Versi Online:
http://journal.ipb.ac.id/index.php/jtip
DOI: 10.6066/jtip.2012.23.2.179
Hasil Penelitian *J. Teknol dan Industri Pangan, Vol. XXIII No. 2 Th. 2012*

CHARACTERISTICS OF WHITE CORN NOODLE SUBSTITUED BY TEMPEH FLOUR

[*Karakteristik Mi Jagung Putih dengan Substitusi Tepung Tempe*]

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Submitted November 08th 2012 / Accepted December 07th 2012

ABSTRACT

Different corn type and processing of corn flour can produce flour with different physical and chemical characteristics. Processing of such flour into noodle will also result in different properties of noodle. While substitution of corn flour with tempeh flour can improve the protein content of the noodle it also impair its sensory characteristics. The objectives of this research were to determine the best combination of corn flour-type, corn flour processing and proportion of corn:tempeh flour to produce the best corn noodles based on physical, chemical and sensory properties. The observed variables of this study were moisture, ash, soluble protein, fat, elongation, colour, flavour, taste, and preferences. The results showed that based on physical, chemical and sensory properties, the best corn noodle could be made from flour made from waxy corn soaked for 24 hours and a ratio of corn:tempeh flour of 80:20. The noodle produced had 12.1% of total protein content, 2.8% of soluble protein, 8.4% of fat, 5.9% of moisture, 3.6% of ash, 69.9% of carbohydrate, 17.6% of elongation, yellow colour, slight flavour of corn/soybean, and 2.6 of preferences.

Keywords: corn, noodle, soaking, tempeh, waxy

ABSTRAK

Jenis jagung (*waxy* dan non *waxy*) *serta proses pengolahan tepung menghasilkan perbedaan sifat tepung jagung, dan apabila diaplikasikan pada pembuatan mi akan menghasilkan sifat mi yang berbeda. Substitusi tepung tempe pada pembuatan mi jagung meningkatkan kadar proteinnya, tetapi dapat mengubah sifat sensori mi. Penelitian bertujuan menentukan kombinasi perlakuan terbaik (antara jenis jagung, proses pengolahan tepung dan proporsi tepung jagung:tempe) yang dapat menghasilkan mi jagung terbaik (berdasar sifat fisik, kimia dan sensoris). Variabel yang diukur meliputi kadar air, kadar abu, protein terlarut, lemak, pemanjangan/elongasi, warna, aroma, rasa dan kesukaan. Hasil penelitian menunjukkan bahwa berdasar sifat fisik, kimia dan sensoris, mi jagung terbaik dibuat dari tepung jagung* waxy *yang dibuat melalui proses perendaman selama 24 jam, dan proporsi tepung jagung: tempe yang digunakan pada pembuatan mi 80:20 ($V_2P_1T_2$). Karakteristik mi adalah sebagai berikut: kadar protein total 12,1%, protein terlarut 2,8%, lemak 8,4% b, air 5,9% bk, abu 3,6%bk, karbohidrat 69,9% bk, elongasi 17,6%, warna kuning, aroma jagung/tempe yang agak terasa, dan kesukaan 2,6.*

Kata kunci: *jagung, mi, perendaman, tempe,* waxy

INTRODUCTION

White corn has high carbohydrate, so it potentially to be used as staple food like noodle. Before processed into a noodle, white corn flour was made first. Corn flour manufacturing consist of seed polishing, washing, soaking, grinding and sieving proces. Soaking in the corn flour manufacture has several functions, namely to separate the corn from germ, skin, and soften texture of to facilitate corn milling (Eneje *et al*., 2004) and as one of the natural fermentation techniques that can produce certain functional properties of corn flour (Aini *et al*., 2010) (Yuan *et al*., 2008). Difference characteristics of the flour caused by soaking will affect characteristics of corn noodles, presumably.

Based on the amylosa-amylopectin levels, white corn can be divided in to non-waxy and waxy corn. Amylose and amylopectin fractions have different properties that will make a difference product characteristic when applied to the food product. Protein content of corn noodles do not meet the noodle standards quality according to SNI 01-2974-1996, which is less than the minimum 8% wb. The corn noodles protein content can be improved by other materials substitution that have a high protein content, such as tempeh flour (Rodríguez *et al*., 2004). Protein content of tempeh flour reaches 41.64% db. Presence of tempeh flour can increase the protein content but change the sensory properties of corn noodles.

The objectives of this research were to determine the best combined treatment (between corn flour-type,corn flour processing and proportion of corn:tempeh flour) to produce the best corn noodles (based on physical, chemical and sensory properties).

Paper was Presented at International Conference on "Future of Food Factors", October 3-4, 2012, Jakarta, Indonesia.
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MATERIALS AND METHODS

Materials

The materials used in this study were waxy corn from Gorontalo, non-waxy white corn from Temanggung, tempeh, corn starch, additional materials for the noodles and chemicals for analysis.

Making of corn flour

The processing of white corn flour was conducted by modification method of Aini *et al*. (2009). Modification was done by soaking treatments (soaking for 24 hours and without soaking). Corn flour then sifted 100 mesh.

Making of corn noodles

To make corn noodles, first the corn flour, tempeh and corn starch were mixed. Then, salt was added gradually while stirring until form a semi solid noodles dough. Once dissolved, the solution was mixed with some warm water. Once the dough was semi-solid form, the yolks and ovalet were added. After all the ingredients mixed, added the remaining water into the mixture then poured in the pan. The next process, it was steaming for 3 minutes to form a sheet of dough that was ready to be molded into noodles. The noodles sheets was trimed and molded, then dried with cabinet dryer at ± 60°C until dry.

Variables

The observed variables of this study were moisture content (AOAC, 2000), ash (AOAC, 2000), soluble protein (AOAC, 2000), fat (AOAC, 2000) and elongation (Muhandri *et al*., 2011). In addition, the analysis of total protein and carbohydrate (by difference) was also performed for the best treatment. The observed sensory variables include colour, texture (firmness), flavour, taste, and preferences were measured by the scoring method.

Design experimental

This research use Completely Randomized Design (CRD) with 20 factorial combinations treatment repeated 2 times. The tested factors were the types of corn (V) i.e. non-waxy (V1) and waxy (V2); the soaking process in the making of corn flour (P) i.e. without soaking (Po) and 24-hour soaking (P1); and the proportion of corn:tempeh flour (T) which consists of five levels, namely 100:0(T0); 90:10(T1); 80:20(T2); 70:30(T3) and 60:40(T4).

Statistical analysis

The obtained physical and chemical data were analyzed with "F" test on 5 percent and 1% significant level. Duncan's Multiple Range Test (DMRT) was conducted if there any significant diversity to determine the difference effects between single and combination treatment level. The sensory variables data were analyzed by the Friedman test followed by multiple comparisons as a further test if there any significant differences.

RESULTS AND DISCUSSION

Moisture content

Moisture content is an important food constituent. It can be expressed in the form of water stating the amount of absolute moisture content in food as a food component in the various number. The types of corn affect to the noodle water content, significantly. Non-waxy corn noodles had a higher water content (7.53 ± 0.32%) than waxy corn noodles (5.16 ± 0.14%) as shown in Figure 1. The water content differences of the corn noodle due to the raw materials differences, mainly corn flour. Non-waxy corn flour has higher moisture content (11.43%) than waxy flour (8.5%).

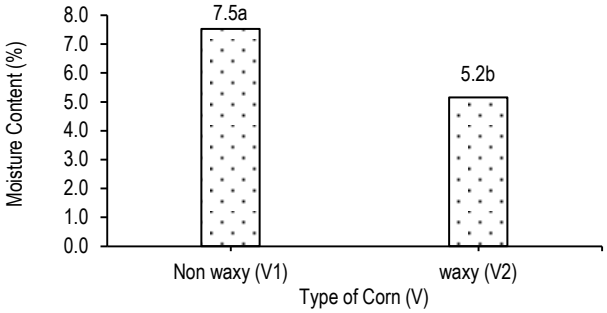

Figure 1. The moisture content of corn noodles

The soaking did not significantly affect the moisture content of corn noodles. The water content of maize flour noodles without soaking corn kernels (P0) is 5.46 ± 0.22% and the soaking seeds (P1) yields 5.75 ± 0.32% dry basis moisture. Noodles was made from corn flour without undergoing the process of soaking corn kernels, have a higher water content, but not significantly different. It is due to the ability of the flour to absorb the water associated with higher levels of amylose.

According to Aini and Hariyadi (2010), a straight-chain amylosa has the ability to absorb water is higher than the branched chain amylopectin. The higher levels of amylosa, the lower water absorption capacity of corn flour. Corn flour that produced without soaking of corn grits have amylosa content 3.69% dry basis. While corn flour that produced from soaking of corn grits have amylosa content 2.17% dry basis, because soaking corn kernels for 24 hours will solute of the amorphous granules. Most of the amylosa present in the amorphous regions, so the leaching section during soaking reduces amorphous amylosa.

Tempeh flour substitution did not significantly affect to the moisture content of corn noodles as well as the interaction between treatments. The moisture content of the corn noodles that have a proportion of corn : soybean flour 100:0(T0) is 6.03 ± 0.29% db, 90:10(T1) is 6.25 ± 0.21% db, 80:20(T2) is 5.60 ± 0.31% db, 70:30(T3) is 5.49 ± 0.21% db, and 60:40(T4) is 4.64 ± 0.19% db.

Corn noodle had moisture content under 10%. It was lower than the water content of yellow corn noodles according Yuan *et al*. (2008). The maximum moisture content of corn noodles according to SNI 01-2974-1996 is 8% for the first quality and 10% for second quality.

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Fat content

Fat has important functions in food processing i.e. as a source of energy, play a role in the formation of texture and sensory quality of food products, medium heat in the frying processas well as the solvent for the essential fat-soluble vitamin.

The types of corn significantly affect to the fat content of corn noodles. Fat content of noodles from waxy corn flour was higher (10.18 ± 0.41%) than non-waxy corn (6.78 ± 0.27%) (Figure 2). This was due to waxy corn has a higher fat content (2.94%) than non-waxy corn (1.58%). According to Lu *et al.* (2003), diversity levels of fat in the product due to fat content variations of raw materials.

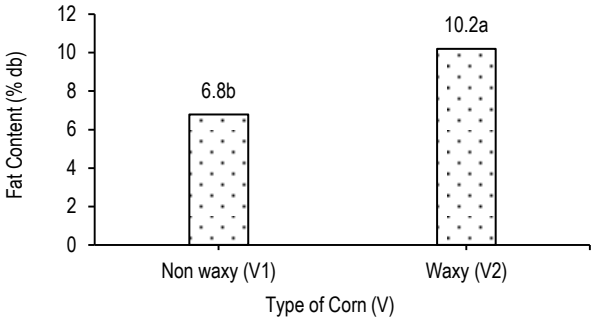
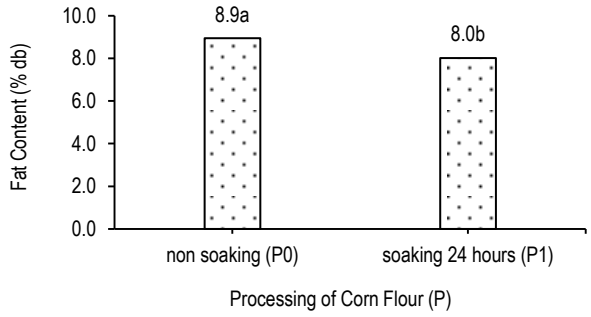


Figure 2. Fat content of corn noodles

The manufacturing techniques of corn flour gave significantly difference to the levels of noodles fat. Corn noodle produced from the immersed corn flour had a lower fat content (8.02 ± 0.32%) than corn noodles made for non immersed corn flour (8.94 ± 0.43%) as shown in Figure 3. This is consistent to the statement Belyea *et al*. (2004) that wet milling of rice flour to produce a smaller amount of fat.



Gambar 3. Effect of soaking in the processing of corn flour to the fat content of corn noodles

The difference in fat content as well as soaking in accordance with Aini *et al*. (2009) that corn fermentation techniques with soaking resulted partly dissolved germ. Fat is a macro chemical component that dominates the germ, so the dissolved germ can reduce the fat content of corn flour. It is suspected as the cause of reduced fat noodles by soaking corn seeds. Fat content of corn flour made through and without soaking proces were 2.43 ± 0.07% db and 2.94 ± 0.06% db, respectively.

The proportion of soybean flour significantly affect the fat content of corn noodles, as shown in Figure 4. Increased levels of fat noodle flour substitution with increasing proportions due to the fat content of soybean tempeh flour is quite high (23.88% db).

Soluble protein

Soluble protein is the percent protein contained in the materials that can be extracted by or dissolved in the water under specified conditions (Young *et al*., 2004). Foodstuffs that have high levels of soluble protein has a good quality because it is more easily utilized by the body.

Type of maize significantly affect soluble protein noodles. Noodles from waxy maize has higher soluble protein content (2.52 ± 0.01% db) compared to corn noodles non-waxy (1.97 ± 0.08% db). Variations in soluble protein content of corn noodles due to differences in the base material, which is waxy maize (1.64% db) has a higher protein content than non-waxy maize (1.16% db).

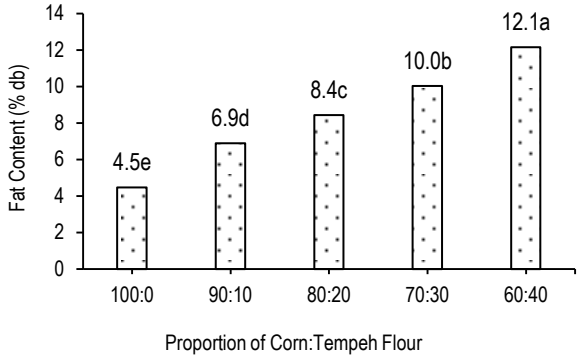


Figure 4. Fat content of corn noodles that influenced by the proportion of corn and tempeh flour

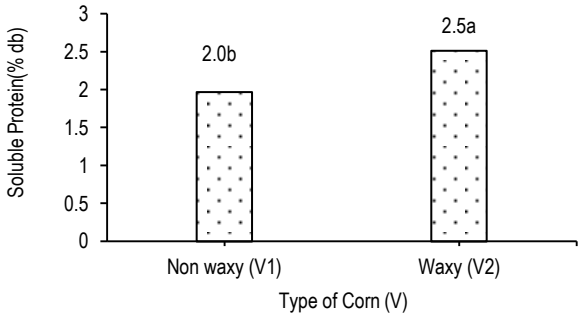


Figure 5. Soluble protein content of different types corn noodle

Soaking in the processing of corn flour can significantly affect on the soluble protein of corn noodles. Noodles made from corn flour with soaking (P1) has a higher soluble protein (2.85 ± 0.11% db) than corn noodles from corn flour without soaking (P0), which had 2.13 ± 0.14% db soluble protein levels (Figure 6). It was influenced by the levels of corn flour dissolved protein. Corn flour made without soaking and soaking had 9.28% and 3.59% of soluble protein respectively. Increased levels of soluble protein of immersed corn flour thought to be caused by a protease enzyme activity during fermentation which can break down proteins into small molecular weight amino acids that soluble in the water (Abdel-Aal, 2008).

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The higher tempe flour in the noodles, the higher levels of noodle soluble protein (Figure 7). This was due to tempeh flour had higher levels of soluble protein (12.89%) than corn starch. During fermentation of soybeans into tempeh, *Rhizopus oligosporus* produces protease enzymes (Rodríguez *et al*., 2006). Protein complexes occur reshuffle into simpler compounds. Protein content expressed as total nitrogen levels did not change during fermentation, but the levels of soluble protein and free amino acid was increased.

Soluble protein is the percent protein contained in the materials that can be extracted by or dissolvedin the water under specified conditions (Rodríguez *et al*., 2004). Foodstuffs that have high levels of soluble protein has a good quality because it is more easily utilized by the body.

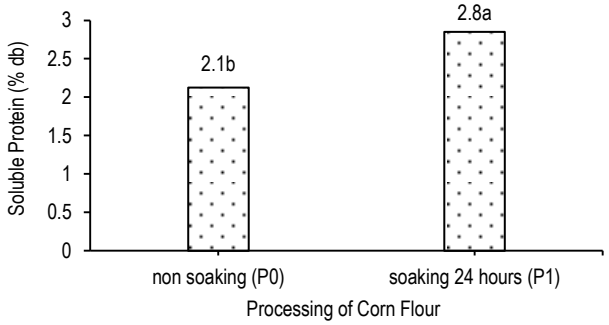


Figure 6. The soaking process effect upon the corn noodles soluble protein content

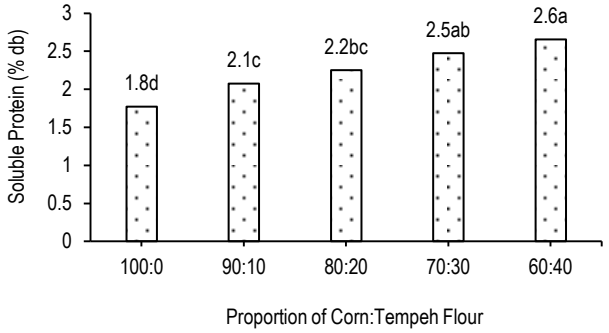


Figure 7. Soluble protein of cor noodles affected by tempeh flour proportion

Texture

Texture of noodle after cooking is one of important indicator to determine the quality of noodles. Texture conducted in an objective measurement using the texture analyzer to determine the noodle elongation (elongation). Elongation show a maximum length of noodles before breaking. Elongation is one of the most important parameters of noodles (Bellido and Hatcher, 2009). High percentage of elongation showed the noodle are not easily broken. This is important characteristic because the noodle is not expected to crumble when eaten (Muhandri and Subarna, 2009).

The interaction between type of corn, soaking in the manufacture of corn flour and tempeh flour substitution significantly affect the noodle elongation. Elongation is a level of the material to stretch or pull before the material to be broken. Elongation measurements performed to determine the noodles resistance againts the pull. The good noodle have high tensile strength, characterized by a high percentage of noodles elongation.

The noodle from non-waxy unsoaked corn flour with 20% of tempeh (V1P0T2) had the lowest elongation 8.68% (Figure 8). This is presumably its because the noodles had the highest water content and cooking loss. The more water that was bound by the components in the noodles, the weaker bond was formed. The high cooking loss was causing noodle to be easily broken up with noodle heavy shrinkage. It can lower the elongation.

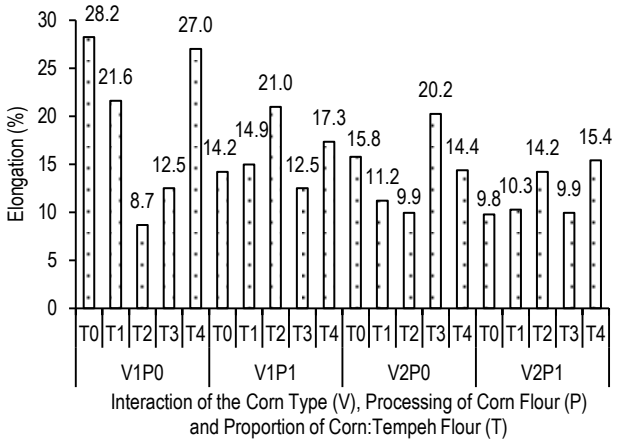


Figure 8. Interaction of the corn type, processing of corn flour and proportion of corn:tempeh flour to the noodle elongation (V_1=non-waxy corn, V_2=waxy corn, P_0= processing of flour without soaking P_1= 24-hour soaking, T= proportion of corn:tempeh flour, T_0= 100:0, T_1= 90:10, T_2= 80:20, T_3 =70:30, T_4 = 60:40)

Non-waxy corn flour noodle had a higher elongation than waxy corn noodles. Non-waxy maize contains more straight-chain amylose so it make easier to change shape due to the pull. Waxy corn has higher levels of amylopectin and the presence of branched structures causing the noodles produced less elongation.

Percentage of corn noodles extension ranged from 8.679 to 28.205%, similar to rice flour noodles ranged from 27.84 to 30.91% (Lu *et al*., 2003). This range was similar to the extension percentage of noodles brand Myojo (28.66%) or Pop Mi (22.5%). However, the research results of Bellido and Hatcher (2009) showed that the percent elongation of rehydrated wet wheat noodles was 107.35%.

The low elongation of corn noodles or other noodles allegedly due to the substantial rehydration during processing of dried noodles into a wet noodle (Bellido and Hatcher, 2009). The solids loss during cooking caused by dispersion of amylose in hot water can be occured. Substantial solids loss causing the increased of rehydration so that the noodles texture to be less compact and easily broken.

Incompletely retrogradation was causing the low percent of elongation. According to Aini *et al*. (2010), at gelatinization, amylose leach from starch granules and form fat-amylose

inclusion complexes. This complex can reduce the tendency of amylose to bind, to form a gel and to retrograde. It causes the formed hydrogen bonds less compact and produce easy to broken noodles. In addition, alternately steaming process causes the dough trough a omission stage that allow to the precipitation.

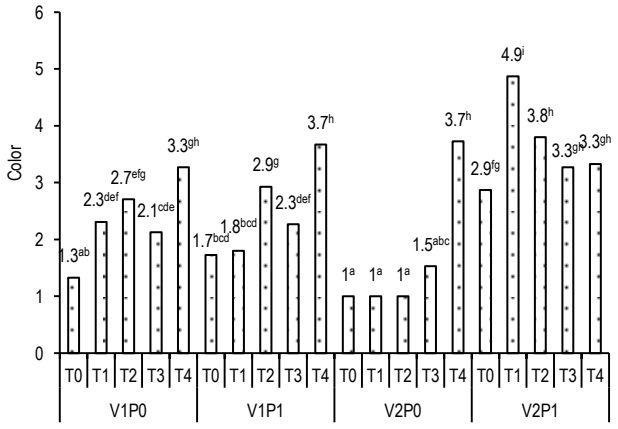
In the absence of gluten, corn noodle texture was more delicate than wheat noodles. Functional properties of soy protein may help to improve the texture of noodles, but the functional properties of carbohydrates in the dough was more dominant in the binding process water, viscosity and dough development. Functional properties of carbohydrates was determined by several factors including the shape and size of starch granules (Moorthy, 2002). Texture strength was supported by the interaction of crystalline starch inter molecular bonds that were less powerful.

Sensory properties

Sensory properties were important properties that will affect the consumer's decision to buy or not. Analyzed sensory properties of corn noodles were include the colour, flavour, taste and preferences.

Colour

Combination treatment of corn types, soaking and tempeh flour substitution had significantly affect to the colour of corn noodles. The result of sensory test showed that the corn noodle colour varies from white to yellow (score of 1 to 4.87) (Figure 9). Variations of corn noodles colour is influenced by raw material, namely white and yellow corn flour. Moreover, soaking process also resulted in the colour of noodles differences. According to Aini *et al*. (2009), the degree of corn white flour that made from soaking corn is higher than non-soaking.



Interaction of the Corn Type(v), Processing Corn Flour (P) and Proportion Corn:Tempeh Flour (T)

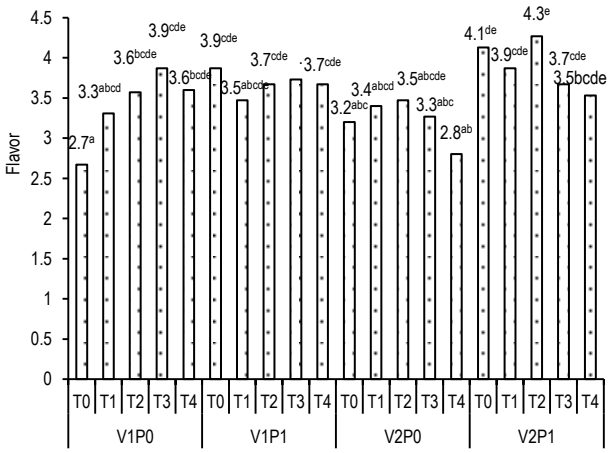
Figure 9. Interaction between corn type, processing of corn flour and proportion of corn:tempeh flour to the colour of noodle (V_1=non-waxy corn, V_2=waxy corn, P_0= processing of flour without soaking P_1= 24-hour soaking, T= proportion of corn:tempeh flour, T_0= 100:0, T_1= 90:10, T_2= 80:20, T_3 =70:30, T_4 = 60:40)

Increasing of the proportion of tempeh flour make the colour more brown. The high protein content of tempeh flour resulted in non-enzymatic browning reactions during drying so that the colour becomes golden brown. In addition, a grayish-white mycelia formed by the mold in the tempeh flour will affect the colour of the flour. This will affect the resulting colour of the corn noodles. In the non-waxy corn noodles, the addition of tempeh flour resulted in increased intensity of the brown-gray colour, while the noodles from waxy corn, the addition of tempeh flour makes better corn noodle colour (more yellow).

Colour is a very important on food. Before other factors considered, the visual colour factors was appearing first and sometimes determines the selection of food products (De Groote and Kimenju, 2008). At corn noodles, the higher value of the resulting indicates the better colour of the noodles with the highest colour is yellow. Usually the panelists preferred colour for the noodles is opaque to yellow (Chung *et al*., 2012). The colours on the noodles are formed by the heating during drying. During the heating process, the amino acids in soy protein were primarily reacted with a reducing sugar of carbohydrate formed a brownish yellow pigment (melanoidin).

Flavour

Combination of corn types, soaking and tempeh flour substitution significantly affect to the corn noodles flavour. The flavour of corn/tempeh were detected in corn noodles ranged from strong-stronger (2.72) to slightly strong (3.56). Effect of interaction between corn types, processing of corn flour and proportion of corn:tempeh flour to the flavour of corn noodles can be seen in Figure 10.



Interaction of the Corn Type(v), Processing Corn Flour (P) and Proportion Corn:Tempeh Flour (T)

Figure 10. Interaction between the corn type, processing of corn flour and proportion of corn:tempeh flour to the flavour of noodle (V_1=non-waxy corn, V_2=waxy corn, P_0= processing of flour without soaking P_1= 24-hour soaking, T= proportion of corn:tempeh flour, T_0= 100:0, T_1= 90:10, T_2= 80:20, T_3 =70:30, T_4 = 60:40)

The expected flavour of corn noodles was not strong (Inglett *et al*., 2005). Combination treatment of local corn types, non-soaking and non-substitution of tempeh flour (V1P0T0) is the best combination. There were some other treatments that also had same value. Combination of local corn types with soaking

and 20% tempeh flour substitution (V2P1T2) had the strongest flavour, although there is some combination of treatments that had similar flavour.

The presence of corn/tempeh flavour allegedly due to the fermentation process during soaking and the manufacture of substituted tempeh. The flavour of fermented corn is more acidic than the unfermented (Maurel *et al*., 2003). Tempeh flour substitution also gives pungent flavour, because during the fermentation of soybeans into tempeh was increasing the number of amino acids, especially phenylalanine and tryptophan increased 20%. Tryptophan is a volatile amino because it has an flavourtic side chain, so the its increase is to strengthen the distinctive flavour of tempe.

Taste

The addition of tempeh flour as a subtitued was lowered the taste of produced corn noodles. Combination of soaking and tempeh flour substitution gave a significant effect to the corn/tempe taste of corn noodles. Sense of taste is referred to the assessment of corn, tempeh or other foreign undesirable taste contained in the corn noodles. Effect of interaction between corn types, processing of corn flour and proportion of corn:tempeh flour to the taste of corn noodles can be seen in Figure 11.

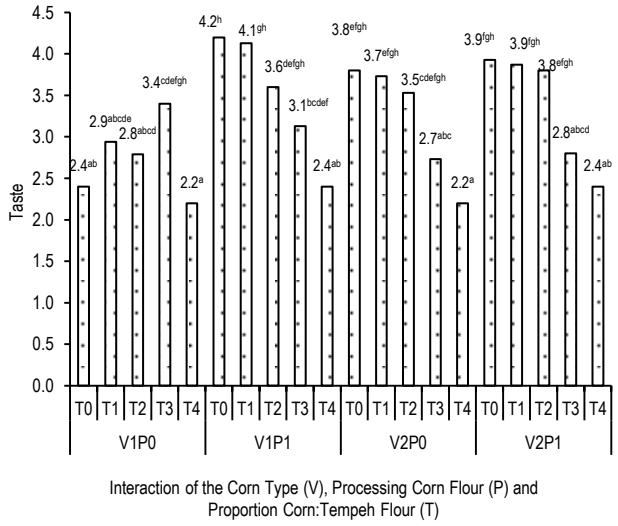


Figure 11. Interaction between the corn type, processing of corn flour and proportion of corn:tempeh flour to the taste of noodle (V_1=non-waxy corn, V_2=waxy corn, P_0= processing of flour without soaking P_1= 24-hour soaking, T= proportion of corn:tempeh flour, T_0= 100:0, T_1= 90:10, T_2= 80:20, T_3 =70:30, T_4 = 60:40)

According to Chelule *et al.* (2010), corn fermentation caused a bitter taste, however it wasn't happened in the 24-hour soaking fermentation. The corn noodles of soaking corn tend to had a better taste characterized by a higher taste score than the noodles of unsoaked corn flour. Unusual characteristic tempeh taste found in the noodles increased as the increase of the proportion of tempeh flour substitution.

Preference

Preference was the conclusion of the quality attributes assessment such as colour, texture, and flavour to determine the accepting of presented material (Van-Kleef *et al*., 2005). Noodle was made from waxy corn, non-soaking and 10 % proportion of tempeh flour % (V2P0T1) was the most preferred product, but not significantly different from V1P1T1, V1P1T0, V2P1T2, and V2P0T4 corn noodles (Table 1). The high value of the combined treatment was caused by its texture (the elasticity) and the best colour, presumably. The most favorite corn noodles had yellow colour, less strong of tempeh flavour and taste, and chewy texture.

The effectiveness index test results show that the best noodle was produced from waxy corn flour made from soaking corn and 20% substitution of tempeh flour. Analysis of nutrient content of the best treatment noodles compared with the Indonesian National Standard (SNI) of noodle SNI 01-2974-1996 can be seen in Table 1. From Table 1 it can be seen that the product can virtually meet the SNI criteria, except for ash content that was worth of 3.18%, still slightly higher than the SNI, 3%.

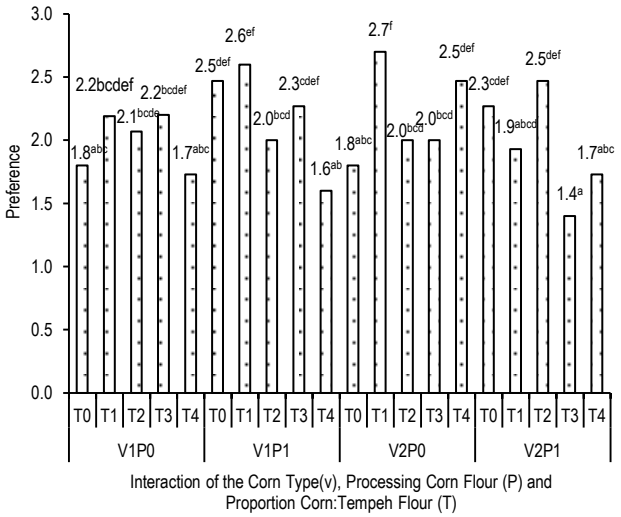


Figure 12. Interaction between the corn type, processing of corn flour and proportion of corn:tempeh flour to the preference of noodle (V_1=non-waxy corn, V_2=waxy corn, P_0= processing of flour without soaking P_1= 24-hour soaking, T= proportion of corn:tempeh flour, T_0= 100:0, T_1= 90:10, T_2= 80:20, T_3 =70:30, T_4 = 60:40)

Table 1. Nutritional value of best corn noodle comparison with SNI

Component	SNI	Corn Noodle
Water content (% wb)	Max 10	5.67
Soluble protein (%db)	-	2.89
Total Protein (%wb)	Min 8	12.12
Fat (%db)	-	8.76
Ash (%wb)	Max 3	3.16
Carbohydrate (%)		70.19
Energi (kkal)		310.7
Texture (N)		1.76
Elongation (%)		12.17

CONCLUSION

Based on physical, chemical and sensory properties, the best corn noodle was made from waxy corn flour in the combined treatment 24 hours of soaking with the subtitution ratio of corn flour:tempeh flour ($V_2P_1T_2$). The characteristics was 12.1% of total protein content, 2.8% of soluble protein, 8.4% of fat, 5.9% of moisture, 3.6% of ash, 69.9% of carbohydrate, 17.6% of elongation, yellow colour, slightly flavour of corn or soybean, and 2.6 of preferences.

ACKNOWLEDGEMENTS

Thanks to Indonesian Agency for Agricultural Research and Development (IAARD) that has funded this research through the Agricultural Research and Higher Education (KKP3T) Partnership in 2010.

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