm 122.33^{b,BC}$
P_2	$4.94 \pm 0.23^{b,B}$	$1,135.216 \pm 100.6^{a,AB}$
P_3	$4.37 \pm 0.26^{bc,B}$	$1,180.8806 \pm 41.82^{a,A}$
P_4	$4.04 \pm 0.11^{c,B}$	$559.9003 \pm 114.4^{c,C}$

Note: Data shown are the average of triplicate observations and \pm shows standard deviation. Superscript letters in the table show significant difference at 95% confidence level (lower case letter) and 99% confidence level (upper case letter) of LSR test.

P_1 = steam blanching

P_2 = soaking in aqueous 2000 ppm sodium metabisulphite

P_3 = soaking in aqueous 2000 ppm sodium metabisulphite followed by steam blanching

P_4 = control

3.3. Effect of pre-treatment on sensory properties of PFSP flours

Table 3 shows that there was a significant difference at 95% ($P < 0.05$) and 99% ($P < 0.01$) in organoleptic value of colour. P_2 had the highest organoleptic value of colour which was probably due to the high anthocyanin content hence its intense purple colour which was favourable by the panellists.

Table 3. Effect of pre-treatment on sensory properties of PFSP flours

Pre-treated flours	Parameter	
	Organoleptic value of colour	Organoleptic value of aroma
P_1	$4.81 \pm 0.24^{bc,AB}$	4.6 ± 0.39
P_2	$6.33 \pm 0.27^{a,A}$	4.87 ± 1.07
P_3	$5.48 \pm 1.06^{ab,A}$	4.67 ± 0.34
P_4	$3.85 \pm 0.46^{c,B}$	4.29 ± 0.34

Note: Data shown are the average of triplicate observations and \pm shows standard deviation. Superscript letters in the table show significant difference at 95% confidence level (lower case letter) and 99% confidence level (upper case letter) of LSR test.

P_1 = steam blanching

P_2 = soaking in aqueous 2000 ppm sodium metabisulphite

P_3 = soaking in aqueous 2000 ppm sodium metabisulphite followed by steam blanching

P_4 = control

3.4. Effect of pre-treatment on physical properties of PFSP cake

Table 4 shows that there was a significant difference at 95% ($P < 0.05$) and 99% ($P < 0.01$) in a, b, °hue for both crust and crumb and shows no significant difference in L value for both crust and crumb, specific volume, hardness, cohesiveness, chewiness, springiness and %deformation. L value for both crust and crumb shows no significant difference but a, b, °hue for both crust and crumb had the same pattern as PFSP flours. Each treatment affected a, b and °hue value of both flour and cake in a similar way resulting in consistent value of a, b, °hue of each treatment for both cake and flour.

Table 4. Effect of pre-treatment on physical properties of PFSP cake

Physical properties	Pre-treated flours			
	P ₁	P ₂	P ₃	P ₄
L crust	32.303±0.65	33.553±0.32	31.916±0.56	33.266±0.56
a crust	7.38±0.2 ^{b,B}	7.96±0.14 ^{a,A}	8.19±0.21 ^{a,A}	7.33±0.09 ^{b,B}
b crust	8.14±0.13 ^{b,B}	7.01±0.10 ^{c,C}	6.6±0.21 ^{d,C}	8.69±0.15 ^{a,A}
°Hue crust	47.806±1.17 ^{a,A}	41.370±0.14 ^{b,B}	38.85±1.44 ^{c,B}	49.837±0.62 ^{a,A}
L crumb	22.72±0.95	24.24±0.34	22.75±0.41	23.81±0.38
a crumb	4.21±0.10 ^{bc,BC}	4.43±0.18 ^{b,B}	5.59±0.29 ^{a,A}	3.83±0.09 ^{bc,C}
b crumb	1.01±0.07 ^{a,AB}	0.81±0.04 ^{b,BC}	0.63±0.04 ^{c,C}	1.13±0.12 ^{a,A}
°Hue crumb	13.46±0.72 ^{b,AB}	10.41±0.9 ^{c,B}	6.45±0.31 ^{d,C}	16.48±1.41 ^{a,A}
Specific volume (ml/g)	1.45±0.0293	1.55±0.0548	1.41±0.0157	1.53±0.0711
Hardness(g)	694±114.55	710±2.12	758±71.77	687±22.63
Cohesiveness	0.32±0.04	0.33±0.04	0.36±0.6	0.34±0.04
Chewiness (g/mm)	1011.75±201.7	1066.1±102.1	1469.38±150	1201.055±27.9
Springiness	6.04±0.79	4.925±0.52	5.125±0.4	5.435±0.18
% Deformation	29.07±2.37	27.61±3.32	27.81±3.76	24.95±3.32

Note: Data shown are the average of triplicate observations and ± shows standard deviation. Superscript letters in the table show significant difference at 95% confidence level (lower case letter) and 99% confidence level (upper case letter) of LSR test.

P₁ = steam blanching

P₂ = soaking in aqueous 2000 ppm sodium metabisulphite

P₃ = soaking in aqueous 2000 ppm sodium metabisulphite followed by steam blanching

P₄ = control

3.5. Effect of pre-treatment on chemical properties of PFSP cake

Table 5 shows that there was a significant difference at 95% ($P < 0.05$) and 99% ($P < 0.01$) significant level in anthocyanin content. Anthocyanin content in PFSP cake had the same pattern as PFSP flour. This was probably due to the combined pre-treatment of steam blanching and sodium metabisulphite soaking that was capable of maintaining anthocyanin pigment.

Table 5. Effect of pre-treatment on chemical properties of PFSP cake

Pre-treated flours	Chemical properties	
	Moisture content (%)	Anthocyanin content (mg/L)
P ₁	22.90±0.76	247.8104±14.91 ^{a,A}
P ₂	19.38±0.26	273.4059±17.63 ^{a,A}
P ₃	19.4674±2.91	281.259±20.38 ^{a,A}

P ₄	19.92±0.85	94.5286±20.38 ^{b,B}
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Note: Data shown are the average of triplicate observations and ± shows standard deviation. Superscript letters in the table show significant difference at 95% confidence level (lower case letter) and 99% confidence level (upper case letter) of LSR test. P₁ = steam blanching, P₂ = soaking in aqueous 2000 ppm sodium metabisulphite, P₃ = soaking in aqueous 2000 ppm sodium metabisulphite followed by steam blanching, P₄ = control

3.6. Effect of pre-treatment on sensory properties of PFSP cakes

Table 6 shows that there was no significant difference for all organoleptic parameters at all levels. The cake had the average scale of 6 (like) for all sensory parameters which indicate PFSP cakes were accepted by the panellists.

Table 6. Effect of pre-treatment on sensory properties of PFSP cake

Organoleptic tests	Pre-treated flours			
	P ₁	P ₂	P ₃	P ₄
Color	6.133±0.16	6.04±0.84	6.04±0.20	5.9467±0.28
Aroma	6.2267±0.22	6.1467±0.46	6.0267±0.17	6.0533±0.17
Taste	6.4±0.36	6.1467±0.85	6.16±0.21	6.1467±0.18
Texture	6.1867±0.26	6.0533±0.76	5.8667±0.06	6.0267±0.08
Overall acceptability	6.0667±0.29	6.0267±0.71	5.92±0.08	5.84±0.16

Note: Data shown are the average of triplicate observations and ± shows standard deviation. Superscript letters in the table show significant difference at 95% confidence level (lower case letter) and 99% confidence level (upper case letter) of LSR test. P₁ = steam blanching, P₂ = soaking in aqueous 2000 ppm sodium metabisulphite, P₃ = soaking in aqueous 2000 ppm sodium metabisulphite followed by steam blanching, P₄ = control

3.7. Chemical properties of the best PSFP cake determined with DeGarmo effectivity index

The best cake was the cake with blanching pre-treatment. The best cake was chosen based on anthocyanin content, organoleptic value of colour; aroma; taste; texture, specific volume and moisture content.

Table 7. Chemical properties of the best PSFP cake determined with DeGarmo effectivity index

Chemical properties	Fresh root	PFSP Flour	PFSP Cake
Moisture content (%)	67.394	6.3347±0.42	22.90±0.76
Anthocyanin content (mg/L)	1676.5014	839.1233±122.33	247.8104±14.91
IC50 (µg/ml)	111.7434	155.98	274.08

Note: Data shown are the average of triplicate observations and ± shows standard deviation. Superscript letters in the table show significant difference at 95% confidence level (lower case letter) and 99% confidence level (upper case letter) of LSR test, P₁ = steam blanching, P₂ = soaking in aqueous 2000 ppm sodium metabisulphite, P₃ = soaking in aqueous 2000 ppm sodium metabisulphite followed by steam blanching, P₄ = control

4. Conclusion

It is concluded that PFSP cake made from steam blanching pre-treated flour was the best cake. It has 22.9% moisture content, 247.81 mg/L anthocyanin and 274.08 µg/ml IC50 antioxidant activity. Purple-fleshed sweet potato flour is a recommended alternative in the making of cakes.

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