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Texture, sensory, antioxidant, and blood glucose profile of gluten-free taro and banana noodles using gathotan flour as texturing agent

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Abstract

Gluten-free taro and banana noodle was made, and examined for their textural, sensory, antioxidant, and postprandial blood glucose profile. We used 'gathotan' (a traditional dried fungal fermented cassava, originated from Indonesia) flour as texturing agent for the noodle and studied the effect of water proportion added in the making of gathotan gel, and ratio between gathotan gel and dried taro or banana flour. Factors affecting hardness of noodles were ratio of water used in gelatinised flour, and interaction between the two factors. Ratio of dry flour affected adhesiveness of banana noodle, but did not affect adhesiveness of taro noodle. The two factors influenced sensory properties of the noodles, in different manners depending on the type of noodle. Consumption of the noodles caused quick increased of postprandial blood glucose level, but it reduced to fasting level in 100 mins after consumption. Inhibition of DPPH, equivalent to vitamin E, and total phenolic compounds in taro noodle were 86.04%, 17.13 mg/100g, and 79.94 mg/100g, respectively; while those of banana noodle were 91.61%, 54.50 mg/100g, and 304.33 mg/100g, respectively.

Introduction

Noodle is a very popular food stuff which gets increasing recognition all around the world recently. In general, there are two types of noodle according to raw material, namely starch noodle and flour based noodle. Most noodle made from flour used wheat flour as raw material, including 'instant noodle'. Instant noodle commonly found in market today is made from wheat flour. Instant noodle production is constantly increasing (World Instant Noodle Association, 2013) and creating economic burden for wheat non-producing countries. On the other hand, gluten-free noodle is not only a mean to improve those countries' economy, but also provides healthier product suitable for people suffering from celiac disease. There are ranges of gluten-free products being developed to fulfil world's need of healthier food. Some non-wheat flour products with functional benefits have been reported, such as hypolipidemic (Choy *et al*., 2013), hypoglycemic (Eleazu *et al*., 2013; Sullivan *et al*., 2013), and antioxidant (Hsu *et al*., 2003) effects. Examples of some gluten-free products including noodle (Lin *et al*., 2006; Liu *et al*., 2012), bread (Mohamed *et al*., 2010; Yousif *et al*., 2012; Choy *et al*., 2013), and pasta (Zandonadi *et al*., 2012; Khan *et al.,* 2013). There are several non-wheat flours used in the study of gluten-free products, including banana or cocoyam (Eleazu *et al*., 2013), sorghum, millet, and pseudocereal (Taylor *et al*., 2014), buckwheat (Stringer *et al*., 2013), barley (Sullivan *et al*., 2013), yam (Hsu *et al*., 2003), and taro (Njintang and Mbofung, 2006).

Taro is one of tubers projected in 2020 to be important food stuff for food security and poverty alleviation, as well as development of small- and medium-scale agro enterprises (Scott *et al*., 2000). Tubers will be ultimate alternative raw material for starchy processed food including noodle (Scott *et al*., 2000). Taro is considered to be underutilized and neglected crop, and it is native to South East Asia (Kreike *et al*., 2004). Similarly, banana has been long recognized as abundant tropical crop which is an important source of resistant starch and potassium (Aurore *et al*., 2014).

A new type of gluten-free noodle reported recently was called 'gathotan noodle' (Purwandari, Arifin, Tamam *et al*., 2014; Purwandari, Tristiana, Hidayati, 2014). Gathotan is mouldy dried cassava which has a very chewy texture when steamed. Therefore, gathotan

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flour can be used as sole raw material for making gluten-free noodle (Purwandari, Arifin, Tamam *et al*., 2014). The main fungus colonised internal part of gathotan is Botryodiplodia theobromae (Purwandari, 2000). As the fungus is a dematiaceous species, its dark coloured mycelia gives black colour of gathotan. This black colour is an important characteristic of the product. Gathotan noodle showed antioxidant and hypoglycemic activity (Purwandari, Tristiana and, Hidayati, 2014). Moreover, gathotan flour has also been used as texturing agent for gluten-free noodle from bread fruit flour (Purwandari, Khoiri, Muchlis *et al*., 2014). In this work, we examined textural, sensory, hypoglycemic, and antioxidant properties of gluten-free noodle made from banana or taro flour.

Materials and Methods

Gathotan making

Mouldy dried cassava (gathotan) pieces were prepared following a method described by Purwandari (2000). In brief, cassava tubers bought from local market in Kamal, Madura, Indonesia, were peeled and washed, then sun-dried until half-dry. Half-dried cassava tubers were then put in a bamboo basket lined with banana leaves, and covered with several layers of the leaves,leaves; let it stand in room temperature for 3 days for fermentation. We modified the process by incorporating 1/100 (w/w) gathotan powder taken from previous batch in the fermentation. Gathotan powder was mixed with potable water at 1:1 (w/w) proportion. Suspension was then spread on the surface of cassava chunks. Taro or banana was also bought from local market in Kamal, Madura, Indonesia. They were peeled, sliced with 1 mm thickness, soaked in 2 ppm sodium metabisulphite for three minutes, rinsed, and dried in a cabinet dryer. Soaking in sodium metabisulphite solution is needed to prevent browning. Drying temperature was set at 40ºC, to ensure considerably fast drying without affecting starch properties in chips. Drying was considered complete when chips gave clear sound when broken with fingers. Chips were then ground using an electric grinder (Miyako BL-151 GF), sifted in 60 mesh sieve, and kept in a tight container until used.

Noodle making

Earlier we noticed that it was not possible to make noodle from solely taro or banana flour. The dough was too weak, too sticky (taro flour) or too crumbly (banana flour), that it could not be sheeted and cut as noodle. When cassava starch (tapioca) was added into each flour, the resulted dough was too soft and sticky, that it could not form thin long thread of noodle. Therefore, we added gathotan flour as texturing agent. We carried out a preliminary experiment to determine water and flour proportion that resulted in normal noodle strips having around 30 cm in length. The levels of water or flour proportion were then defined to be used in the main experiment. Noodle was prepared by first making gelatinised gathotan flour. Proportion of water to gathotan flour varied depending on type of noodle. For taro noodle, ratios of gathotan flour and water in gelatinised flour were 1:6, 1:7, 1:8 (w/w), while ratios of gelatinised gathotan and dry taro flour were 1:1 and 1:1.25 (w/w). Banana noodle was made by mixing gelatinised gathotan flour (gathotan flour:water 1:7, 1:8, 1:9 w/w) and dry banana flour with 1:1.1 and 1:1.2 (w/w) proportion. Water was mixed with gathotan flour in a beaker glass, thenand then heated in a water bath at 90°C until all flour turned into gel. The gel was cooled down to about 50°C, and then mixed with dry taro or banana flour in certain proportion according to experimental design. Proportion of gelatinised flour and dry flour was also different among noodle type. Noodle dough was then passed into a manual roller with 2 mm thick gap, for at least 7 times until smooth sheet was formed. The sheet was then steamed for 15-30 minutes depending on types of noodle, until all part of dough was fully gelatinized. After cooling at room temperature, dough was cut into 2 mm wide strips, and dried in a cabinet dryer. Drying temperature was set at 40ºC, to allow relatively fast drying while avoiding overheating and overcooking. Dry noodle was kept in a plastic bag and stored at room temperature until used.

Textural examination

Ten 5 cm long noodle strips from three batches were taken for examination. Each strip was individually cooked in boiling water according to its cooking time, drained for 10 minutes, and let it cool at room temperature. Strip was then put under cylinder probe of 35 mm (P/35) in a texture analyser (TAXT Plus, Stable Microsystem, Goldaming, Surrey, UK). The cooked strips were measured only for hardness and adhesiveness using default method for pasta product. The noodle was not analysed using Texture Profile Analysis method.

Sensory examination

Sensory analysis was carried out using two methods: hedonic and scoring techniques. Hedonic test was done by employing untrained 20 panellists consisted of university students, all of them were non-smokers. The panellists were asked not to take any meal nor drink two hours prior to the test. A questionnaire consisted of five questions were given to the panellists for them to identify their preference on a 1 to 7 scale, for colour, aroma, taste, mouth feel, and overall preference of each noodle. Test for each type of noodle were conducted in separate day.

Scoring test was done by ten semi-trained panellists consisted of research students who had been working on various noodle projects, and thus were familiar with evaluation of noodle sensory characteristics. All panellists were non-smokers. On 1 to 9 scale, they were asked to score noodle on several sensory attributes: colour (light to dark), shininess (dull to shiny), transparency (opaque to transparent), texture as felt by fingers (not elastic to very elastic), mouth-feel (not chewy to very chewy), stickiness in mouth (not sticky to very sticky), aroma (weak to strong), stickiness among noodles strips (not sticky to very sticky), taste (weak to strong taste), hardness (soft to very hard), and firmness (soft to very firm).

Blood glucose concentration

Seven participants were recruited from students in the department (age 18-22 years, body mass index 17-25, non-smokers, do not drink alcohol, and do not have diabetes history in the family), and given a brief session to explain procedure of the test. Ten hours in the night prior to the test, they were asked not to take any meal nor drink except water up to two glasses. During the test, they were given meal equals to 50 g of flour, and a glass of water. For reference meal, we used white bread made from white wheat flour. Each participant consumed pieces of bread made from 50 g of flour. Test meal was banana or taro noodle. Each participant consumed noodle made from 50 g of banana or taro flour. Blood glucose concentration was measured before taking meal and every 15 mins after meal, up to 120 mins. Postprandial glucose was measured using a commercial glucometer testing kit (Gluco DR™/AGM-2100 Biosensor, equipped with GlucoDr™ AGS Biosensor Strip). The test was repeated twice for each type of noodle, allowing 5 days of break between tests.

Antioxidant activity

Gathotan pieces were made into suspension in methanol by blending 10 g of gathotan pieces and 100 mL methanol, in a Waring blender (type 8010S/8010G, Waring Laboratory Science, Winsted, CT, USA), for 10 mins until smooth slurry was formed. Suspension was filtered using #1 Whatman paper, and filtrate was evaporated in a rotary evaporator (RV 8, IKA®-Werke, GmbH & Co. KG, Germany) at 45°C, for 30 mins. Dried sample was then diluted in distilled water upon colorimetric method, following previously used method by Shin *et al.* (2007). Total phenolic compound was determined by first mixing diluted sample (0.1 mL) with Folin-Ciocalteu reagent (10%, 0.5 mL), and then allowed to stand for 8 mins at ambient temperature. After that, it was added mixed with Na_2CO_3 (4.5 mL, 2%), and kept in the dark room for 60 mins at room temperature. Using a spectrophotometer (SP-3000, Plus Optima, Japan) at wave length of 765 nm, absorbance of the mixture was determined, and result was expressed as gallic acid equivalents/100 g sample.

For determination of DPPH scavenging activity, dried methanol extract was diluted in methanol to make suspension containing 20-100 μg dried extract, following a previous method (Arabshi-Delouee and Urooj, 2007). Suspension (5 mL) was then mixed with 1 mL DPPH (1 mmol/L in methanol) and vigorously mixed using a vortex mixer (Vortex 3, IKA, Krackeler Sci. Ltd., Albany, NY). It was left in the dark at ambient temperature for 30 min before measuring the absorbance at 517 nm with a spectrophotometer (SP-3000, Plus Optima, Japan). DPPH scavenging activity was calculated relative to control, according to the following equation:

$$\text{DPPH scavenging activity (\%)} = \frac{(\textit{Absorbance of control} - \textit{Absorbance of sample})}{\textit{Absorbance of control}} \times 100$$

Result was expressed as vitamin E equivalents/100 g sample, using sample, using All measurements were repeated three times.

Data processing

All data were processed using a statistical package SPSS® version 16 (SPSS, Inc.), for analysis of variance. Duncan method at 5% confidence level was then used to analyse any statistical difference among means.

Results and Discussion

Textural properties of taro or banana noodle

Analysis of variance showed that hardness or adhesiveness was influenced significantly ($P<0.05$) by proportion of water or interaction between two factors studied. Proportion of taro flour did not affect hardness nor adhesiveness. The more water added in pre-gelatinisation, the more adhesive and harder the noodle. The hardest and most adhesive noodle was resulted from water proportion of 8 and taro flour proportion of 1 (Table 1), although statistically did not differ from others except noodle made from water pproportion of 7 and taro flour proportion of 1 (Table 1). Therefore, Tthe softest and least adhesive

Table 1. Hardness and adhesiveness of taro noodle as affected by proportion of water or flour

Proportion of water (w/w)	Proportion of taro flour (w/w)	Hardness (g)	Adhesiveness (g)
6	1	3428[ab]	-306.00[b]
6	1.1	3190[ab]	-275.60[ab]
7	1	2393[a]	-100.90[a]
7	1.1	3553[ab]	-288.70[ab]
8	1	4055[b]	-587.90[c]
8	1.1	3632[ab]	-333.90[b]

Numbers with same superscripts in a column indicated no significant difference (P≥0.05)

Table 2. Hardness and adhesiveness of banana noodle as affected by proportion of water or flour

Proportion of water (w/w)	Proportion of banana flour (w/w)	Hardness (g)	Adhesiveness (g)
7	1.1	2606[b]	-52.60[b]
7	1.2	2202[ab]	-19.60[a]
8	1.1	2185[ab]	-29.50[ab]
8	1.2	2049[a]	-21.40[ab]
9	1.1	2302[ab]	-40.30[b]
9	1.2	2551[b]	-28.70[ab]

Numbers with same superscripts in a column indicated no significant difference (P≥0.05)

noodle contained water proportion of 7 and taro flour proportion of 1. Taro noodle had similar hardness with that of Chinese wheat noodle (3211 g) (Lu *et al.*, 2009), but more adhesive than Chinese or Japanese wheat noodle (Baik *et al.*, 1994). Compared to gluten-free breadfruit noodle made by using gathotan flour as texturing agent (Purwandari, Khoiri, Muchlis *et al.*, 2014), taro noodle showed better hardness, and comparable adhesiveness. Gathotan noodle, noodle made of solely gathotan flour has relatively hard texture (5823.6 g), and high adhesiveness (-379.6 g to -2428.0 g) (Purwandari, Tamam, Arifin *et al.*, 2014). Therefore, mixing taro and gathotan flour may be considered as a way to rectify textural drawback in gathotan noodle. Taro starch had small granule size (Aboubakar *et al.*, 2008; Aprianita *et al.*, 2009), which may contribute to the development of smooth dough and relatively soft and good noodle texture of taro noodle. It was apparent that gathotan flour is more influential in determining textural properties of taro noodle. Gathotan flour has lower gelatinisation temperature and much higher peak viscosity (72.8°C and 5663 cP, respectively) (Purwandari, Tamam, Arifin *et al.*, 2014) compared to that of taro flour (93.6°C and 1946 cP, respectively) (Kaushal *et al.*, 2012). Another work reported low peak temperature (62.9°C) and peak viscosity (1050 cP) of taro flour (Yadav *et al.,* 2014). Although taro flour tended to cause formation of very firm gel, and influenced firmness of gel of flour blend (taro, rice, and pigeon pea flour) (Kaushal *et al.*, 2012), this effect diminished in blend of taro and gathotan flour during taro noodle making. Taro flour had relatively high content of amylopectin and higher swelling properties (Aprianita *et al.,* 2009), which may contribute to hardness of taro noodle. However, again, this effect was not shown in the case of taro noodle texture in our experiment, probably due to greater effect of gathotan flour. When added at 25%, taro in dough of wheat noodle lowered hardness, and cooking time as compared to control wheat noodle (Yadav *et al.*, 2014).

Similar to taro noodle, hardness of banana noodle was affected significantly ($P<0.05$) by proportion of water in gelatinised gathotan flour. The higher water proportion, the harder the noodle. Possibly, higher water proportion in the gel resulted in runny or less elastic texture to unable better holding dried flour, which in turn gave harder texture of noodle. However, unlike taro noodle, adhesiveness of banana noodle was not affected by water proportion, but was influenced by banana flour proportion instead. The more banana flour added into dough, the less adhesive the noodle. Hardness or adhesiveness of banana noodle was influenced by interaction of both factors. The hardest (2551 and 2606 g) noodle contained lowest (7) or highest (9) water proportion, indicating there was optimum water proportion to affect hardness of noodle (Table 2). Similarly, the more adhesive (-40.300 and -55.600 g) noodle was resulted from lowest (7) or highest (9) water proportion.

Banana noodle in our experiment showed comparable hardness (Lu *et al*. 2009) or adhesiveness to that of Chinese or Japanese noodle (Baik *et al.*, 1994). Banana flour was used to replace up to 30% of wheat flour in noodle (Choo and Aziz, 2010) or macaroni (Alvarenga *et al.*, 2011), without affecting sensory preference (Choo and Aziz, 2010; Alvarenga *et al.*, 2011), although extensibility reduced by about half of that of normal macaroni noodle (Alvarenga *et al.*, 2011). Incorporating 47% banana flour in pasta resulted in reduce of firmness, but increase in stickiness (Zandonadi *et al.,* 2012).

Sensory properties of taro or banana noodle

Proportion of taro flour affected significantly ($P<0.05$) shininess, transparency, and stickiness in mouth (data not shown). The more taro noodle in the dough, the more shiny it became. Higher proportion of taro noodle resulted in more transparent and stickier noodle. Water proportion in gelatinised flour significantly ($P<0.05$) affected transparency, stickiness in mouth, and hand feel of taro noodle. The higher proportion of water resulted in noodle with more transparent, more elastic, and less sticky.

Table 3. Blood glucose level of volunteers consuming reference food or taro noodle

Time (minute)	Blood glucose level (mg/dL)	
	White bread	Taro noodle
0	83.710^{a}	88.143^{a}
15	101.714a^{b}	131.143^{c}
30	115.143b^{c}	123.929b^{c}
45	131.429^{c}	121.000b^{c}
60	121.000b^{c}	100.929^{ab}
75	106.929^{b}	96.714^{ab}
90	107.929^{b}	100.286^{ab}
105	92.643^{ab}	85.000^{a}
120	95.214^{ab}	82.214^{a}

Numbers with same superscripts in a column indicated no significant difference (P≥0.05)

Table 4. Blood glucose level of volunteers consuming reference food or banana noodle

Time (minute)	Blood glucose level (mg/dL)	
	White bread	Banana noodle
0	86.250^{a}	90.650^{ab}
15	100.250^{a}	131.350^{c}
30	121.000^{bc}	137.050^{c}
45	133.250^{c}	127.300^{c}
60	122.500^{bc}	113.850^{b}
75	112.000^{bc}	96.700^{b}
90	106.950^{bc}	91.100^{ab}
105	98.600^{a}	84.000^{a}
120	99.750^{a}	85.350^{a}

Numbers with same superscripts in a column indicated no significant difference (P≥0.05)

Analysis of variance of hedonic test data of banana noodle indicated that proportion of banana flour positively affected (P<0.05) preference for colour and mouth feel (data not shown). However, none of the factor studied affected (P≥0.05) preference for taste, aroma, or overall preference. Results of scoring test on sensory properties showed that proportion of water or banana flour influenced (P<0.05) colour of noodle, while less water or more banana flour resulted in lighter colour of noodle. Contrary, none of the factors affected aroma, taste, or mouth feel.

Previous reports on banana pasta (containing 47% banana flour) (Zandonadi *et al*., 2012), macaroni (containing 30% banana flour) (Alvarenga *et al*., 2011), or noodle (containing 30% banana flour) (Choo and Aziz, 2010) showed superiority of sensory characteristics of banana products over normal wheat counterparts. People with celiac disease showed better preference for banana pasta than wheat pasta (Zandonadi *et al*., 2012), in all sensory characteristics being tested (aroma, appearance, texture, flavour and overall preference). Consumption of banana flour pasta (Zandonadi *et al*., 2012) or noodle (Choo and Aziz, 2010) improved nutritional status, by increasing mineral content (Zandonadi *et al*., 2012) especially phosphorous, potassium, calcium, and magnesium content (Choo and Aziz, 2010). Another nutritional benefit from banana product (banana pasta) is increase in calorie and carbohydrate (Zandonadi *et al*., 2012), as well crude protein and resistant starch content (Choo and Aziz, 2010). However, some previous work reported reduce in protein content of banana macaroni (Ovando-Martinez *et al.,* 2009; Alveranga *et al*., 2011; Zandonadi *et al*., 2012). One drawback of banana pasta product is increased solid loss (Ovando-Martinez *et al.*, 2009; Zandonadi *et al.*, 2012). Our result further highlighted the importance of banana flour as raw material for processed food with good sensory characteristics, health, and functional benefits (Aurore *et al*., 2014).

Blood glucose concentration after consumption of taro or banana noodle

Blood glucose concentration upon consumption of either taro or banana noodle showed similar trend, where it was peaking around 20 (taro noodle) (Table 3,4) or 30 mins (banana noodle) (Table 54) after consumption, and then followed by a constant decrease toward 120 mins (Table 43, Table 54). Also, blood glucose concentration at the end of testing period was slightly lower than that at the beginning of the test, i.e. blood glucose at fasting level. At the end of testing period (120 mins), blood glucose level was lower than fasting level. Quick raise of postprandial glucose and quick decrease caused by consumption of taro or banana noodle most likely reflected the influence of gathotan (Purwandari, Tristiana, Hidayati, 2014). Although the glycemic index of either taro or banana noodle was high, some features in postprandial blood glucose may give potential health benefits, those were quick increase of postprandial blood glucose at the beginning, and lower level at the end of testing. The quick increase of blood glucose level may mean that taro or banana noodle can provide energy shortly after consumption. Whilst, the low glucose level at the end of testing indicated that the noodles potentially lowered blood glucose concentration.

Taro starch showed lower rate of hydrolysis compared to white bread (Simsek and El, 2012). While white bread was completely hydrolysed in 60 mins, only 80% of taro starch was hydrolysed (Simsek and El, 2012). Taro flour had 35.19 % resistant starch content, and 50.42% digestibility (Aprianita *et al*., 2009). Again, although gathotan flour was present in relatively low amount in taro noodle, it seemed to affect substantially glycemic index and postprandial glucose of the noodle.

Table 5. Antioxidant activity in taro or banana noodle

Type of noodle	DPPH inhibition (%)	Equivalent to vitamin E (mg/100g)	Total phenolic compound (mg/100g)
Taro noodle	86.03±0.228	17.14±0.43	79.95±0.06
Banana noodle	91.61±0.13	54.61±0.08	304.33±1.79

Values were means of three replications.

Banana flour is good source of resistant starch (Ovando-Martinez *et al.,* 2009) as it contained 42.54% resistant starch with 57.75% insoluble and 2.36% soluble fractions (Ovando-Martinez *et al*., 2009). Consequently, any product containing 30-45% banana flour had higher content of resistant starch, lower digestibility, and lower glycemic index (Ovando-Martinez *et al*., 2009; Choo and Aziz, 2010).

Antioxidant activity

Antioxidant activity in taro noodle showed 86.04% inhibition of DPPH, 17.13 mg/100 g vitamin E equivalent, and 79.94 mg/100 g phenolic compound (Table 5). In banana noodle, inhibition of DPPH was 91.61%, vitamin E equivalent was 54.60 mg/100 g, and total phenolic compound was 304.33 mg/100 g.

Taro showed antioxidant activities as expressed by total phenolic compounds, DPPH, nitric oxide radicals and superoxide radicals scavenging activity, lipid peroxides and hyaluronic acid inhibition (Goncalves *et al*., 2013). It is not clear in our research whether DPPH scavenging activity of taro noodle was more influenced by DPPH scavenging activity in gathotan flour or taro. Taro noodle showed similar DPPH scavenging ability to gathotan noodle (Purwandari, Tristiana, Hidayati, 2014). In term of phenolic content and vitamin E equivalent, taro noodle was higher than gathotan noodle, suggesting that taro contributed substantially to antioxidant level in the noodle.

Banana is a good source of antioxidant due to its high content of gallocatechin (Someya *et al*., 2002). Our result of phenolic compounds in banana noodle (304.33 mg/100 g) was higher than in previous report (232 mg/100 g (Someya *et al.,* 2002), which may due to difference in variety (Sulaiman *et al*., 2011). Phenolics content in banana noodle seemed to come from banana flour and not from gathotan flour. Phenolics content in gathotan flour (419.43 mg/100 g) reduced in a great extent when the flour was made into noodle (Purwandari, Tristiana, Hidayati, 2014). It was not clear whether antioxidant activity of banana noodle caused by phenolics compound, since there was a little correlation between phenolics content and DPPH inhibition activity (Sulaiman *et al*., 2011). Soaking and boiling can reduce phenolic compounds, but antioxidant activity was not substantially altered (Vadivel *et al*., 2012).

Conclusion

Gluten-free taro or banana noodle can be made using gathotan flour as texturing agent. Taro or banana noodle had comparable hardness to dried wheat noodle. However, while banana noodle was not adhesive, taro noodle was more adhesive than dried wheat noodle. Taro flour induced adhesiveness and transparency of noodle, while banana flour caused lighter colour of noodle. Either taro or banana noodle showed postprandial blood glucose lowering effect, and high antioxidant activity.

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