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# Textural, cooking quality, and sensory evaluation of gluten-free noodle made from breadfruit, konjac, or pumpkin flour

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**Abstract**

Three types of gluten-free noodle were made using flour of breadfruit, konjac, and blend of pumpkin and tapioca. Due to different characteristics of the three raw material, preparation were carried out in three different methods in three separate experiments. Breadfruit and pumpkin noodle were made by using a texturing agent: fermented cassava flour and tapioca flour, respectively. Whilst, konjac noodle did not need any texturing agent. This work aims to study the effect of preparation method of each type of noodle on textural and sensory properties of gluten-free noodles. Results showed that samples of breadfruit noodle had hardness ranging from 2520 to 3890 g and had preference score of 5.60 out of 9. Water ratio in pregelatinized flour, and proportion of dry breadfruit flour in noodle dough affected hardness of breadfruit noodle, while interaction of the two factors influenced hardness, adhesiveness and cooking time of breadfruit noodle. Cooking loss was not affected by preparation method. Cooking time of breadfruit noodle ranging from 3.11 to 4.77 min, and cooking loss ranging from 12.45 to 17.04%. Konjac noodle textural characteristics were affected by preparation method being examined. Konjac noodle had hardness of 3094 to 5204 g and adhesiveness of -406 to -920 g. Cooking quality of konjac noodle was not reported. Sensory evaluation of konjac noodle was influenced by preparation method, and the highest score for overall preference was 6.6 out of 9. Pumpkin noodle had hardness ranging from 2237 to 4954 g, and adhesiveness of -158.05 to -351.41 g, cooking time ranging from 2.30 to 5.0 min, and cooking loss was 11.20 to 27.38%. The highest preference score was 6.0 given to noodle containing 54% pumpkin flour.



## Introduction

Noodle has been increasingly important food commodity worldwide, with annual production of 101,420 million packs in 2012, and a steady increase of 3% annually since 2010 (World Instant Noodle Association, 2013). Most noodle is made of wheat as raw material, thus noodle consumption led to a dependency on massive imported wheat in non-wheat producing countries. Apart from wheat importation, wheat consumption may cause allergy, asthma, autoimmune response, or gluten sensitivity (Rosell *et al*., 2013) in some group of people, leading to increasing demand of gluten-free products. Therefore, it is imperative to create new types of noodle made from non-wheat flour. Several works have been done on gluten-free noodle using different types of flour, although rice flour (Inglett *et al*., 2005; Yadav *et al*., 2011; Heo *et al*., 2013b) seems to be the best replacement for its small granule sizes to benefit noodle textural characteristics. Some other raw materials for gluten-free noodle include sorghum (Liu *et al*., 2012), and corn starch (Yuan *et al*., 2008; Yousif *et al*., 2012) or corn flour (Padalino *et al*., 2013). Lately, sweet potato starch (Silva *et al*., 2013), pseudo-cereal such as amaranth flour in combination with cassava starch (Fiorda *et al*., 2013) were also used for the making of gluten-free pasta.

The absence of gluten in non-wheat noodle compositions adversely affects noodle quality. Therefore, non-gluten-free noodle was treated to improve its characteristics. Several techniques commonly used for starch textural improvement are annealing and hydrothermal treatment (Hormdok and Noomhorm, 2007), gelatinization (Yousif *et al*., 2012), fermentation (Yuan *et al*., 2008), addition of hydrocolloids such as carboxymethylcellulose (Choy *et al*., 2012), addition of konjac glucomannan (Zhou *et al*., 2013), β-glucan (Inglett *et al*., 2005; Heo *et al*., 2013a), addition of transglutaminase (Gan *et al*., 2009; Kim *et al*., 2014), and acetylated starch (Choy *et al*., 2012). In this work, pumpkin, konjac,

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or breadfruit, was used to make gluten-free noodles, and to study textural and sensory properties of noodle as affected by preparation method. Each noodle was made using different preparation method.

## Methodology

*Noodle making*

First step was preparing flour from the three raw materials for gluten-free noodle. Similar method was applied to breadfruit, konjac corm, and pumpkin. Mature but unripe breadfruit commercially available in local market in Kamal, Madura, Indonesia, was peeled, and then sliced about 1-2 mm thick. The slices were soaked into a 1% sodium metabisulphite solution for 5 minutes, then drained well. Three times washing with water were done to remove excess of sodium metabisulphite. It was then followed by drying in a cabinet dryer at 55°C until the chips were fully dry. They were then ground using electric grinder, and passed through a 60 mesh sieve. Breadfruit flour was kept in a tight container until its uses. Fully mature konjac corms were bought from local market in Nganjuk, East Java Province, Indonesia. Pumpkin was collected from local market in Sampang, Madura, Indonesia. The corms and pumpkin were treated similary as breadfruit to make flour.

Each type of noodle was made using three different methods, due to individual characteristics of raw material. The breadfruit noodle was made by mixing it with pregelatinised fungal fermented cassava flour (Purwandari, 2000) as texturing agent. The preparation of pregelatinised flour varied in flour to water proportions of 1:4, 1:5, 1:6 (w/w). The suspension was heated using moderate heat on a hot plate (85°C) until all starch gelled. This gel was then mixed in ratios of pregelatinised to breadfruit flour of 1:10, 1:11, 1:12 (w/w). After mixing, the dough was let to stand for 30 min at room temperature. It was then passed into a roller 7-9 times until smooth sheet was formed, then cut into strips of 10 mm width and 1 mm thick. The strips were steamed for about 30 min or until opaque in the center of strip disappeared, then they were dried in a cabinet dryer at 55°C until dry.

Konjac noodle was firstly made by preparing pregelatinised konjac flour and water of various ratios: 1:10, 1:11, 1:12 (w/w). The pregelatinised flour was then mixed with dry konjac flour in ratios of 1:0.10, 1:0.13, 1:0.18 (w/w). After equilibration, the dough was made into smooth sheet, and then cut into strips, steamed, dried, and stored.

Pumpkin noodle was made by mixing pumpkin flour with tapioca flour with various ratios of 41:59, 39:61, 36:64, 37:63, 34:66, 32:68 (w/w). Distilled water was then added at 83, 75, and 67% (w/w). After mixing, the dough was passed into a roller 7-9 times until smooth and elastic sheet was formed; cut, steamed, and dried in a cabinet dryer at 50°C until the strips were fully dry.

*Textural properties*

Textural characteristics of noodle were measured as hardness and adhesiveness on a texture analyser TA-XT Plus (Stable Micro Systems, Surrey, UK). Ten 10 cm-long dried noodle strips taken from two separate batches of every treatment was put into a boiling distilled water according to their cooking time to enable gelling of all part of noodles, then were drained and cooled at room temperature for around 10 min, then put each strip under the probe. The probe used was a cylider type with 35 mm diameter (P/35).

*Cooking quality*

Dried breadfruit and pumpkin noodle was subjected to cooking loss, cooking time, and water absorption measurement, according to a standard method by AACC (2000) with some modifications. Dried noodle strips (10 cm long) of known weight were cooked in boiling water about 10 times weight of dried noodles. First, cooking time was determined by put strips into boiling water, and checked the disappearance of opaque at the center of the strip. The time of disappearance of opaque center was recorded as cooking time. Cooking loss was determined as the quantity of dry solid in cooking distilled water after cooking noodle strips according to their cooking time, expressed as percentage over the weight of dried noodles. Water absorption was the increase in weight of dried noodles after cooking in boiling water according to their cooking time.

*Sensory evaluation*

Sensory test was carried out by employing 20 untrained panelists from University students and staff. They were asked to score their preferences for sensory attributes (colour, aroma, taste, mouth feel, and overall) of cooked noodles, ranging from 1 (dislike very much) to 9 (like very much), using questionnaire sheets.

*Data processing*

Analysis of variance of data of each type of noodle was carried out on a statistical package SPSS (SPSS Inc.), for full factorial design consisting two factors with three levels for each factor. The differences among mean values were analysed using Tukey method with significance level of 0.05.

## Results and Discussions

Table 1. Hardness, adhesiveness, cooking time, and cooking loss of breadfruit noodle

| Flour:Water (g/g) | Pregelatinised flour:Breadfruit flour (g/g) | Hardness (g) | Adhesiveness (g) | Cooking Time (min) | Cooking Loss (%) |
|---|---|---|---|---|---|
| 1:4 | 10:10 | 3878$^{b}$ | -846.690$^{c}$ | 4.55$^{a}$ | 17.04$^{a}$ |
| | 10:11 | 4031$^{b}$ | -1097.00$^{a}$ | 4.61$^{a}$ | 16.66$^{a}$ |
| | 10:12 | 2520$^{a}$ | -1006.00$^{a}$ | 4.77$^{a}$ | 14.50$^{a}$ |
| 1:5 | 10:10 | 4313$^{b}$ | -458.239$^{b}$ | 3.11$^{c}$ | 12.45$^{a}$ |
| | 10:11 | 3890$^{b}$ | -863.750$^{c}$ | 3.50$^{bc}$ | 13.94$^{a}$ |
| | 10:12 | 3218$^{ab}$ | -959.875$^{c}$ | 3.39$^{bc}$ | 13.07$^{a}$ |
| 1:6 | 10:10 | 3966$^{b}$ | -951.044$^{c}$ | 3.22$^{bc}$ | 15.21$^{a}$ |
| | 10:11 | 2990$^{a}$ | -597.500$^{bc}$ | 3.38$^{bc}$ | 15.33$^{a}$ |
| | 10:12 | 5074$^{c}$ | -659.125$^{bc}$ | 3.61$^{b}$ | 13.66$^{a}$ |

Same superscripts within a coloumn indicate no significant difference (P > 0.05)

Table 2. Hedonic score of breadfruit noodle

| Flour:Water proportion (g/g) | Preference for | | | | | |
|---|---|---|---|---|---|---|
| | Colour | Aroma | Taste | Mouth feel | Appearance | Overall |
| 1:4 | 4.60$^{a}$ | 4.83 | 4.21 | 4.86 | 4.35$^{a}$ | 4.76$^{a}$ |
| 1:5 | 5.08$^{ab}$ | 4.90 | 4.50 | 4.98 | 4.71$^{ab}$ | 5.22$^{ab}$ |
| 1:6 | 5.68$^{b}$ | 4.95 | 4.80 | 5.23 | 5.40$^{b}$ | 5.73$^{b}$ |
| Pregelatinised flour: dry flour (g/g) | | | | | | |
| 10:10 | 4.98$^{ab}$ | 4.88 | 4.52 | 4.90 | 4.68$^{a}$ | 5.15$^{ab}$ |
| 10:11 | 5.60$^{b}$ | 4.98 | 4.58 | 5.33 | 5.47$^{b}$ | 5.63$^{b}$ |
| 10:12 | 4.78$^{a}$ | 4.82 | 4.42 | 4.85 | 4.32$^{a}$ | 4.93$^{a}$ |

Same superscripts within a coloumn indicate no significant difference (P > 0.05)

Table 3. Hardness and adhesiveness of konjac noodle

| Flour: Water (g/g) | Pregelatinised flour:konjac flour (g/g) | Hardness (g) | Adhesiveness (g) |
|---|---|---|---|
| 1:9 | 10:1.0 | 4632$^{bc}$ | -406$^{b}$ |
| | 10:1.3 | 3937$^{b}$ | -539$^{b}$ |
| | 10:1.8 | 4656$^{bc}$ | -589$^{b}$ |
| 1:10 | 10:1.0 | 3094$^{a}$ | -816$^{ab}$ |
| | 10:1.3 | 5042$^{c}$ | -597$^{ab}$ |
| | 10:1.8 | 4810$^{bc}$ | -575$^{b}$ |
| 1:11 | 10:1.0 | 3284$^{ab}$ | -920$^{a}$ |
| | 10:1.3 | 5204$^{c}$ | -583$^{b}$ |
| | 10:1.8 | 4683$^{bc}$ | -715$^{ab}$ |

Same superscripts within a coloumn indicate no significant difference (P > 0.05)

### *Breadfruit noodle*

Analysis of variance (table not shown) showed that each of the two factors as well as their interactions gave significant effects ($p < 0.05$) on hardness of breadfruit noodle. The hardest breadfruit noodle (hardness level of 5074 g) was resulted from water proportion of 1:6 and flour proportion of 10:12 (Table 1). Whilst, the softest breadfruit noodle (2520 g) was made from water proportion of 1:4, and flour proportion of 10:12. Compared to hardness of Japanese or Chinese white wheat noodle, breadfruit noodle had higher hardness. However, a relatively high hardness (3211 g) was shown by a Chinese wheat noodle in a previous report (Lu *et al*., 2009), so that breadfruit noodle was slightly softer or almost twice harder, depending on the preparation method. Adhesiveness of breadfruit noodle ranged from -458.23 to -1097 g (Table 1), which were way higher than that of Japanese (-49.1 g) or Chinese (-48.4 g) noodle (Baik *et al*., 1994), or instant noodles made from Australian soft wheat (-20.4 g) and Baker's wheat (-8.2 g) (Choy *et al*., 2013). Less water used in making pregelatinised flour tended to give more adhesive noodle. Similarly, the more breadfruit flour in dough tended to give higher adhesiveness. The interaction of the two factors was significant ($p < 0.05$, anova table not shown). Considering pregelatinised flour used here likely contained glucose polymers i.e. dextrin as a result of enzymatic degradation, more concentrated dextrin in the noodle seemed to cause less water available for uptaking by breadfruit flour (Miyazaki *et al*., 2004; Yousif *et al*., 2012), and then reduced hardness and increase adhesiveness (Miyazaki *et al*., 2004; Yousif *et al*., 2012). Similarly, germinated brown rice added into noodle flour also reduces hardness but increases adhesiveness (Chung *et al*., 2012) likely due to formation of smaller water soluble molecules such as glucose to weaken noodle structure (Chung *et al*., 2012).

Cooking time was also affected significantly by the interaction of the two factors, and ranging from 3.11 to 4.77 min (Table 1). Lower proportion of breadfruit flour in dough gave lower cooking time. The more water in pregelatinised flour reduced cooking time. Cooking loss was not affected significantly by the two factors studied (Table 1), and was two or three times higher that cooking loss of a wheat noodle in previous report (5-8%) (Lu *et al*., 2009). Modification of breadfruit by several treatments (annealing, heat-moisture treatment, acetylated, and oxidization) improve water retention capacity, peak viscosity, and swelling power of starch (Adebowale *et al*., 2005). Breadfruit may need starch modification to reduce cooking loss of breadfruit noodle.

Sensory evaluation showed that aroma, taste, and mouth-feel of breadfruit noodle were not affected by treatments (Table 2). However, the more water used in pregelatinised flour gave significant increase in the preference for colour, appearance, and overall preference (Table 2). Meanwhile, the best preference was given to noodle containing flour ratio of 10:11. The higher proportion of flour reduced preference of breadfruit noodle. The sensory evaluation of bread fruit biscuit is found inferior to that of biscuit made of wheat (Omobuwajo, 2003). However, prawn cracker made from breadfruit starch does not differ in overall preferences from that of prawn cracker made from wheat (Omobuwajo, 2003). Similarly, breadfruit chip overall preference was the same as that of potato chips (Omobuwajo, 2003).

### *Konjac noodle*

Hardness and adhesiveness of konjac noodle was affected significantly ($p < 0.05$) by the preparation method (Table 3). The more flour added into dough, the hardness of konjac noodle tended to increase, with the highest hardness (5204 g) was about three times higher than that of standard Chinese or Japanese wheat noodle, which was 1621 g and 1957 g, respectively (Baik *et al*., 1994). Similarly, the more proportion of water in pregelatinised flour, the harder konjac noodle became. Higher ratio of water in pregelatinised

Table 4. Hedonic score for konjac noodle

| Flour: Water (g/g) | Pregelatinised flour:konjac flour (g/g) | Preference for | | | | |
|---|---|---|---|---|---|---|
| | | Colour | Aroma | Taste | Mouth feel | Overall |
| 1:9 | 10:1.0 | $3.95^{a}$ | 5.45 | 4.95 | $5.15^{ab}$ | $5.20^{ab}$ |
| | 10:1.3 | $5.55^{b}$ | 5.90 | 5.25 | $5.30^{ab}$ | $5.90^{ab}$ |
| | 10:1.8 | $6.40^{b}$ | 5.60 | 6.00 | $5.95^{b}$ | $6.65^{b}$ |
| 1:10 | 10:1.0 | $4.95^{ab}$ | 4.95 | 5.10 | $3.90^{a}$ | $5.05^{ab}$ |
| | 10:1.3 | $5.05^{ab}$ | 5.50 | 5.00 | $4.55^{ab}$ | $5.05^{ab}$ |
| | 10:1.8 | $4.95^{ab}$ | 5.50 | 5.40 | $5.20^{ab}$ | $6.00^{ab}$ |
| 1:11 | 10:1.0 | $4.50^{ab}$ | 4.90 | 4.90 | $4.40^{ab}$ | $5.00^{a}$ |
| | 10:1.3 | $5.55^{b}$ | 5.55 | 5.45 | $5.70^{b}$ | $5.60^{ab}$ |
| | 10:1.8 | $5.70^{b}$ | 5.90 | 5.75 | $5.90^{b}$ | $6.20^{ab}$ |

Same superscripts within a coloumn indicate no significant difference (P > 0.05)

Table 5. Hardness, adhesiveness, cooking time, and cooking loss of pumpkin noodle

| Tapioca flour:pumpkin flour (g/g) | Water (%) | Hardness (g) | Adhesiveness (g) | Cooking time (min) | Cooking loss (%) |
|---|---|---|---|---|---|
| 41:59 | 83 | $3528^{cd}$ | $-314.17^{b}$ | $3.5^{c}$ | 13.41 |
| | 75 | $2993^{bc}$ | $-351.41^{b}$ | $5.0^{e}$ | 12.70 |
| | 67 | $4000^{cd}$ | $-165.49^{a}$ | $4.0^{d}$ | 19.79 |
| 39:61 | 83 | $4414^{d}$ | $-158.05^{a}$ | $4.3^{de}$ | 16.35 |
| | 75 | $3762^{cd}$ | $-338.72^{b}$ | $3.1^{bc}$ | 17.67 |
| | 67 | $3694^{cd}$ | $-348.07^{b}$ | $2.6^{ab}$ | 16.25 |
| 36:64 | 83 | $2237^{a}$ | $-201.56^{a}$ | $3.5^{c}$ | 16.67 |
| | 75 | $3685^{cd}$ | $-286.09^{ab}$ | $2.6^{ab}$ | 16.49 |
| | 67 | $4954^{d}$ | $-319.74^{b}$ | $4.1^{d}$ | 14.57 |
| 34:66 | 83 | $3528^{bc}$ | $-204.03^{a}$ | $4.0^{d}$ | 20.96 |
| | 75 | $2727^{ab}$ | $-316.80^{b}$ | $4.8^{e}$ | 19.10 |
| | 67 | $3606^{c}$ | $-338.14^{b}$ | $2.3^{a}$ | 13.76 |
| 32:68 | 83 | $3173^{bc}$ | $-345.41^{b}$ | $4.6^{e}$ | 11.24 |
| | 75 | $3493^{bc}$ | $-316.40^{b}$ | $3.8^{cd}$ | 20.28 |
| | 67 | $3247^{bc}$ | $-291.61^{ab}$ | $2.8^{b}$ | 20.13 |
| 30:70 | 83 | $2899^{b}$ | $-268.41^{ab}$ | $3.5^{c}$ | 16.10 |
| | 75 | $2651^{ab}$ | $-276.08^{ab}$ | $4.6^{e}$ | 27.38 |
| | 67 | $2673^{ab}$ | $-188.841^{a}$ | $4.1^{d}$ | 11.20 |

Same superscripts within a coloumn indicate no significant difference (P > 0.05)

flour seemed to result in more adhesive noodle, as shown in breadfruit as konjac noodle in this work. Adhesiveness of konjac noodle was about ten times higher than othat of wheat flour noodle (48.44 to 49.10 g) (Baik *et al*., 1994). Konjac glucomannan-containing noodle had higher stickiness and hardness than one without it (Zhou *et al*., 2013).

Similar to breadfruit noodle, the preferences for aroma and taste of konjac noodle was not affected by preparation method (Table 4). However, interaction of the two factors in the preparation method affected significantly ($p < 0.05$) preference for colour, mouth-feel, and overall preferences. The highest score for preference colour, mouth feel and overall was noodle made from flour:water ratio of 1:9 and flour ratio of 10:1.8. Konjac noodle seemed to have better score for preference as compared to breadfruit noodle. Addition of konjac glucomannan improved sensory perception of wheat noodle (Zhou *et al*., 2013), although high level of addition reduced preference, since noodle became too sticky (Zhou *et al*., 2013).

*Pumpkin noodle*

In general, hardness (2237 to 4954 g) and adhesiveness (-158.05 to -348.72 g) of some pumpkin noodle samples (Table 5) were higher than that of Japanese (1621 g, -49 g) or Chinese (1957 g) wheat noodle (Baik *et al*., 1994), and were also higher that that of instant Australian soft wheat noodle (Choy *et al*., 2013). The hardness of pumpkin noodle reduced by increasing proportion of pumpkin wheat flour. The higher water proportion in the mixture also tended to increase hardness. The hardest pumpkin noodle was resulted from pumpkin flour of 59% (and 67% water), 61% (and 87%) and 64% (and 67% water).

Tabel 6. Hedonic score for pumpkin noodle

| Tapioca flour:pumpkin flour (g/g) | Water (%) | Preference for | | | | |
|---|---|---|---|---|---|---|
| | | Colour | Aroma | Taste | Mouth feel | Overall |
| 41:59 | 85 | $5.36^{c}$ | $5.03^{b}$ | $4.56^{b}$ | $4.96^{b}$ | $5.00^{bc}$ |
| | 73 | $3.20^{ab}$ | $3.63^{a}$ | $3.60^{ab}$ | $4.00^{ab}$ | $3.63^{ab}$ |
| | 67 | $4.30^{b}$ | $4.03^{ab}$ | $3.96^{ab}$ | $4.06^{b}$ | $4.00^{ab}$ |
| 39:61 | 85 | $5.46^{c}$ | $4.50^{ab}$ | $4.26^{b}$ | $4.70^{b}$ | $4.90^{bc}$ |
| | 73 | $3.93^{b}$ | $4.06^{ab}$ | $3.80^{ab}$ | $4.13^{b}$ | $4.06^{ab}$ |
| | 67 | $3.06^{ab}$ | $3.80^{ab}$ | $3.23^{a}$ | $3.13^{ab}$ | $3.43^{a}$ |
| 36:64 | 85 | $6.00^{c}$ | $5.20^{b}$ | $5.00^{b}$ | $4.93^{b}$ | $5.46^{c}$ |
| | 73 | $4.80^{bc}$ | $4.90^{b}$ | $4.30^{b}$ | $4.63^{b}$ | $4.66^{bc}$ |
| | 67 | $4.13^{b}$ | $4.40^{ab}$ | $4.06^{ab}$ | $4.03^{b}$ | $4.23^{ab}$ |
| 34:66 | 85 | $4.60^{bc}$ | $4.43^{ab}$ | $3.90^{ab}$ | $4.16^{b}$ | $4.53^{b}$ |
| | 73 | $4.16^{b}$ | $4.43^{ab}$ | $4.36^{b}$ | $4.43^{b}$ | $4.40^{b}$ |
| | 67 | $3.96^{b}$ | $4.30^{ab}$ | $4.00^{ab}$ | $4.23^{b}$ | $4.30^{ab}$ |
| 32:68 | 85 | $4.26^{b}$ | $4.53^{b}$ | $4.23^{b}$ | $4.36^{b}$ | $4.26^{ab}$ |
| | 73 | $3.80^{ab}$ | $4.50^{ab}$ | $4.16^{b}$ | $4.30^{b}$ | $4.36^{b}$ |
| | 67 | $3.16^{ab}$ | $3.90^{ab}$ | $3.46^{ab}$ | $3.03^{a}$ | $3.60^{ab}$ |
| 30:70 | 85 | $3.83^{ab}$ | $4.23^{ab}$ | $3.86^{ab}$ | $4.26^{b}$ | $4.23^{ab}$ |
| | 73 | $3.03^{ab}$ | $3.80^{ab}$ | $3.56^{ab}$ | $3.16^{ab}$ | $3.70^{ab}$ |
| | 67 | $2.93^{a}$ | $4.06^{ab}$ | $3.56^{ab}$ | $3.73^{ab}$ | $3.56^{ab}$ |

Same superscripts within a coloumn indicate no significant difference (P > 0.05)

Adhesiveness of pumpkin noodle was affected by interaction of both factors in the preparation method studied. The higher pumpkin flour proportion and lower water proportion tended to result in more adhesive noodle. The cooking time was also affected by interaction of both factors, with increasing pumpkin flour or water proportion tended to increase cooking time. Cooking loss of pumpkin noodle (Table 5) did not differ significantly among samples, but was higher than cooking loss of wheat noodle in previous work (Lu *et al*., 2009). Sensory properties of pumpkin noodle seemed to still rather low, with maximum score of 6.0 out of 9 (Table 6). The higher score for all attributes was shown by pumpkin noodle containing 54% of pumpkin flour.

Pumpkin seemed to be superior compared to other vegetables added into pasta, to have higher sensory preference score than others including carrot, eggplant, and green pepper (Padalino *et al*., 2013). Pumpkin starch was able to form a continuous network when prepared in a very fine particle size of around 100 µm (Ahmed *et al*., 2014). This pumpkin flour nature may contribute to relatively acceptable textural or sensory characteristic of pumpkin noodle or pasta.

## Conclusion

Gluten-free noodle can be made from breadfruit, konjac, or pumpkin flour. While konjac noodle did not need any texturing agent, breadfruit or pumpkin noodle needs a texturing agent, which were fermented cassava flour or tapioca flour, respectively. Hardness, adhesiveness, and cooking loss of the noodles were in general still higher than that of wheat noodle. Preference for the noodles were relatively low.

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