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The effect of pre-treatment in orange-fleshed sweet potato (OFSP) flour manufacturing process on cake's quality

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Abstract. Orange-fleshed sweet potato can be processed into flour to increase its economic value and used in a wide variety of food, such as cake. This research was carried out in order to identify the effect of pre-treatment in orange-fleshed sweet potato flour manufacturing process on cake's quality and also to know the antioxidant activity and digestibility index from the flour and cake. This research was carried out with randomized block design with single factor which consisted of four methods, i.e. soaking in 2000 ppm ascorbic acid solution for 15 minutes followed by steam blanching for 5 minutes, soaking in 2000 ppm ascorbic acid solution for 15 minutes, steam blanching for 5 minutes and without pretreatment (control). The best pre-treatment was obtained by soaking in 2000 ppm ascorbic acid solution for 15 minutes. Antioxidant activity and digestibility index were analysed on flour and cake with the best pre-treatment. The measured antioxidant activity IC₅₀ value) of orange-fleshed sweet potato flour and cake with the best treatment were 164.16µg/ml and 206.85µg/ml respectively, while the digestibility index of the cake was 46.96%.

1. Introduction

Increasing the population of the world induces problems on food's availability, one of them is malnutrition. Sweet potato has the potency to reduce the problem because of its significant content of energy and protein. At least 80-90% of sweet potato's compositions were carbohydrate in form of starch and sugar [1]. The β -carotene content on sweet potato ranges from 4619-4889 µg/100 g [2]. The high β -carotene content in sweet potato could be beneficial in dealing with vitamin A deficiency and it can also act as an antioxidant [3]. Sweet potato could be processed into flour and help widen food diversity. In addition, sweet potato flour has many benefits, such as wheat flour substitution, contributing special flavour, colour and dietary fibre into processed food such as bread, pasta products and other food [4].

However, sweet potato flour also has undesirable and distinctive odour, especially when the flour is processed into bakery products. In the flour processing, the sweet potato pigment will be degraded which causes colour change. The colour pigment from sweet potato will degrade and go through a colour change when processed into flour. Due to these reasons, pre-treatment is required to maintain colour and to minimize the odour. The change of colour during processing is due to browning reaction.



However, the enzymatic browning could be prevented by minimizing contact between food and oxygen and also by the addition of antioxidants like ascorbic acid [5]. Ascorbic acid acts as a reducing agent by lowering o-quinone from PPO (polyphenol oxidase) back to its o-diphenol form. Unfortunately, this reaction will not completely disappear and would happen again once the reducing agent oxidized [6]. Blanching is also one of the treatments to prevent enzymatic browning reaction on food. Polyphenol oxidase was an indigenous active enzyme in sweet potato root that greatly affected the quality of sweet potato. Heating at 90°C for 1 min can completely inactivate extracted enzyme from sweet potato [7]. Blanching sweet potato slices for 1 min at 94°C is not enough to inactivate enzyme and even accelerate enzyme activity [8]. The objective of this research was to evaluate the effect of pretreatment on orange fleshed sweet potato flour for cookies production.

2. Materials and methods

Orange-fleshed sweet potato (OFSP) was purchased from Saree Village Aceh Besar Regency Indonesia. Cake's ingredients such as egg, sugar, margarine, skim milk, vanilla flavouring and baking powder were purchased from supermarket in Medan.

2.1. Sample preparation and treatment

Orange-fleshed sweet potatoes were sorted, washed with tap water and then peeled manually. The peeled roots were sliced with a slicer machine and divided into four groups: chips were dipped into 2000 ppm of ascorbic acid solution for 15 minutes (AA), chips were dipped into 2000 ppm of ascorbic acid solution followed by steam blanching for 5 minutes (AAB), chips were steam blanched for 5 minutes (B) and without pretreatment chips as control.

2.2. Preparation of OFSP flour

The treated chips were dried using a drying oven at 55°C for 20 hours. Then, the dried chips were milled into flour with a disc mill. The resulting flour then sieved with an 80-mesh sifter to get the finer flour. The flour then packaged in polyethylene bags and stored at room temperature before used.

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

The physical properties observed were colour (°Hue and L value), browning index [9] and bulk density [10]. The colour of flour was determined by using Minolta Chroma meter CR-400 (Minolta Camera Co., Ltd., Tokyo, Japan). The hunter lab colour system L*, a* and b* value were recorded [11]. The chemical properties analysed were moisture content and β -carotene content using the method described by AOAC [12]. The sensory properties analysed were hedonic value of colour and aroma with 25 non-trained panellist using 9 point hedonic scale (9= extremely like and 1 = extremely dislike).

2.4. Cakes production

The formulation of cake were 100 g of OFSP flour, 3 g of baking powder, 125 g of eggs, 100 g of sugar, 50 g of skim milk, 10 g of margarine and 2 g of vanilla flavouring. Cake batters were made according to Julianti et al [13] as follow: OFSP flour and baking powder were mixed manually. Eggs, sugar, skim milk and vanilla flavouring were placed in a separate bowl and mixed with hand mixer at high speed for 6 minutes. Afterwards, flour and baking powder mixture were added gradually into cream mixture and mixing was continued for 3 minutes at low speed. The completely mixed batter was immediately deposited into a greased baking pan and baked at 180°C for 35 minutes in preheated electric oven. The cakes were allowed to cool for 30 minutes at room temperature and were then removed from pans. The cool caked were sensory evaluate and wrapped in aluminium foil and stored inside a refrigerator for 1 day before the cakes were analysed.

2.5. Analysis of cake's quality

The chemical, physical and sensory properties of the cake samples were analysed. Moisture and β -carotene content were analysed according to the using the method described by AOAC [12]. The cakes colour were measured on crumb and crust surface using a Minolta Chroma meter CR-400 (Minolta Camera Co., Ltd., Tokyo, Japan). The L^* value (lightness) was recorded and hue angle ($\tan^{-1} b/a$) was calculated according to Hutching [14]. The volume of the cakes were measured by seed displacement test using AACC Approved method 10-05 and the specific volume (volume/weight) was calculated [15]. A texture analyser (TA-XT2, Stable Micro System) was used for texture profile analysis of the cakes crumbs. Texture parameters (gumminess, cohesiveness, adhesiveness, chewiness, hardness, springiness and % deformation) were calculated [16]. The sensory properties analysed were hedonic value of colour, aroma, taste, texture and general acceptability with 25 non-trained panellist using 9 point hedonic scale with 9 = extremely like and 1 = extremely dislike. Cake with the best quality was chosen based on the highest score of organoleptic value, then was analysed for its antioxidant activity and digestibility index. Antioxidant activity was measured by using DPPH (1,1 diphenyl-2-picrylhydrazil) radical scavenging and IC50 value which is the concentration of sample required to inhibit 50% of the DPPH free radical was calculated using inhibition curve [17]. Digestibility index was determined by starch digestibility of cake by using the methods described by Anderson [18].

2.6. Data analysis

This research was designed by implementing factorial randomized block design with single factor. The data reported in all tables are an average of triplicate observations subjected to one-way analysis of variance (ANOVA). Differences between the ranges of the properties were determined by using the method of Least Significant Range (LSR) tests at 95% confidence level ($P < 0.05$).

3. Results and discussions

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

Table1. Effect of pre-treatment on physicochemical and sensory properties of OFSP flour

Parameter	Pre-treatment			
	AA	AAB	B	Control
Colour				
$^{\circ}$ Hue	81.33 \pm 1.11 ^b	84.57 \pm 0.91 ^a	85.29 \pm 0.73 ^a	80.75 \pm 0.87 ^b
L^* value	64.99 \pm 1.01 ^a	58.14 \pm 3.03 ^b	60.09 \pm 2.65 ^{ab}	62.83 \pm 2.14 ^{ab}
Bulk density (g/ml)	0.65 \pm 0.04	0.65 \pm 0.04	0.67 \pm 0.02	0.68 \pm 0.01
Browning index	0.41 \pm 0.05 ^b	0.33 \pm 0.04 ^c	0.33 \pm 0.01 ^c	0.54 \pm 0.04 ^a
Moisture content (%)	8.13 \pm 0.42	6.70 \pm 0.28	7.86 \pm 1.07	7.88 \pm 0.24
β -carotene content (mg/100 g)	4.99 \pm 0.17 ^{bc}	5.38 \pm 0.40 ^{ab}	5.65 \pm 0.54 ^a	4.30 \pm 0.21 ^c
Colour (hedonic)	6.56 \pm 0.14 ^a	4.92 \pm 0.46 ^c	5.21 \pm 0.54 ^c	6.32 \pm 0.26 ^b
Aroma (hedonic)	5.12 \pm 0.04	4.96 \pm 0.52	5.03 \pm 0.16	5.15 \pm 0.02

*) AA = chips were dipped into 2000 ppm of ascorbic acid solution for 15 minutes, AAB = chips was dipped into 2000 ppm of ascorbic acid solution followed by steam blanching for 5 minutes, B = chips was steam blanched for 5 minutes and Control = chips without pretreatment.

The values are expressed as the mean of three replicates.

Means followed by different letter in each row are significantly different among pretreatments ($p < 0.05$)

Table 1 shows that there was a significant difference at 5% level on lightness (L^* value). $^{\circ}$ Hue and browning index, meanwhile no significant difference was observed on bulk density. The OFSP flour which was treated with 2000 ppm ascorbic acid solution for 15 minutes followed by steam blanching and OFSP flour with steam blanching had the highest $^{\circ}$ Hue and the lowest browning index score. Meanwhile, the OFSP flour that treated with 2000 ppm ascorbic acid solution for 15 minutes had the

highest lightness (L^* value). The steam blanching will inactivate phenolase enzyme which acts as a catalyst in the enzymatic browning of polyphenol inherent in sweet potato [19, 20].

Table 1 shows that there was a significant difference at the 5% level on β -carotene content and no significant difference on moisture content. The OFSP flour that treated with and steam blanching and dipped in 2000 ppm ascorbic acid solution for 15 minutes followed by steam blanching had the highest β -carotene content. Blanching as a heat treatment will inactivate the enzyme (peroxidases and lipoxygenases) which have a capacity in degrading β -carotene [21] and β -carotene degradation was delayed. All the sensory attributes were liked slightly-moderately. The colour of OFSP flour treated by dipped into 2000 ppm of ascorbic acid solution for 15 minutes was liked more due to the increasing pigment extraction as the result of broken protein-carotenoid complex [22].

3.2. Effect of pretreatment on physical, chemical and sensory properties of cake

Table 2 shows that there was a significant difference ($p < 0.05$) on $^{\circ}$ Hue and lightness (L^* value) of cake's crumb, L^* value of cake's crust, gumminess, cohesiveness, chewiness and springiness, while no significant difference on $^{\circ}$ Hue of cake's crust colour, adhesiveness, hardness and percentage of deformation. L^* value of cake's related to the L^* value of OFSP flour. The cake made from treated OFSP flour with 2000 ppm ascorbic acid solution for 15 minutes had the highest crumb's $^{\circ}$ Hue because of the Maillard reaction (browning) that took place during baking resulting in the increases of the crumb redness [23-24].

The blanched OFSP flour (either treated with 2000 ppm ascorbic acid solution for 15 minutes followed by steam blanching or treated with steam blanching) had the highest score on gumminess, cohesiveness, chewiness and springiness. Blanching treatment not only made the starch became swollen and easily gelatinized, but also increasing the starch's viscosity and causing the cake's dough became thick [25]. It was assumed that starch gelatinization was responsible for gummier, chewier, springier and more cohesive texture on cake.

Table 2. Effect of pretreatment on physical properties of cake

Parameter	Pre-treatment			
	AA	AAB	B	Control
Crumb colour				
- $^{\circ}$ Hue	84.36 \pm 1.80 ^a	80.81 \pm 2.80 ^a	77.22 \pm 1.61 ^b	83.28 \pm 1.09 ^a
- L^* value	37.97 \pm 1.64 ^a	29.18 \pm 3.07 ^{ab}	31.70 \pm 1.00 ^{bc}	35.10 \pm 2.30 ^c
Crust colour				
- $^{\circ}$ Hue	73.28 \pm 6.64	67.91 \pm 8.55	66.88 \pm 1.76	64.09 \pm 6.99
- L^* value	35.52 \pm 1.70 ^a	29.54 \pm 1.93 ^{ab}	31.64 \pm 0.88 ^{ab}	32.01 \pm 1.86 ^b
Specific volume (ml/g)	1.27 \pm 0.08	1.18 \pm 0.08	1.37 \pm 0.09	1.56 \pm 0.19
Gumminess (g)	116.79 \pm 18.06 ^b	165.01 \pm 14.27 ^a	185.10 \pm 19.31 ^a	123.41 \pm 19.48 ^b
Cohesiveness	0.25 \pm 0.01 ^c	0.38 \pm 0.05 ^a	0.31 \pm 0.01 ^b	0.28 \pm 0.04 ^{bc}
Adhesiveness (g.s)	359.84 \pm 43.12	378.01 \pm 51.18	352.16 \pm 35.61	528.52 \pm 12.49
Chewiness (g.mm)	592.00 \pm 158.88 ^c	906.64 \pm 98.01 ^b	1085.74 \pm 96.17 ^a	597.46 \pm 36.22 ^c
Hardness (g)	451.17 \pm 41.12	479.50 \pm 49.49	540.67 \pm 25.77	415.00 \pm 69.29
Springiness (mm)	4.94 \pm 0.83 ^b	6.70 \pm 0.31 ^a	5.44 \pm 0.22 ^b	4.88 \pm 0.19 ^b
% Deformation	36.40 \pm 2.47	36.01 \pm 1.04	35.01 \pm 0.08	34.97 \pm 0.05

*) AA = chips were dipped into 2000 ppm of ascorbic acid solution for 15 minutes, AAB = chips was dipped into 2000 ppm of ascorbic acid solution followed by steam blanching for 5 minutes, B = chips was steam blanched for 5 minutes and Control = chips without pretreatment.

The values are expressed as the mean of three replicates.

Means followed by different letter in each row are significantly different among pretreatments ($p < 0.05$)

Table 3 shows that there was a significant difference ($p < 0.05$) β -carotene content and no significant difference on moisture content. The cake made from OFSP flour that treated with steam blanching had the highest β -carotene content and it is related to β -carotene of OFSP flour as main ingredient. The β -carotene content of cake was lower than that in OFSP flour. During the baking process, the presence of oxygen and high temperature made the carotenoid cause β -carotene degradation [25].

Table 3. Effect of pre-treatment on chemical properties of cake

Parameter	Pre-treatment			
	AA	AAB	B	Control
Moisture content (%)	24.70 \pm 2.14	23.11 \pm 0.31	22.79 \pm 1.16	23.40 \pm 1.70
β -carotene content (mg/100 g)	1.44 \pm 0.06 ^{ab}	1.59 \pm 0.22 ^a	1.70 \pm 0.22 ^a	1.19 \pm 0.08 ^b

*) AA = chips were dipped into 2000 ppm of ascorbic acid solution for 15 minutes, AAB = chips was dipped into 2000 ppm of ascorbic acid solution followed by steam blanching for 5 minutes, B = chips was steam blanched for 5 minutes and Control = chips without pretreatment. The values are expressed as the mean of three replicates. Means followed by different letter in each row are significantly different among pretreatments ($p < 0.05$)

Table 4 shows that there was a significant difference ($p < 0.05$) on the hedonic value of texture and no significant difference ($p > 0.05$) on hedonic value of colour, aroma, taste and overall acceptability. Cake made with steam blanched OFSP flour had the highest acceptability due to the softer and chewier texture. The higher temperature produced in blanching process led to the greater degree of starch gelatinization [26]. The gelatinized starch will affect the dough elasticity and increase the capacity of dough to store gas which caused the cake to be more porous and its texture became softer [25].

Table 4. Effect of pre-treatment on sensorial properties of cake

Parameter	Pre-treatment			
	AA	AAB	B	Control
Colour	6.16 \pm 0.25	5.17 \pm 0.82	5.57 \pm 0.22	5.39 \pm 0.34
Aroma	6.07 \pm 0.26	5.44 \pm 0.32	5.71 \pm 0.30	5.49 \pm 0.20
Taste	5.68 \pm 0.48	5.75 \pm 0.02	6.05 \pm 0.12	5.65 \pm 0.27
Texture	5.20 \pm 0.05 ^b	5.55 \pm 0.38 ^{ab}	5.81 \pm 0.06 ^a	5.19 \pm 0.34 ^b
Overall acceptability	5.97 \pm 0.10	5.48 \pm 0.28	5.93 \pm 0.22	5.61 \pm 0.20

*) AA = chips were dipped into 2000 ppm of ascorbic acid solution for 15 minutes, AAB = chips was dipped into 2000 ppm of ascorbic acid solution followed by steam blanching for 5 minutes, B = chips was steam blanched for 5 minutes and Control = chips without pretreatment. The values are expressed as the mean of three replicates. Means followed by different letter in each row are significantly different among pretreatments ($p < 0.05$)

3.3. Determination of Pre-treatment method resulted in flour and cake with the best chemical characteristic

According to the result of OFSP flour's physical, chemical and sensorial characteristic analysis, the best pre-treatment was chosen based on the highest score of organoleptic value of colour, organoleptic value of aroma, β -carotene content, organoleptic value of taste, organoleptic value of texture, organoleptic value of overall acceptability, moisture content and specific volume, respectively, using the method of effectivity index [27]. The finding result showed that the best pre-treatment method was the pre-treatment by soaking the orange-fleshed sweet potatoes in 2000 ppm of ascorbic acid solution for 15 minutes. Antioxidant activity and digestibility index were analysed on the flour and the cake with the best treatment. IC50 is the concentration of antioxidant needed to decrease the initial DPPH

concentration by 50%. It is a parameter widely used to measure the antioxidant activity [28]. Sample that had $IC_{50} < 50$ ppm was very strong antioxidant, 50-100 ppm was strong antioxidant, 101-150 ppm was medium antioxidant, while weak antioxidant has $IC_{50} > 150$ ppm [29]. Table 5 shows both OFSP flour and cake had weak antioxidant capacity. The digestibility index of cake sample was 45.96%. The low digestibility index on cake were caused by starch gelatinization during baking process, as the gelatinized starch was difficult to digest [30].

Table 5. Chemical characteristic of OFSP flour and cake with best pre-treatment

Parameter	Best Pre-treatment	
	OFSP Flour	Cake
IC_{50} value ($\mu\text{g/ml}$)	164.16 \pm 18.92	206.85 \pm 18.87
Digestibility index (%)	-	45.96 \pm 0.62

*) The values are expressed as the mean of three replicate

4. Conclusion

The study has shown that different pre-treatment had an effect on OFSP flour's and cake's quality. The best pre-treatment method was OFSP flour with pre-treatment in 2000 ppm ascorbic acid solution for 15 minutes which had high acceptability for its sensorial characteristics and had adequate content of β -carotene. The best cake had low antioxidant intensity and digestibility index. The result shows that pretreated orange fleshed sweet potato flour is a good alternative for producing cake.

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