New healthy food product crafted from sweet potato flour and pasta: Brownies

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Abstract. Sweet potato (SP) provides good nutrition to maintain public health status. It has a high energy content, protein, fat, and considerable dietary fiber. Four of SP varieties i.e., *Beta 1*, *Beta 2*, *Antin 2*, and *Antin 3* contain bioactive compounds such as anthocyanin and beta-carotene. In their fresh form, *Antin 2* and *Antin 3* contained higher calories compared to *Beta 1*. Meanwhile, in the form of flour, *Beta 1* had more beta carotene (29.41±0.06 mg/100g) than *Beta 2* (27.26±0.13 mg/100g), and *Antin 3* contained more anthocyanin (47.66±0.05 mg/100g) than *Antin 2* (29.04±0.01mg/100g). The aim of this study was to test the brownies made using SP pasta (SPP) and SP flour (SPF), and to evaluate the physicochemical and sensory properties of resulting brownies. Results show that there were various differences in moisture content (2.35–3.99%), ash (2.67–3.66%), fat (11.50–24.62%), protein (2.46–3.65%), carbohydrate (65.07–79.52%), and energy (436.98–494.86 kcal), but the differences were not systematic. The sensory evaluation demonstrated that the product was well-accepted by the panelists in terms of color, flavor, taste, texture, and overall acceptability, indicating that SP have a potential as raw material for food products and further utilization to support sustainable agriculture.

1 Introduction

Beside rice, sweet potato (SP) is also a main food crop in the tropical area [1], including in Indonesia. It provides good nutrition and can be utilized as carbohydrate source due to its high carbohydrate content. Various types of soils suit SP to grow. In addition, it needs less fertilizer than other food plants, and quite productive with short period of planting, which is about 3 to 6 months [2]. There are several cultivars of SP i.e. white SP, yellow SP, red (orange) SP, and purple SP [3]. These SP cultivars are rich in carbohydrate, polyphenol (in the form of anthocyanin in the purple-fleshed sweet potato), carotenoids (in orange-fleshed sweet potato), low in fat and as good sources of dietary antioxidants, acts as anti-inflammatory, anti-cancer [1], and can prevent vitamin A malnutrition [4]. These also contain a range of minerals beneficial for human health including iron, phosphorus, calcium, magnesium, potassium, sodium, zinc, and manganese [3, 5]. Potassium is the mineral with the greatest concentration in SP (averaged 396 mg/100 g), with phosphorus, calcium, magnesium, iron, copper, and magnesium are also present in significant amounts [5].

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Purple-fleshed SP contains a large number of anthocyanin ranging from 110.51 mg/100 g, varies depending on the intensity of the purple color [3]. Anthocyanin is also potential for coloring agent (dyes) [2]. Many research across the globe have investigated anthocyanin in the purple-fleshed SP reporting the benefits of anthocyanin to the human health, particularly in relationship with its antioxidant capacity [1], [5–9].

Another rich in nutrients-SP is orange-fleshed SP. It is rich in beta-carotene and can be acting as source of vitamins and dietary fiber [4]. Moreover, it is drought resistant, and a cheap source of Vitamin A [10]. Generally speaking, flesh-colored (orange, red) SP contains phytochemicals, pro-vitamins, and antioxidants beneficial for human health. Cooked sweet potato has moderate glycemic index (around 63-66) [11], which is good to maintain reasonable blood glucose level. Even so, Astawan dan Widowati [12] stated that the processing method affects the GI value food and that frying was the best method compared to roasting and boiling (GI values of fried, boiled, and roasted SP were 47, 62, and 80, respectively).

To increase SP utilization, an effort is needed. Promoting SP consumption can be done by creating more food products made of SP. Previous research have made various SP-based products such as noodle [13], bread [14], and spaghetti [15]. For this research, brownies are chosen as food model because not much research has been conducted regarding this modern food. According to Nakamura et al., [8], dehydrated powder and puree are the best form of colored-SP (such as orange-fleshed and purple-fleshed SP) to be further processed into food products which need nutritional ingredients. Thus, we intended to proceed SP into pasta and flour in advance to obtain flexible raw material from SP when further mixed with other ingredients.

The aim of this research was to study the capability of SP either in flour or pasta form to produce a new crafted food product i.e., brownies. We chose brownies as a food model to test its nutrient composition as well as its acceptance by panelists by performing a sensory evaluation. Brownies are cakes with the appearance of solid chocolate, made by mixing wheat flour, eggs, fat, granulated sugar and chocolate followed by baking [16], with other ingredients added to improve nutrients [17]. The hypothesis was that panelists will accept brownies made of SP without the addition of wheat flour (as it is a common practice to produce baked products which need maximum development) and that the products have à good nutrient as well, beside can be used for carbohydrates source, also for improving healthy degree due to its bioactive compounds such as beta-carotene and anthocyanins (from the colored-flesh SP).

2 Materials and Methods

The materials used were SP from cultivars i.e. *Beta 1*, *Beta 2*, *Antin 2* and *Antin 3*, provided by Indonesian Legumes and Tubers Research Institute (ILETRI). The equipment used includes processing equipment and analysis equipment. Methods conducted were production of sweet potato pasta (SPP), sweet potato flour (SPF), sweet potato food product as food model (brownies) and nutrient analyses of the resulting brownies.

2.1 Production of sweet potato pasta (SPP)

Sweet potato pasta was made by using a method adopted from Mulyawanti et al., [18]. The sweet potato was first washed, drained, steamed for 20 min, peeled, blended, and stored in the freezer.

2.2 Production of sweet potato flour (SPF)

The process of SPF production followed Richana and Widaningrum [19]. Basically, SPF production involves fresh SP washing, peeling, slicing, chips drying, and grinding to produce flour prior to sieving using 80-100 mesh of sieves.

2.3 Food model (brownies) preparation

Brownies from SPP were made as follows: 100 g of margarine (as butter replacement) and 100 g of dark chocolate were cooked until melted, then set aside until cool. As many as 3 pcs of chicken egg and 75 g of refined sugar were mixed until developed well, then a 25 g of sweet potato pasta, 25 g of *mocaf* (modified cassava flour), and 12.5 g of chocolate powder were added. After that, the melted butter and margarine that have been prepared previously were added to the dough to be mixed well. The dough was then poured onto the tray and distributed evenly or sliced into a 'bar-like form' then baked using electric oven at 170 °C for 50 min until done and brownies from sweet potato were ready to serve. The similar procedure was applied to the preparation of brownies from sweet potato flour (SPF), with the SPP was replaced with SPF, yet different proportion of SPP was used i.e., 35 g of flour from each SP and 15 g of modified cassava flour (*mocaf*), for every production batch.

2.4 Analyses

Physico-chemical characteristics (moisture, ash, fat, protein) were analyzed from flour and pasta of SP. Beta-carotene content was analyzed from *Beta 1* and *Beta 2* cultivars, meanwhile anthocyanin content was analyzed from *Antin 2* and *Antin 3*. Moisture, ash, protein, fat, carbohydrate, and energy (proximate analyses) were analyzed from all cultivars using the methods from AOAC (2006) [20] and sensory evaluation was conducted to SP brownies made of flour and pasta SP as a food model, using the methods from Meilgaard et al. [21].

3 Results and Discussion

3.1 Nutrients composition of SPP

As ingredients for making food model brownies, here are the nutrient composition of SPP (Table 1). From the Table 1 it can be seen that *Beta 1* SPP has the highest moisture content (78.32%) among others, quite significantly different from *Beta 2* SPP (73.60%) and significantly different from *Antin 2* SPP as well as *Antin 3* SPP (61.91% and 61.97%, respectively). Factors affecting nutrient composition of SP varies depending on the cultivar, growing conditions, maturity, and storage [5]. Overall, distinct moisture content across the samples might affect the physicochemical properties of the resulting food model i.e., brownies.

Table 1. Nutrient composition of SPP from four cultivars (*Beta 1*, *Beta 2*, *Antin 2* and *Antin 3*)

Sweet potato pasta (SPP)	Nutrient composition of SPP from four cultivars (*Beta 1*, *Beta 2*, *Antin 2* and *Antin 3*)					
	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (by difference; %)	Energy (kcal)
Beta 1	78.32±0.22^{d}	0.96±0.06^{ef}	0.72±0.02^{e}	1.44±0.04^{bcd}	18.58±0.22^{a}	86.48±1.21^{a}
Beta 2	73.60±0.07^{bc}	0.97±0.05^{ef}	0.15±0.06^{a}	1.27±0.05^{a}	24.03±0.13^{c}	102.47±0.23^{b}
Antin 2	61.91±0.03^{a}	0.92±0.02^{de}	0.38±0.01^{c}	1.74±0.03^{e}	35.06±0.06^{d}	150.60±0.27^{d}
Antin 3	61.97±0.01^{a}	0.85±0.04^{cd}	0.40±0.01^{c}	1.59±0.00^{d}	35.20±0.03^{d}	150.76±0.24^{d}

Numbers in the same column followed by the same letter show no significant difference at the 5% level on Duncan's different test

In terms of ash content, even though there are a little bit of differences, the values are relatively comparable (0.85%–0.97%), meanwhile for fat content, *Beta 1* SPP has the highest fat content (0.72%), followed by *Antin 3* SPP which is not different from *Antin 2* SPP (0.40%

and 0.38%, respectively), both are from purple-fleshed SP, with the least belongs to *Beta 2* SPP (0.15%) and is significantly different from all others.

For protein, *Antin 2* SPP has the highest protein content (1.74%) and is significantly different from the nearest value i.e., *Antin 3* SPP (1.59%), both from the purple-fleshed sweet potato. *Beta 1* SPP ranks third (1.44%), significantly different (P>0.05) from *Beta 2* SPP which ranks last (0.15%) protein content, both come from the orange-fleshed sweet potato. For carbohydrate content, *Antin 3* SPP and *Antin 2* SPP have the highest carbohydrate content (35.20% and 35.06%), whilst *Beta 2* SPP has only 24% of carbohydrate, with the least belongs to *Beta 1* SPP which has 18.58% of carbohydrate and is significantly different among others. For energy, due to its linearity with the carbohydrate, fat, and protein content (energy value is obtained by multiplying it with 4 kcal from carbohydrate, 9 kcal from fat, and 4% from protein), the order is the same as carbohydrate level (Table 1).

For bioactive compounds such as beta-carotene and anthocyanins, the values are listed in Table 2. *Beta 1* SPP has 1.93 mg/100g beta-carotene while *Beta 2* SPP has 1.59 mg/100 g beta-carotene, respectively. For anthocyanin, *Antin 3* SPP has the high anthocyanin content, 63.58 mg/100 g, far above anthocyanin content of *Antin 2* SPP, which has only 13.72%.

Table 2. Beta-carotene and anthocyanin content of SPP from four cultivars (*Beta 1*, *Beta 2*, *Antin 2* and *Antin 3*)

Sweet potato pasta (SPP)	Beta-carotene and anthocyanin content of SPP from four varieties	
	Beta-carotene (mg/100g)	Anthocyanin (mg/100g)
Beta 1	1.93±0,03^{f}	NA
Beta 2	1.59±0,03^{e}	NA
Antin 2	NA	13.72±0.00^{f}
Antin 3	NA	63.58±0.04^{g}

Remarks: Numbers in the same column followed by the same letter show no significant difference at the 5% level on Duncan's different test, NA = Not Analyzed

3.2 Nutrient composition of SPF

Chemical composition data of SPF are presented in Table 3, whereas functional nutrients (beta-carotene and anthocyanin) data of SPF are presented in Table 4. From the data in Table 3, all types of SPF have comparable composition in terms of moisture (4.75–6.77%), ash (1.94–4.64%), fat (1.18–2.18%), protein (2.09–4.07%), carbohydrate (84.34–89.33%), and energy values (365–379 kcal). According to Truong et al., [5], sweet potato contains protein in the range of 1.73–9.14%. *Beta 1* SPF has a higher beta-carotene content (29.41 mg/100g) than *Beta 2* SPF (27.26 mg/100g), corresponding to the anthocyanin content of SPF, where anthocyanin content in *Antin 3* SPF was higher (47.66%) than in *Antin 2* SPF (29.04 mg/100g) (Table 4). As one type of the phenolic compound, anthocyanin is responsible for the purple color intensity in the purple-fleshed sweet potato [1], in this study Antin 3 is darker than Antin 2.

Table 3. Chemical composition of SPF from four cultivars (*Beta 1, Beta 2, Antin 2, and Antin 3)*

Sweet potato flour	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Energy (kcal)
Beta 1	6.77±0.09	4.64±0.01	2.18±0.04	2.09±0.01	84.34±0.05	365.26±0.49
Beta 2	5.64±0.03	3.93±0.03	1.25±0.11	4.07±0.04	85.00±0.08	368.52±0.21
Antin 2	4.75±0.03	1.94±0.06	1.18±0.01	2.75±0.10	89.33±0.07	379.14±0.04
Antin 3	4.85±0.02	2.18±0.01	1.26±0.06	2.64±0.02	89.09±0.11	378.23±0.18

Table 4. Beta-carotene and anthocyanins of SPF from four cultivars (*Beta 1, Beta 2, Antin 2, and Antin 3)*

Sweet potato flour (SPP)	Beta-carotene (mg/100g)	Anthocyanin (mg/100 g)
Beta 1	29.41±0.06	NA
Beta 2	27.26±0.13	NA
Antin 2	NA	29.04±0,01
Antin 3	NA	47.66±0,05

Remarks: NA = Not analyzed

3.3 Nutrient composition of SP brownies

The brownies made of *Beta 2* and *Antin 3* SP (after being mixed will all other ingredients) can be seen Figure 1 to Figure 4, as representative of all dough made in this research. Brownies are a popular cake. Brownies is usually consumed as dessert and texture can either be fudgy or cakey, depending on the individual preferences [22]. The products have hard texture outside, but spongy and compact inside. Apparently, there is no difference in color between brownies made of *Beta 1* and *Beta 2,* and between *Antin 2* and *Antin 3*. Nevertheless, regarding the texture of products, brownies made of pasta have moister texture in comparison of these made of flour, which have solid and compact texture inside. Images shown here only representatives of all brownies produced.

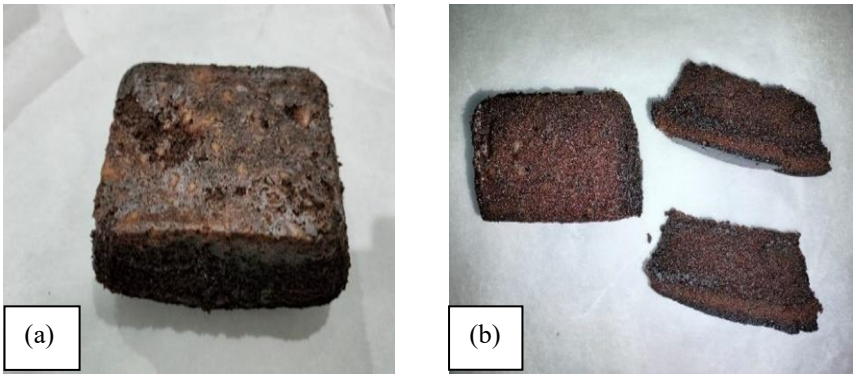

Fig. 1. Appearance of brownies from *Beta 2* SPP (a): a whole brownie, (b): pieces from the whole brownies

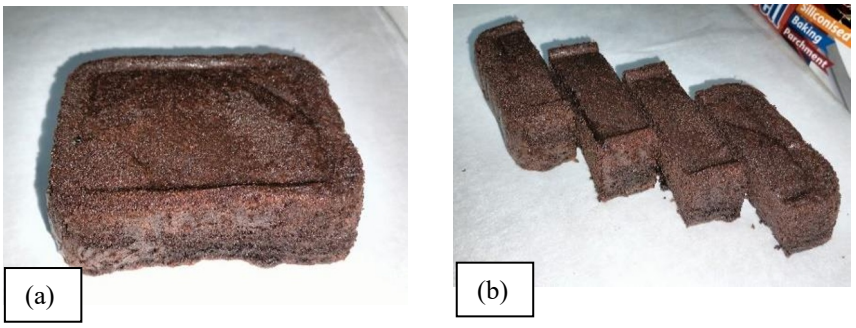

Fig. 2. Appearance of brownies from *Beta 2* SPF (a): a whole brownie, (b): pieces from the whole brownies

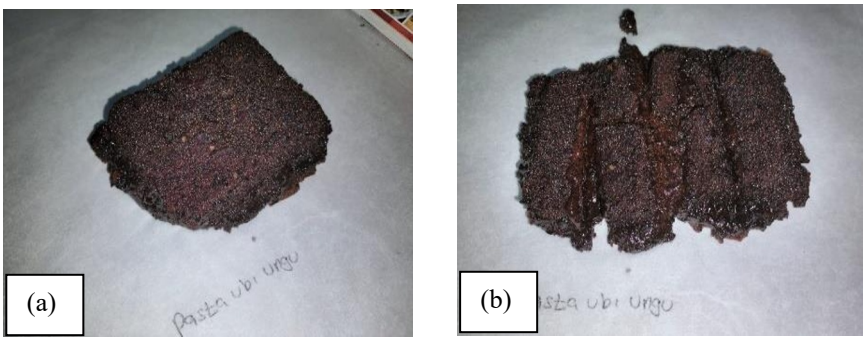

Fig. 3. Appearance of brownies from *Antin 3* SPP (a): a whole brownie, (b): pieces from the whole brownies

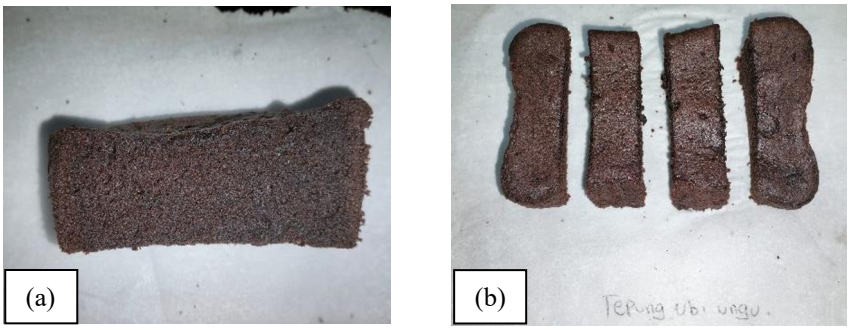

Fig. 4. Appearance of brownies from *Antin 3* SPF (a): a whole brownie, (b): pieces from the whole brownies

Regarding nutritional composition of sweet potato brownies (Table 5), moisture content of brownies ranging from 2.35–3.99%, significantly different each other (<0.05), but not different (P>0.05) with their initial ingredient (pasta and flour). Meanwhile ash content is ranging from 2.64–3.66%. Yet, their differences are not systematic.

For fat content, brownies made of *Antin 2* SPF has the highest fat content (24.62%), but it is not different from brownies made of *Antin 2* SPP (23.69%) and is quite similar with brownies made of *Beta 2* SPF (22.59%), and with brownies made of *Beta 1* SPP (20.72%). It is then followed by fat content of brownies made of *Antin 3* SPP, quite lower from the fat content (17.36%), and the least are brownies made of *Beta 2* SPP (13.01%), which is not different with fat content of brownies made of *Beta 1* SPF (11.50%). A possible reason to explain this difference is the initial moisture content of SPP and SPF, which is higher in SPP rather than in SPF, resulting in lower fat content, except for *Beta 1* SPP. The increase in fat content in the resulting brownies overall is highly likely influenced by fat content from the other ingredients such as margarine (which has 11% of fat) and from dark chocolate (8% of fat) in the dough.

Surprisingly, within *Beta 1* variety, the fat content of SPF brownies is much lower (11.50%) than in the SPP brownies (20.72%). The possible reason of this might have been caused by the incomplete stirring of *Beta 1* SPP brownies when the dough was prepared, which may result in the thick and full of fat area in one side, yet another side has thin and less of fat area, or the dough was not quite homogeneous. Nevertheless, this needs further investigation.

Truong et al., [5] reported that orange-fleshed sweet potato has low dry matter content (18-25%), which means that it has high moisture content, as it is also reflected in this research results (*Beta 1* and *Beta 2* SPP, Table 1, and *Beta 1* and *Beta 2* SPF, Table 3, in comparison

with *Antin* varieties). Therefore, brownies made of *Beta 1* and *Beta 2* SPP and SPF have characteristic of moister texture after cooking due to its high moisture content.

Table 5. Nutritional composition of brownies made of sweet potato (SP) pasta and flour.

Sample of sweet potato	Nutritional composition of brownies made of sweet potato pasta (SPP) and sweet potato flour (SPF)						
	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%; by difference)	Energy (kcal)	Moisture (%)
Beta 1	Pasta	2.35^{a}	3.22^{bc}	20.72^{cd}	2.46^{a}	71.27^{bc}	481.32^{b}
Beta 1	Flour	3.24^{c}	2.67^{a}	11.50^{a}	3.08^{c}	79.52^{d}	436.98^{a}
Beta 2	Pasta	2.68^{b}	3.45^{cd}	13.01^{ab}	2.79^{b}	78.07^{d}	440.53^{a}
Beta 2	Flour	3.65^{e}	2.64^{a}	22.59^{cd}	3.20^{c}	67.93^{abc}	487.81^{b}
Antin 2	Pasta	3.59^{e}	2.82^{a}	23.69^{d}	3.60^{d}	66.47^{ab}	494.86^{b}
Antin 2	Flour	3.99^{f}	3.09^{b}	24.62^{d}	3.25^{c}	65.07^{a}	478.01^{b}
Antin 3	Pasta	2.61^{b}	3.66^{d}	17.36^{bc}	3.53^{d}	72.85^{c}	461.74^{ab}
Antin 3	Flour	3.45^{d}	3.53^{d}	21.57^{cd}	3.65^{d}	67.81^{abc}	479.97^{b}

Remarks: Numbers in the same column followed by the same letter show no significant difference at the 5% level on Duncan's different test

For protein content, brownies made of *Antin 2* and *Antin 3* both from SPP and SPF have the higher value of protein (3.25–3.60%) rather than those made of *Beta 1* and *Beta 2* (2.46–2.79%), except for *Beta 2* SPF and *Beta 1* SPF which have protein content 3.20% and 3.08% in the resulting brownies, respectively. Yet, the results are not systematic. Higher moisture content in *Beta* varieties SPP as brownies ingredient might have affected the protein content of the resulting brownies by replacing protein with water. The second plausible reason is that these brownies are made of SPP and SPF with the addition of modified cassava flour (*mocaf*), which has low fat (0.38%) and low protein content (3.43%), made the resulting brownies have similar values of protein. Yet, the low fat and protein content are typical for most tubers or roots.

For carbohydrate (*by difference*) content in brownies, the higher content come from *Beta* varieties (67.93%–79.52%), with one comes from *Antin* varieties (72.85% for *Antin 3* SPP brownies) even though it is not so different with *Antin 3* SPF brownies (67.81%) (Table 5). The energy values show the linearity with the carbohydrate content, ranging from 436.98 kcal for brownies made of *Beta 1* SPF to 494.86 kcal for brownies made of *Antin 2* SPP, all are showing their capacity as carbohydrate source from modern cake like brownies.

Brownies as a new crafted food model from orange-fleshed sweet potato and purple-fleshed sweet potato has not been much investigated, not like noodle. For noodles, the addition of purple-fleshed sweet potato flour (PFSPP) indeed increases the anthocyanin content of the resulting noodle. Nevertheless, the more PFSPP added, the tensile strength and elasticity decreased [23]. Hence, it is important to get the right proportions with other ingredients in the preparation of any food development.

Based on the SPP and SPF brownies formula in this study without the use of wheat flour so that it can be categorized as a gluten-free product. Currently, many people are adopting a gluten-free consumption pattern, especially for children with autism and for individuals with a gluten-free diet. A similar gluten-free product formula has been developed by Darniadi et al., [23] on the processing of gluten-free biscuits from rice grit flour.

3.4 Sensory Evaluation of Brownies made of Beta and Antin SPP and SPF

Sensory evaluation was carried out on SPP and SPF brownies to confirm consumer acceptance in terms of color, taste, texture, and overall taste and acceptance. The results of sensory evaluation are presented in the Table 6. Panelists, representing consumers in general,

have determined their acceptance rate by giving marks to every sensory attribute for each product i.e., brownies from sweet potato, both from pasta and flour.

Table 6. Sensory evaluation of SP brownies

Sample of sweet potato		Brownies evaluation based on sensory parameters (n=30 semi-trained panelists)				
		Color	Flavor	Texture	Taste	Overall acceptance
Beta 1	Pasta	3.80	3.63	3.43	3.33	3.53
Beta 1	Flour	3.83	3.80	3.73	3.83	3.87
Beta 2	Pasta	3.77	3.60	3.70	3.63	3.67
Beta 2	Flour	3.83	3.73	3.53	3.67	3.63
Antin 2	Pasta	3.77	3.63	3.50	3.50	3.63
Antin 2	Flour	3.70	3.90	3.77	3.67	3.77
Antin 3	Pasta	3.60	3.77	3.73	3.67	3.63
Antin 3	Flour	3.83	3.60	3.40	3.37	3.57

Remarks: 1=very dislike, 2=dislike, 3=neutral, 4=like, 5=very like

From the Table 6 it can be observed that all of the parameters (color, flavor, texture, taste, and overall acceptance) are well-rated, or in the other words the panelists like most of the product based on each parameter, but there are some attributes such as texture for brownies made of *Beta 1* SPP which is marked 3.43 for texture and 3.33 for taste, meaning 'neutral to dislike'. Brownies for *Antin 2* SPP is marked 3.5 for texture and 3.5 for pasta, meaning neutral to like, just the same as texture of brownies made of *Antin 3* SPF, which is marked 3.40 for texture and 3.37 for taste. The other parameters from all samples are marked more than 3.51 close to 4, which are liked. For overall acceptance, brownies from *Beta 1* SPF is marked 3.87, the highest mark among other samples. Nonetheless, there are no significant differences among all samples, indicating that the panelists cannot really differ the brownies whether they are made of pasta or flour, which is expected.

Results from Selvakumaran et al., [22] show that substitution of wheat flour with orange-fleshed sweet potato (OSP) puree increased moisture and fat. The higher amount of OSP puree (50% and 75%) had higher scores for color, texture, flavor, and overall acceptance, further revealing the improvement of sensory properties of the resulting brownies. In the present study, where wheat flour is replaced with modified cassava flour (*mocaf)*, we hope it can also contribute to the utilization of other local food carbohydrate sources such as cassava, sorghum, arrowroot, etc., which are available abundantly in Asia in general, and in Indonesia in particular.

4 Conclusion

Sweet potato is available abundantly in Indonesia and has no harvesting season. Due to its high nutritional content, it makes sweet potato a very attractive option to improve its capacity to be processed into several intermediate products such as pasta and flour, hence make it flexible to be stored and transported. This present study has shown that a food model namely brownies has been successfully produced from specialty Indonesian sweet potato flour and pasta (orange-fleshed *Beta 1, Beta 2* and purple-fleshed sweet potato *Antin 2* and *Antin 3*) with the addition of modified cassava flour but without the addition of wheat flour, so that the product can be called 'gluten-free food' and is sensorially acceptable. This further supports the potential of local carbohydrate sources to maintain sustainable agriculture in developing countries.

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