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Gluten-free noodle made from gathotan (an Indonesian fungal fermented cassava) flour: cooking quality, textural, and sensory properties

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Abstract

Gathotan is fermented cassava originated from Java, Indonesia. Its cooked form has very chewy tsxture. We examined gelatination profile of gathotan flour, and apply it on the making of gathotan noodle. A factorial design consisting two factors were applied. First factor was proportion of water in pre-gelatinised flour, having three levels (flour:water were 1:6, 1:7, and 1:8). The second factor was proportion of gathotan flour over pre-gelatinised flour, with three levels (pre-gelatinised:gathotan flour were 5:5, 5:5.5, and 5:6). Cooking time, cooking loss, and water absorption, hardness, and adhesieveness were determined using standard methods. A hedonic test was performed by employing 20 untrained panelists to score their preference for colour, aroma, taste, mouth feel, and overall preference. Results showed that hardness of the noodle ranged from 5860 to 5957 g, and was affected significantly by proportion of water or flour. Higher proportion of flour resulted in higher hardness. Similarly, adhesiveness of the noodle ranged from -937.6 to -1461 g, was also affected by either water or flour proportion. The more flour used in the dough, the more adhesive the noodle. Sensory test results showed that either factor did not affect significantly ($P > 0,05$) panelists' preference for all the characteristics examined. Further evaluation using partial least square regression method showed that the main predictor affected overall preference for gathotan noodle was mouth feel, followed by preference for aroma.

Introduction

Noodle has been an important food worldwide, with steady increase of global market as stated by World Instant Noodle Association (2013). The major markets for instant noodle are China (44,030 millions packets), followed by Indonesia (14,100 millions packets), Japan (5,410 millions packets), Vietnam (5,060 millions packets), and India (4,360 millions packets) in 2012 (World Instant Noodle Association, 2013). As some of them are not wheat-producing countries, high noodle consumption creates economic burden within the countries due to large wheat importation. Most of types of noodle are made of wheat, while some other types are made of different types of other starch or flour, such as canna starch, rice flour, corn starch, and buck wheat flour (Tan *et al*., 2009). There have been broad studies on development of new types of noodle to improve its functional health benefit, such as by addition of hydrocolloids (Inglett *et al*., 2005, Choy *et al*., 2012), banana flour (Choo and Aziz, 2010), buckwheat flour (Choy *et al.*, 2013), and yam (Li *et al*., 2012). However, noodle texture is most likely to be affected by the addition of non-wheat flour. Noodle containing up to 20% yam flour showed higher firmness, chewiness, and gummines (Li *et al*., 2012). Similarly, noodle substituted with up to 60% buckwheat had softer texture and higher cooking loss (Choy *et al*., 2013). Palatability was slightly reduced in noodle containing 20% yam flour (Li *et al*., 2012), but overall preference was not altered in banana noodle (Choo and Aziz, 2010).

One of important starchy materials is cassava. Cassava is an important root for the diet of people living in Asia and Africa, since it can grow in marginal land. Fresh tubers may be consumed by boiling/ steaming, frying, fermenting followed by drying and steaming. It is also widely used in the form of starch (tapioca) or flour. Therefore, cassava starch or flour is cheap and available in the area. It was incorporated into noodle making by mixing it with wheat flour (Charles *et al*., 2007) in order to utilise local source for food security. The resulted noodle had high tensile strength, cutting force, and biting force (Charles *et al*., 2007) which can be reduced by adding cassava mucilage (Charles *et al*., 2007). Addition of cassava starch in natural (Charles *et al*., 2007) or esterified (Eguchi *et al*., 2014) form into noodle dough also reduced cooking time and cooking loss (Charles *et al*., 2007; Eguchi *et al*., 2014). Sensory characteristics of noodle containing esterified cassava starch was low (Eguchi *et al*., 2014).

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A fermented cassava product called gathot originated from Java, Indonesia, has very chewy texture. Therefore, it is a good candidate for production of gluten-free noodle. The process of making gathotan (dried moldy cassava chunks as raw material for gathot), had been summarised by Purwandari (2000), and fungi growing during the fermentation had also been identified (Purwandari, 2000) with *Botryodiplodia theobromae* being a dominant fungus growing inside of tuber. The product was proven free from aflatoxin B1 (Purwandari, 2000), even when toxigenic strains grew in cassava (Purwandari, 2000; Dias *et al*., 2011). Aflatoxin was not found in all cassava samples that were contaminated by *A. flavus* (Adjovi *et al*., 2014). Therefore, gathot is safe for consumption based on aflatoxin content. This work aims at studying the making of a gluten-free noodle using gathotan flour, and assessing textural and sensory properties of the product.

Methodology

Experimental design

Experiment on noodle making was conducted in factorial design with two factors, namely proportion of water in pre-gelatinised flour, and flour proportion in noodle dough. Each factor has three levels (flour:water in pre-gelatinised flour, 1:7, 1:8, 1:9, and pre-gelatised flour:dry flour, 5:5, 5:5.5, 5:6).

Preparation of gathotan flour

Gathotan flour was made by first fermenting cassava tubers according to a method mentioned by Purwandari (2000). Cassava tubers at their fully ripe stage were bought from local market in Kamal, Madura, Indonesia. They were peeled, then soaked in water for 48 hours, washed thoroughly, then sun-dried until half-dry. Tubers were then piled in a bamboo basket, and covered with plastic sheet for 48-72 hours, until tubers were grown by fungi. Fermentation was followed by sun-drying, when black fungus has grown inside tuber to give patchy greyish appearance in the interior of tuber. Water spraying was done occasionally to adjust the moisture. Dried moldy tuber was called gathotan, which was then crushed and ground into flour. The flour was sifted using 60 mesh sieve, and stored in a sealed plastic container in a refrigerator until used.

Gelatinisation profile

Gelatinisation profile was determined using Rapid Visco Amylography (RVA) technique in a Brabender® Viscoamylograph. As much as 3.5 g flour sample with 14% water content was mixed thoroughly with 25 mL distilled water, before mounting into the chamber. The suspension was then heated from 35 to 95ºC at heating rate of 1.5ºC/min, and then held at 95ºC for 30 minutes. After that, it was cooled down to 50ºC and held for another 30 minutes. Parameters recorded were peak viscosity, final viscosity, peak time, pasting time, breakdown viscosity, and setback viscosity.

Noodle making

Noodle was made by first making pre-gelatinised flour. One part of gathotan flour was mixed thoroughly with 7, 8, or 9 part of distilled water, then cooked until gel was formed. Gel was cooled at room temperature. A portion of pre-gelatinised flour was then mixed with dry gathotan flour of various proportion ranging from 5:5, 5:5.5, to 5:6 to form dough. Dough was mixed with hands for 15 minutes, then left in a bowl at room temperature for 30 minutes to allow water penetrating into flour evenly. After that, dough was run into a roller 20 times or until smooth sheet was developed. Sheet was then cut into strips with 1 mm thick, and 5 mm width. Strips were then steamed until fully cooked as indicated by gelation of all part of noodle or when opaque part completely disappeared. Strips were then dried in a cabinet dryer at 55ºC until dry.

Cooking quality of noodle

Cooking loss and water absorption of gathotan noodle was examined using standard method (AACC, 2000). In short, about 5 g of dried noodle was put in 50 mL boiling water until all part of noodle turned into perfect gel. Strips of noodle were drain while drain water was collected and mixed with the rest of boiling water. Cooked noodle was weighed, while water was evaporated in a drying oven at 110°C until all water evaporated. Dry material left from the water was then weighed. Cooking loss was calculated as weight of dried material left in water devided by weight of dried noodle, and was expressed in percent. Water absorption was the weight difference between cooked and dry noodle divided by dry noodle weight, expressed in per cent.

Textural properties of noodle

Textural properties of noodle were expressed as hardness and adhesiveness, and was examined using 35 mm diameter cylindrical probe (P/35) for a texture analyzer (TAXT-Plus, Stable Micro Systems, Surrey, UK). Strip of noodle was cooked until opaque in the center disappeared, drained for about 10 minutes at room temperature, then placed under the probe.

Sensory evaluation of noodle

A hedonic test for sensory evaluation was performed involving 20 untrained panelists consisted of students and staff of the faculty. In order to figure out the preference for gathotan noodle compared to normal noodle, we used commercial dried noodle as control. Panelits were asked to score their preference for colour, taste, aroma, mouthfeel, and overall preference for gathotan noodle, from 1 (dislike very much) to 9 (like very much). Test was conducted in two separate sets. First test did not use a control, while the second test used a commercial dried noodle as control. Furthermore, to discover main factor influencing overall preference for gathotan noodle, a partial least square regression was carried out.

Data processing

All data were processed for analysis of variance on a statictical package SPSS™ version 16.0, using General Linear Model with factorial design consisting of two factors. Difference among means was determined using Tukey method at confidence level of 95 %.

Result and Discussion

Gelatinisation profile of gathotan flour

Gelatinisation profile of gathotan flour was shown by peak viscosity of 5663 cP, trough viscosity of 2171 cP, breakdown viscosity of 3492 cP, final viscosity of 3432 cP, peak time of 8.72 minutes, and pasting temperature of 72.8°C (Figure 1). Gathotan flour showed higher peak viscosity than native cassava flour which ranged from 1200-1440 cP, and even higher than that of cassava starch (2400-3000 cP) (Charoenkul *et al.*, 2011) or, in other study, it was 2100 cP (Beninca *et al.*, 2013). Pasting temperature of gathotan flour was also higher than that of native cassava flour (66.8-70.4°C) (Aryee *et al.*, 2006). Bacterial fermentation of cassava also resulted in relatively higher peak viscosity of cassava starch, to reach 2633 cP (Dias *et al.*, 2011). Compared to that of wheat flour (Yildiz *et al.*, 2013), gathotan flour has comparable peak viscosity (Chung *et al.*, 2012) and higher pasting temperature (Chung *et al.*, 2012).

High peak viscosity, peak time, and final viscosity of gathotan flour seems to have correlation with glucoamylase activity which can increase gelation profile of starch (Chung *et al.*, 2012; Dura *et al.*, 2014). Fungal fermentation by Botryodiplodia theobromae in gathotan (Purwandari, 2000) may degrade cassava starch into glucose molecules, by means of glucoamylase (Navaratnam *et al.*, 1996), or β-glucosidase enzymes (Umezurike, 1971;

Table 1. Cooking loss and water absorption of gathotan noodle as affected by water proportion in pre-gelatinised flour

Flour: Water, in pre-gelatinised flour	Cooking loss (%)*	Water absorption*
1:7	3.858[b]	0.859[b]
1:8	3.176[a]	0.830[ab]
1:9	3.176[a]	0.797[a]

*: same letter in a coloumn indicates no significant (P > 0.05) difference

Table 2. Cooking loss and water absorption of gathotan noodle as affected by flour proportion in dough

Pre-gelatinised flour:dry flour	Cooking loss (%)*	Water absorption*
5:5	3.767[b]	0.864[b]
5:5.5	3.246[a]	0.831[ab]
5:6	3.332[a]	0.787[a]

*: same letter in a coloumn indicates no significant (P > 0.05) difference

Tabel 3. Cooking loss and water absorption of gathotan noodle as affected by water and flour proportion

Flour: water, in pre-gelatinised flour	Pre-gelatinised flour: flour in dough	Cooking loss (%)*	Water absorption*
1:7	5:5	4.761[b]	0.922[b]
1:7	5:5.5	3.199[a]	0.824[ab]
1:7	5:6	3.626[a]	0.833[ab]
1:8	5:5	3.172[a]	0.847[b]
1:8	5:5.5	3.116[a]	0.838[b]
1:8	5:6	3.241[a]	0.806[ab]
1:9	5:5	3.368[a]	0.823[ab]
1:9	5:5.5	3.433[a]	0.830[ab]
1:9	5:6	3.129[a]	0.722[a]

*: same letter in a coloumn indicates no significant (P > 0.05) difference

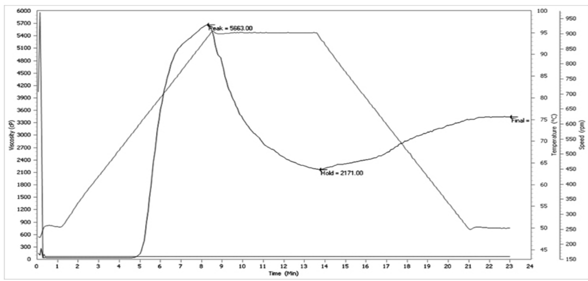

Figure 1. Gelatinisation profile of gathotan flour, showing peak viscosity of 5663.00 cP and viscosity at holding of 2172.00 cP

Umezurike, 1975). Cassava was used as growth and glucoamylase production medium for *B. theobromae* (Navaratnam *et al.*, 1996). Glucoamylase altered surface of starch granule in more effective way as compared to β-amylase (Dura *et al.*, 2014) by forming larger pores on granule surface (Dura *et al.*, 2014), and consequently produced more free sugar (Dura *et al.*, 2014), although glucose released by the two enzymes was not different substantially (Dura *et al.*, 2014). Nevertheless, another report stated that glucoamylase produced more glucose molecules than β-amylase (Soni *et al.*, 2003). As it was not clear from our study what types of enzyme involved in the fermentation of cassava during gathotan making process, there was a possibility of the role of various enzymes in the process, including those from glucosidase group (Umezurike, 1971; Umezurike, 1975). Nevertheless, enzyme production in cassava was not high (Navaratnam *et al.*, 1996), leaving residue of large size of polysaccharide polymers.

Cooking quality of noodle

Cooking loss and water absorption of gathotan noodle were affected significantly ($P < 0.05$) by water proportion in pre-gelatinised flour, flour proportion in dough, and the interaction between the two factors (Anova table not shown). The more water used in pre-gelatinisation, the lower cooking loss or water absorption of noodle (Table 1). Hence, smaller proportion of water may not enough for gelatinisation of all flour, resulting in less cohesive structure of noodle, and consequently, higher cooking loss (Table 1). Cooking loss of gathotan noodle was lower than that of wheat noodle (Lu *et al.*, 2009). Relatively low cooking loss of gathotan noodle may indicate strong gel of gathotan flour. The more dry gathotan flour added into pre-gelatinised flour resulted in lower both cooking loss and water absorption. As noodle made from flour proportion of 5:6 and water proportion of 1:9 showed lowest both cooking quality and water absorption (Table 2), it may indicate optimum proportion of flour or water in dough for good cooking quality noodle. There was no significant difference ($P > 0.05$) between from that of 5:5.5 or 1:8 composition. The highest coooking lost belonged to noodle resulted from flour: water proportion of 1:7, and flour proportion of 5:5 (Table 3).

Gathotan flour likely contained dextrin as the result of enzyme hydrolysis during its fermentation process. *B. theobromae*, a predominant fungus in gathotan, is capable of producing β-glucosidase which degrades starch into glucose and dextrin (Umezurike, 1971; Umezurike 1975). Dextrin added into wheat flour in noodle making was reported to reduce water absorption, swelling power, but increase syneresis, and cooking loss (Yousif *et al.*, 2012). Reduce in water absorption also resulted from addition of dextrin into dough (Miyazaki *et al.*, 2004). Gathotan noodle also showed similar trend where more flour in noodle resulted in less water binding, although unlike their result, gathotan noodle had lower cooking loss with the increase in flour quantity. This may cause by different nature of dextrin used in the studies. Dextrose equivalent (DE) of dextrin added into baking flour determined water absorption of dough (Miyazaki *et al.*, 2004), where higher DE dextrin caused reduce in water absorption of dough. In this case, different water binding nature may then affect its influence on cooking quality of noodle. Gathotan flour seems to behave like dextrin. Low cooking loss in gathotan noodle may also be attributed to cassava amylose and/or mucilage content (Charles *et al.*, 2007).

Our result was in contrast to previously reported relation between cooking loss and water absorption of noodle (Oh *et al.*, 1985) where cooking loss

Table 4. Hardness and adhesiveness of gathotan noodle as the effect of water proportion in pre-gelatinised flour

Flour:water, in pre-gelatinised flour	Hardness (g)	Adhesiveness (g)*
1:7	5959.3^b	-961.7^b
1:8	5823.6^a	-1512^a
1:9	5954.3^b	-1100^b

*: same letter in a coloumn indicates no significant ($P > 0.05$) difference

Table 5. Hardness and adhesiveness of gathotan noodle as the effect of flour proportion

Pre-gelatinised flour:dry flour	Hardness (g)	Adhesiveness (g)*
5:5	5886.4	-719.0^a
5:5.5	5953.6	-841.4^a
5:6	5897.2	-2015^b

*: same letter in a coloumn indicates no significant ($P > 0.05$) difference

Table 6. Adhesiveness of gathotan noodle as affected by water and flour proportion

Flour: water proportion in pre-gelatinised flour	Pre-gelatinised flour: flour in dough	Adhesiveness (g)*
1:7	5:5	-1130.0^b
1:7	5:5.5	-509.6^a
1:7	5:6	-1246.0^b
1:8	5:5	-533.0^a
1:8	5:5.5	-1635^b
1:8	5:6	-2371^c
1:9	5:5	-494.5^a
1:9	5:5.5	-379.6^a
1:9	5:6	-2428.0^c

*: same letter in a coloumn indicates no significant ($P > 0.05$) difference

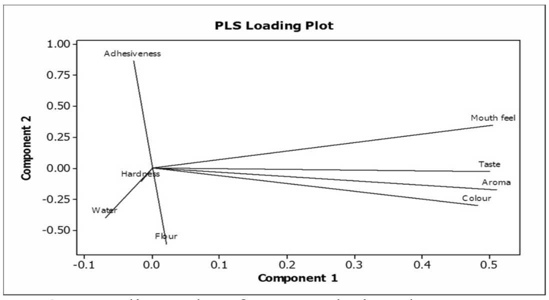

Figure 2. Loading plot for correlation between overall preference with textural and sensory characteristics of gathotan noodle

negatively correlated to water absorption. It may be an indication of weak structure or less cohesive of gathotan noodle as absorption of more water resulted in more cooking loss. Cohesiveness was strongly but negatively correlated to cooking loss (Lu *et al.*, 2009). However, our finding on the increase of water absorption by the increase of gathotan flour in noodle confirmed previous report (Chung *et al.*, 2012) where β-amylase hydrolised starch facilitated higher water absorption. As more water in pre-gelatinised flour led to lower water absorption and cooking loss, it may indicate that more diluted flour helped hydration to further assist gelation of noodle, thus reducing cooking loss.

Textural properties of noodle

Analysis of variance showed that hardness of gathotan noodle was affected significantly ($P < 0.05$) by flour:water proportion in pre-gelatinised flour (Anova table not shown), but was not affected ($P > 0.05$) by flour proportion in dough nor the interaction between the two factors (Anova table not shown). Hence, water proportion of 1:8 gave lower hardness (5823.6 g) of noodle compared to other proportion (Table 4). Hardness of gathotan noodle did not vary considerably among samples. On the other hand, adhesiveness of gathotan noodle was affected significantly ($P < 0.05$) by all factors studied (Table 4 and Table 5) and their interaction (Table 6). Adhesiveness of the noodle greatly varied, from -379.6 g to -2428.0 g (Table 6). Lowest adhesiveness was shown by noodle made with 1:7 water proportion and 5:5.5 flour proportion, although it did not statistically differ from several other samples (Table 6). Noodle with highest adhesiveness (-2428.0 g) was resulted from 1:9 water proportion and 5:6 flour proportion, and did not significantly different from noodle made with 1:8 water proportion and 5:6 flour proportion (-2371 g). Hence, highest proportion of flour gave highest adhesiveness.

Hardness of gathotan noodle was higher than hardness of wheat noodle (Lu *et al*., 2009), although peak viscosity of the two flours were similar. Our result was comparable to previous reports where higher water absorption correlated to lower hardness (Oh *et al*., 1985; Sawatari *et al*., 2005; Hatcher *et al*., 2008; Yuan *et al*., 2008; Choy *et al*., 2012). The more dextrin presented in noodle, the less swelling power (Yousif *et al.*, 2012), and consequently, increased hardness. Fermentation also shown before to result in harder noodles (Yuan *et al*., 2008), likely indicating formation of higher long to short chain amylopectin ratio to cause more rigid structure of gel, as a consequence of hydrolization of short chain amylopection in amorphous region by β-amylase during fermentation of starch (Yuan *et al.*, 2008). Konjac glucomannan when added into wheat flour (Zhou *et al.*, 2013) or mushroom β-glucan (Heo *et al.*, 2013), showed similar effect to gathotan flour, where the more konjac glucomannan in noodle mixture, the less cooking loss. Water status in noodle negatively correlated to firmness (Lai and Hwang, 2004), and this was only true between noodle made with water ratio of 1:9 and 1:8 in our experiment. Adhesiveness of gathotan noodle seems similar to that of noodle containing glucomannan (Zhou *et al*., 2013) or germinated brown rice flour (Chung *et al*., 2012), where glucomannan or germinated brown rice increased adhesiveness of noodle. Contrary, some hydrocolloids, such as CMC (Choy *et al*., 2012), wheat bran (Chen *et al*., 2011), reduced adhesiveness.

Sensory evaluation of noodle

Analysis of variance of gathotan noodle showed

Table 7. Mean score of preference for sensory characteristics of gathotan noodle as compared to commercial dried wheat noodle

Noodle type*	Colour**	Aroma**	Taste**	Mouth feel**	Overall**
7,5	4.7^{ab}	4.7^{a}	4.6^{a}	4.9^{a}	4.8^{a}
7,5.5	4.8^{ab}	4.7^{a}	4.4^{a}	4.8^{a}	4.7^{a}
7,6	5.0^{ab}	4.8^{ab}	4.6^{a}	5.4^{a}	5.5^{a}
8,5	4.6^{a}	4.5^{a}	4.1^{a}	5.1^{a}	4.5^{a}
8,5.5	4.9^{ab}	5.0^{ab}	4.9^{a}	5.1^{a}	4.8^{a}
8,6	4.8^{ab}	4.9^{ab}	4.4^{a}	4.7^{a}	4.5^{a}
9,5	4.5^{a}	4.7^{a}	4.2^{a}	4.9^{a}	4.8^{a}
9,5.5	4.2^{a}	4.5^{a}	4.5^{a}	4.7^{a}	4.6^{a}
9,6	4.5^{a}	4.4^{a}	4.9^{a}	4.6^{a}	4.3^{a}
Control	7.1^{b}	7.2^{b}	7.4^{b}	7.8^{b}	7.6^{b}

*:first digit indicates water proportion to one part of flour in pre-gelatinised flour
**: same letter in a coloumn indicates no significant ($P > 0.05$) difference

Table 8. X-variance of regression for overall preference

Components	X-variance	Error SS	R^2
1	0.511751	47.8889	0.693129
2	0.648234	44.7368	0.713328
3	0.748413	43.6963	0.719995
4	0.836041	43.4679	0.721459

Table 9. Regression coefficients for overall preference

Components	Coefficient
Constant	2.07785
Hardness	-0.00022
Adhesiveness	0.00005
Preference for colour	0.07510
Preference for aroma	0.16738
Preference for taste	0.12530
Preference for mouth feel	0.47459

there was no significant ($P > 0.05$) effect of factors on panelists' preference for several sensory characteristics being examined (data not shown). Contrary, when compared to commercial noodle as control, some of gathotan noodle showed characteristics not significantly ($P > 0.05$) different from those of control (Table 7). Taste, mouthfeel and overall preference of gathotan noodle were significantly ($P < 0.05$) inferior to commercial noodle. However, colour and aroma of some samples of gathotan noodle were suprisingly comparable to those of control. Gathotan noodle has distinct black colour and rather strong flavour. Further analysis using partial least square regression correlating textural and sensory properties revealed that there were four main components to influence overall preference (Table 8), with the first component comprised 51%, and R^2 of 0.63. This may indicate that the first component may not have dominant role. Analysis on coefficient of correlation showed that mouth feel was the most influential factor determined panelists' overall preference, with positive correlation (Table 9). All factors studied showed positive correlation to overall preference, except hardness. The equation for overall preference was:

$$Y = 2.07785 - 0.00022\,X_1 + 0.00005\,X_2 + 0.07510\,X_3 + 0.16738\,X_4 + 0.12530\,X_5 + 0.47459\,X_6$$

where, Y: overall preference, X_1: hardness, X_2: adhesiveness, X_3: preference for colour, X_4: preference for aroma, X_5: preference for taste, X_6: preference for mouth feel.

It was also shown that there were four components in the regression, with first component comprised

51.1% variance and R^2 of 0.69.

Loading plot indicated strong and positive correlation of mouth feel to overall preference, both in first and second components. This showed a very important role of mouth feel in determining overall proference of noodle. Other three factors contributing overal preference were preference for taste, aroma, and colour, which had positive correlation in the first component, but negative correlation in the second component. Hardness had negative correlation with overall preference in both components. Water also showed negative correlation with overall preference as shown in both first and second components.

Sensory properties of noodle in our work was focused only on appearance and eating quality, as well as overall acceptability. Hence, some characteristics are important, such as firmness, elasticity, colour, flavour, surface smoothness (Choo and Aziz, 2010); firmness, cohesiveness, and stickiness (Li *et al*., 2012); hardness, sliperiness, chewiness, and elasticity (Yuan *et al*., 2008); colour, flavour, texture, and mouth feel (Yousif *et al.*, 2012). Assessing sensory quality of noodle can vary depending on the type of noodle. Transparancy, for example, seems only applied to starch noodle (Tan *et al*., 2009). Substitution of wheat flour with different types of material may result in various sensory response, depending on types and concentration of material being added. The application of dextrinised corn, for example, reduced sensory preference for all attributes being assessed (Yousif *et al.*, 2012). Similarly, addition of purple yam flour (Li *et al.*, 2012), wheat bran (Chen *et al*., 2012), also resulted in inferior sensory characteristics as compared to control noodle. Contrary, noodle made of fermented corn flour had improved sensory properties (Yuan *et al.*, 2008) in term of hardness, sliperiness, chewiness, elasticity, and overall acceptability. Positive effect on sensory characteristics was also shown by incorporation of banana flour (Choo and Aziz, 2010), or addition of hydrocolloid under brand name Nutrim5 (Inglett *et al*., 2005). Noodle made from blend of potato and rice flour had better acceptance as relatively low hardness and chewiness (Sandhu *et al.*, 2010) as compared to noodle made from each type of flour.

Conclusion

Gathotan noodle had relatively higher hardness and adhesiveness, and had inferior sensory properties as compared to commercial wheat noodle. However, colour and flavour of gathotan noodle was as preferred as commercial noodle. The most important attribut of gathotan noodle was mouth feel. Further studies needed on its health benefit effect, and also its utilization in other flour-based products.

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