



## The effect of carbonized rice straw levels on the *dawet* gel properties

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### KEYWORDS

*Dawet* Gel Properties

Minerals Content

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### ABSTRACT

*Merang*, part of rice straw, waste generated from rice harvesting process, is abundantly available in Indonesia. Incomplete burning of *merang* generates carbonized rice straw (CRS). This study is aimed to identify selected minerals (K, Ca, Na and Fe) contents of CRS using AAS, and to evaluate the effect of different concentrations (1.5-3%) of CRS addition on the pasting properties of rice:sago mix-flour (55:45), and on the black color intensity, texture, and sensory properties of *dawet* gel. CRS contains potassium ( $20599.91 \pm 776.44$  ppm), calcium ( $307.58 \pm 70.71$ ), sodium ( $30.59 \pm 1.03$  ppm) and iron ( $1079.98 \pm 20.75$  ppm). Despite the temperature similarity, pasting properties of mixed flour such as final viscosity and peak time are significantly decreased in response to CRS addition. Increase in CRS concentration results to significant increase of the black color intensity and texture of *dawet* gel. Sensory evaluation suggests that most of the panelists prefer the color and firmness showed by *dawet* gel with addition of 2.5% of carbonized rice straw. This result suggests that CRS could be an interesting new food ingredient for increasing black color intensity and texture of food product.

### Introduction

Harvesting rice generates a huge amount of solid waste in form of rice straw. Furthermore, its top part and leafless panicle is called *merang* in Indonesia. World rice production, as mentioned in the review written by Singh et al. (2016), reached 721.4 MT in 2011 producing roughly 973.89 MT of rice straw waste scattered all over the field. Hence, more rice straw waste was generated (roughly 1.35 times) than its total rice production. The same case also occurs in Indonesia for rice straw is abundantly available. According to the data released by FAOSTAT (2020), Indonesia became the third world largest rice producer in 2018 with total production at 83,037,000 tonnes. By using the aforementioned conversion (amount of rice straw = amount of rice production x 1.35), about 112 million tonnes of rice straw waste was generated in 2018, a fantastic amount of material that has to be properly utilized.

According to Sing et al. (2016) only about 20% of rice straw has been utilized as a raw material in industrial process whereas 80% of it is left on the field as waste. Rice straw consists of 70% leaves (leaf blade and leaf sheath) and 30% stem (straw) (Vadiveloo, 2000). The chemical

composition of rice straw as reported by Hessien et al (2009) in Singh et al. (2016) consists of cellulose (33-47%), hemicellulose (19-27%), lignin (5-24%), and silica (18.3%). Due to its rich content of cellulose and hemicellulose in particular, its utilisation is limited to animal feed.

In Indonesia, a small portion of rice straw is burnt to produce carbonized rice straw (CRS) and applied as hair shampoo most of rice straws are either left and burnt at the field or used as animal feed. Indeed, in small portion as well, the rice straw is burnt to produce the CRS, and can also be traditionally applied in local food products such as black *dawet* and *jongkong* cake as black colorant (Murtini et al., 2018). However, there is no report or study discussing the scientific aspect of CRS utilisation and its effects on the *dawet* gel qualities. Given that rice straw is abundantly available, discovering its utilisation in food sector will increase its value as an alternative of natural food additive while decreasing the amount of waste.

Rice straw burning process will result to carbonized rice straw consisting inorganic residues such as minerals. Miller (2008) suggested that about 25 essential minerals, C, H, O, N elements excluded, are existed in living creatures' cell.

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These elements are essential especially in regulating metabolism systems, acting as enzyme co-factor, promoting bone and tooth growth as well as transporting oxygen-carbon dioxide in blood. Further, there are many foods have been fortified with calcium and iron to tackle various mineral deficiency issues.

Minerals also serve important roles in determining food quality. Calcium has been used to strengthen the texture of wheat starch gel (Yang et al., 2014) and cheese (Miller, 2008). Hsu and Chiang (2002) also reported that calcium addition in form of Calcium Chloride results to increase in surimi gel brightness. Furthermore, calcium and iron cation ( $\text{Ca}^{2+}$  and  $\text{Fe}^{2+}$ ) can also be used as a substitution of thickener agents to modify the product's texture (Mierczynska et al., 2015). The most popular mineral salt, Sodium Chloride (table salt) has been widely used as food flavor modifier and food preservation in both household and industry. When dissolved in water in low concentration, it can penetrate starch granule and interacts with its hydroxyl and phosphate group. Furthermore, it changes starch structural properties resulting in increasing of its mechanical strength, glass transition temperature and plasticising properties (Chuang et al., 2015).

*Dawet* is a gelatinous Indonesian local beverage mostly made of starch. Similar food product, *cendol*, one of fifty the best global desserts, nevertheless, can also be found throughout ASEAN countries (CNN, 2021). It is usually served with liquid brown sugar and coconut milk. Furthermore, other carbohydrate sources such as rice, maize, sweet potato, agar and tapioca can also be used as the main ingredient to make *dawet*. In *dawet* making process flour is mixed with water (with proportion of 1:4 or 1:5) at first. Afterwards, the batter is heated while been stirred. As it has become viscous, it is placed in the mold and soaked in the water to form perfect gels. To date, *dawet* and its quality have not been recorded in Indonesian standard (SNI), thus its quality and identity cannot be accurately determined.

In general, this study is aimed to utilize CRS as food additive. Particularly, it focused on evaluating its essential mineral contents such as calcium, potassium, sodium and iron. Furthermore, these minerals are expected to affect the physical properties of *dawet* gel made of rice flour and sago starch. However, due to limited information on how much CRS to be added, the study on the effect of various concentrations of CRS addition on flour pasting properties and *dawet* gel texture had to be done beforehand. Moreover, its effect on increasing

black color intensity of *dawet* gel was conducted for it is naturally colored black. In addition, several sensory assessments were performed.

## Research Methods

### Materials

Materials used in this study are dried rice straw (consists of a 30 cm-long of top straw and 15 cm-long of leafless panicle). The supporting materials are rice flour (Rose Bran), sago flour (BJ- Bintang Jaya), tap water, and table salt.

### The CRS Preparation

The CRS was prepared following Murtini and Lorenza (2019) with some modifications. The rice straw was burned inside a cauldron at open air with temperature about 500-600°C to produce the CRS. The CRS then was ground and sieved through 100-mesh screen. The CRS then was placed in a plastic bag and kept in a covered jar until used.

### The Selected Minerals (Calcium, Potassium, Sodium and Iron) Analysis

The selected minerals (Ca, K, Na and Fe) contents were analysed using Atomic absorption spectrometry (AAS) Shimadzu series AA-6300. The procedure for Fe content analysis followed the AOAC official method number 999.11 (AOAC, 2000), whereas preparation of Ca, K and Na content analysis followed AOAC official method number 990.08 (AOAC, 1993). Firstly, the CRS sample was weighed  $2 \pm 0.01$  g and placed in a porcelain cup. Afterwards, the samples were burnt by using the furnace with gradual temperature increases up to 500°C. Then, they were added with 10 mL of nitric acid ( $\text{HNO}_3$  65%) and mixed to obtain homogenous mixtures. Lastly, the mixture solutions were filtered by using Whatman paper and ready to be analyzed using AAS. Concentration of the selected minerals obtained by plotting the absorbance with standard curve prepared before.

### Flour Pasting Properties

Pasting properties of the blending rice: sago (55:45) flour was measured using Rapid Visco Analyzer (RVA-4 Stand-Alone, Newport Scientific, Australia) following the AACC (1999) standard method 76-21.01. The flour sample and deionized water were weighted for 2.5g and 20g. The deionized water was added into a canister first following by the flour. A paddle then was placed into canister to mix and push any lumps sample down. Canister and the paddle were placed to RVA motor coupling. Sample temperature was

equilibrated at 50°C for 1 min, the temperature was increased from 50 to 95°C (for 4 min) and hold sample in the heating cycle for 2.5 min. The temperature was decreased from 95 to 50°C (for 4 min) and hold the sample in the cooling cycle for 2 min with a minimum temperature of 50°C.

#### **Dawet Gel Preparation**

The formulation used in making *dawet* gel consisted of 110 g mixed-flour (rice: sago in ratio 55:45), 440 mL of water, CRS (with levels following the treatment 1.5, 2.0, 2.5 and 3.0% w/w of flour). All the ingredients were mixed to create batter and heated while continuously stirred for about 5 minutes till gel formation. The gel was then formed by passing through a *dawet* screen that directly placed on the top of container filled with cold water. The formed *dawet* gel was allowed set inside the cold water. For color and texture analysis purpose, the *dawet* gel was formed in a small square and flat container with 3 cm depth, and was allowed to set for 1 h before color and texture analysis.

#### **Dawet Gel Physical and Sensory Analysis.**

Black color of the *dawet* gel is analyzed using Color Reader (Minolta CR-100). The firmness texture of *dawet* gel is tested using texture analyzer. The sensory test is done by involving of 110 non-trained panelists. They are asked to give their preference on the color, texture, aroma and overall appearance of the provided *dawet* gel samples.

#### **Data Analysis**

Data of the selected mineral concentration is reported in the form mean  $\pm$  standard error. Data of *dawet* gel qualities as affected by CRS

concentration are statistically analyzed using ANOVA randomized complete design with degree of confidence of 95% and post hoc test using LSD 5%.

### **Results and Discussion**

#### **Merang and CRS Characteristics**

The appearance of *merang* used as raw material in this study is presented in Figure 1a. It consists of the top straw with 30 cm length and panicle about 15 cm length without leaf and free from rice grain.

Incomplete burning of *merang* produces CRS with average yield of 20.42 $\pm$ 0.44%. As comparison, Jenkins et al. (1998) reported that a whole rice straw when burned would produce 18.67% ashes, 15.86% fixed carbon and 65.47% volatile compounds. As shown in the Figure 1b, the CRS particles obtained directly from burned *merang* is still rough and needed to be ground and then sieved through 100-mesh screen to obtain a finer CRS particle (Figure 1c). Given that it has smaller particle size, fine CRS also has increased surface area. It will be essential in food application since CRS with larger surface area will be more easily react with food components. In addition, smaller particles will decrease the CRS sandiness mouthfeel and be easily distributed to the entire *dawet* gel product. Study on the effect of wheat flour particle size conducted by Niu et al. (2014) suggested that smaller particle size of flour corresponds to better quality of noodles. The finer flour particle also increases noodle dough Farinograph stability, product lightness and overall texture quality such as hardness, springiness, cohesiveness and resilience.



**Figure 1.** (a) *Merang*, (b) the CRS, and (c) The CRS passed through a 100 mesh screen

**Table 1.** Average potassium, calcium, sodium and iron contents of CRS

CRS form	Potassium (ppm)	Calcium (ppm)	Sodium (ppm)	Iron (ppm)
Solid	20599.91 $\pm$ 776.44	307.58 $\pm$ 70.71	30.59 $\pm$ 1.03	1079.98 $\pm$ 20.75
Filtrate	26912.66 $\pm$ 709.72	48.74 $\pm$ 4.51	18.50 $\pm$ 2.88	26.98 $\pm$ 4.56

Note: Mean  $\pm$  standard error from 3 replications

### The Selected Minerals Content of CRS

Burning process will destruct most of rice straw's organic compound hence results to mineral remains. According to Dobermann and Fairhurst (2002) burning rice straw eliminates all of its nitrogen content. Furthermore, certain burning methods eliminate 20% of potassium and 5-60% of Sulphur. The analysis on minerals contents of CRS is done in both solid and water-immersed CRS. It is focused on measuring 4 (four) essential minerals; potassium (K), calcium (Ca), sodium (Na) and iron (Fe). The analysis result is provided in Table 1.

The contents of selected minerals; potassium, calcium, and iron of solid CRD as shown at Table 1 are relatively high. The iron and potassium content of this CRS are similar to previously reported by Murtini et al. (2019), that CRS of rice-*merang* as detected using XRF contains 0.1%  $Fe_2O_2$  and 18% of  $K_2O$ . This result suggests that solid carbonized rice straw will provide more calcium and iron which are beneficial for both improving texture and nutrition content of *dawet* gel. Hence, it might be further utilized to tackle prevalent mineral deficiency issues in Indonesia. Based on Recommended Dietary Allowance (RDA) standard, adult requires 4700 mg of potassium, 1000-1300 mg of calcium, 1500 mg of sodium and 8-18 mg of iron daily (Gropper et al., 2009). However, when the CRS is soaked in water for one night and filtered for obtaining the CRS filtrate, as common traditional practice people used it as food coloring, all of minerals content except potassium are decreased. The solubility of potassium in water may be better than other minerals. The high potassium

content causes the CRS filtrate to be alkaline. Murtini et al. (2019) reported that pH of CRS filtrate ranges from 10-11.

### The Effects of CRS Levels on the Pasting Properties of Mixed Flour (Rice : Sago; 55:45)

The effect of different concentration of CRS addition (0% - 3%) on pasting properties of the flour is analyzed using RVA. The result is provided in Figure 2.

Furthermore, as shown on Table 2, several parameters such as trough1, breakdown, final viscosity and peak time are significantly affected by the addition of CRS. Final viscosity as reported by Liu et al. (2019) affected by starch content and composition of amylose and amylopectin. Addition of CRS that mostly minerals reduces starch content of sample, therefore it decreases the final viscosity. Reducing of starch content of sample also reduces peak time (Edun et al., 2018). However, it does not show significant effect on some parameters such as peak 1, setback and pasting temperature.

In particular, 1.5% of CRS have already shown significant reduction of trough1 and final viscosity while increasing breakdown. Then, increase in CRS concentration to 2.0% only results to significant reduction of peak time. Further increases, nevertheless, do not affect the pasting properties of the flour. It indicates that 2.0% of CRS is adequate to affect the *dawet* gel properties. Pasting properties of flour is affected by many factors, such as type of flour, the milling method and the mineral contents of flour.

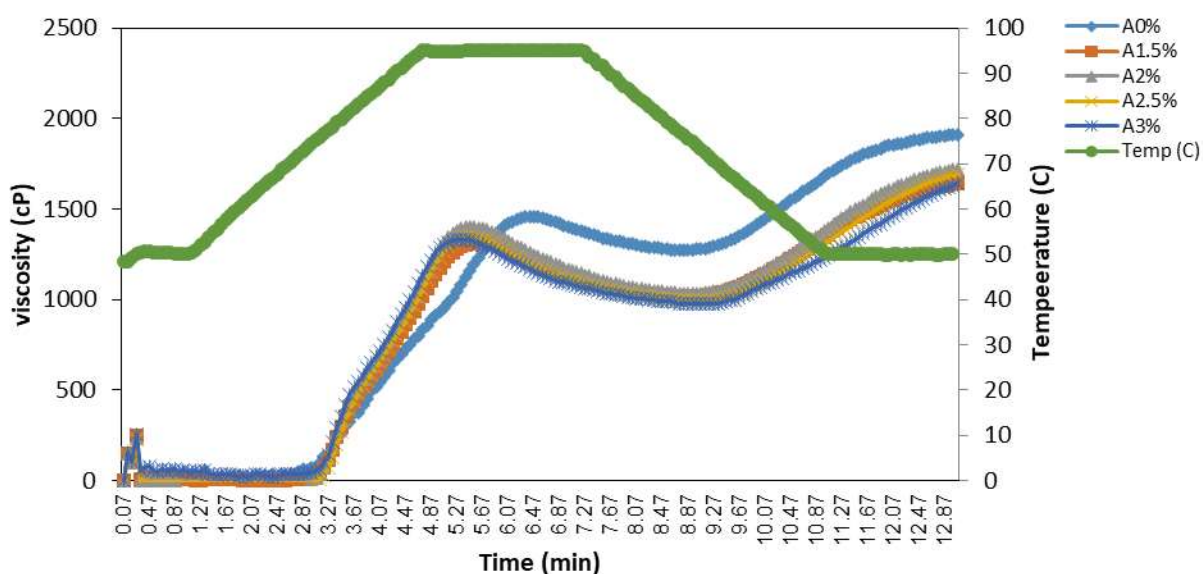


Figure 2. Pasting properties of rice:sago mix flour (55:45) with several levels of CRS (0-3%).

**Table 2.** Pasting properties of rice:sago mix flour (55:45) at different levels (0-3%) of CRS

CRS (%)	Peak1	Trough1	Break-down	Final viscosity	setback	Peak time	Pasting temperature (°C)
0	1462.3	1271.2 a	191.2 b	1910.3 a	639.2	6.4 a	66.4
1.5	1325.8	1015.5 b	310.3 ab	1649.5 b	634.0	5.6 b	74.3
2.0	1404.2	1024.7 b	379.5 a	1717.3 b	692.7	5.4 c	74.4
2.5	1501.5	1009.8 b	491.7 a	1686.7 b	676.8	5.4 c	71.0
3.0	1343.0	981.0 b	362.0 ab	1655.0 b	674.0	5.2 c	66.7

Note: Data is means from 3 replications. Means within the same column followed by similar letter are not significantly different at  $\alpha=0.05$

The rice:sago mix flour (55:45) used in the *dawet* gel formulation has pasting temperature at about 66.4-74.4°C which means it requires heating process within this temperature ranges to properly form the *dawet* gel. Addition of carbonized rice straw in the *dawet* formulation reduces this temperature range so as to reduce the cooking time. According to Prasad et al. (2012), pasting and viscosity characteristics of rice flour are affected by milling methods. It is reported that basmati variety rice flour milled by dry, semi dry and wet method has different pasting temperature of 59.4°C, 51.8°C and 65.5°C respectively. According to Karim et al. (2008) sago flour has gelatinisation temperature of 69.5-70.2°C. It has high viscosity after gelatinized, but it has low directivity score (44.6% after 72 h of hydrolysis).

Due to its mineral content, especially calcium, addition of carbonized straw also decreases the product final viscosity. Based on Srijunthongsiri et al. (2016) calcium, in either  $\text{Ca}(\text{OH})_2$  or  $\text{C}_6\text{H}_{10}\text{CaO}_6$  form, can be used to modify the pigeon pea starch (*Cajanus cajan*). Its addition significantly increases the starch swelling power, amylose solubility and viscosity but does not affect the pasting properties. In addition, calcium-modified starch shows the best freeze-thaw properties as well as excellent pseudo-plastic flow behavior (Srijunthongsiri et al., 2016).

#### ***The Effect of Carbonized Rice Straw Concentration on Dawet's Gel Texture and Color***

The gel quality is measured from its physical characteristics such as texture and color. The data is

provided on Table 3. Statistically, different concentration of CRS addition results to significant difference on the product brightness and texture. However, it does not significantly affect the samples redness (a) and yellowness (b).

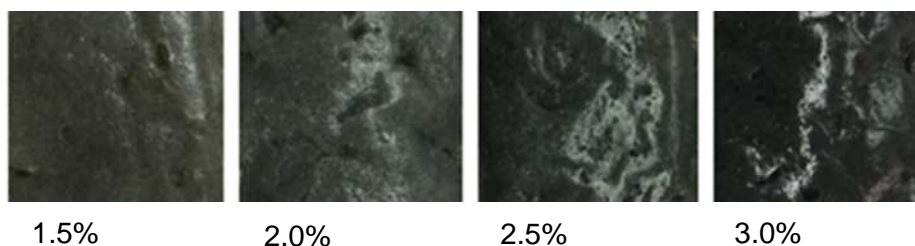
Each *dawet* gel (3 cm thickness) is pressed by using round probe to measure its texture. In general, it requires more energy (N) to press the gel with higher concentration of CRS. However, significant energy pressure is started to show from the samples with 2.5% of CRS addition. Improvement on *dawet* gel texture can be correlated with mineral contents of CRS. On Table 3, it can be seen that CRS contains calcium and iron. These minerals have been reported to be able to improve the texture of apple product (Mierczynska et al., 2015). In addition, calcium also improves the pasting properties as well as texture stability of dough (Salinas and Puppo, 2013).

In regards of product's brightness, higher concentration of CRS addition decreases L value of the product. As seen on Figure 3. Higher concentration of CRS tends to darken the product's color. Black color in the carbonized rice straw is most likely due to its carbon contents. According to Murtini et al. (2018) the second largest compound of CRS is carbon (37%), and the carbon determines the black color. This residual carbon is probably produced because unlike high temperature incineration (>700°C) which completely eliminates carbon, burning process merely reduces it. Based on Kanokkanjana and Garivait (2013), burning process reduces rice straw's carbon content up to 17%.

**Table 3.** Texture and color of *dawet* gel in response to several levels of CRS addition

CRS levels (% b/b)	Texture (N)	L	a	b
1.5	4.50±0.11 a	37.26± 0.26 a	0.8± 0.09	0.8±0.13
2.0	4.66±0.13 a	35.12± 0.19 b	0.9± 0.14	0.4± 0.09
2.5	4.84±0.05 a	33.87± 0.24 c	0.7± 0.13	0.9± 0.19
3.0	5.24±0.19 b	32.09± 0.24 d	0.8± 0.13	0.7± 0.11

Note: Data is means of 4 replications ± standard error. Means within the same column followed by similar letter are not significantly different at  $\alpha=0.05$



**Figure 3.** *Dawet* gel color in response to different concentration of CRS addition

**Table 4.** Sensory characteristics of overall *dawet* gel's appearance, color, juiciness and aroma.

CRS levels (%)	Overall	Color	Juiciness	Aroma
1.5	2.7±0.42 c	2.6±0.39 c	2.7±0.44 ab	3.0±0.45
2.0	2.9±0.40 bc	2.9±0.43 b	2.5±0.41 b	3.1±0.44
2.5	3.2±0.49 a	3.5±0.42 a	2.8±0.47 a	3.0±0.46
3.0	3.1±0.46 ab	3.4±0.44 a	2.7±0.47 ab	2.8±0.42

Note: Data is means of 110 panilists' data. Means within the same column followed by similar letter are not significantly different at  $\alpha=0.05$

### **The Effect of CRS Addition on Sensory Properties of Dawet's Gel**

Generally, overall perception of panelists on *dawet* gel's color, juiciness and appearance are affected by different concentration of CRS addition. Their perception on its aroma, nonetheless, does not show any effect in response of CRS addition. The results of *dawet* gel's sensory analysis are provided on Table 4.

Increasing level of CRS increase panelist's preference on the color and overall apperance of *dawet* gel. Generally, higher value is given by panelists to the sample with 2.5% of CRS addition. On the other hand, insignificant difference in aroma is actually preferable so as to ensure that CRS addition does not result to unfavorable aroma change.

### **Conclusion**

The CRS contains essential minerals such as potassium, calcium, sodium, and iron of  $20599.91 \pm 776.44$ ,  $307.58 \pm 70.71$ ,  $30.59 \pm 1.03$  and  $1079.98 \pm 20.75$  ppm subsequently. CRS significantly affects the breakdown and final viscosity of the flour while having insignificant effect on the pasting temperature of rice: sago mixed flour (55:45). Furthermore, different concentrations of CRS addition (1.5% - 3.0%) affect *dawet* gel's brightness and texture. In general, increase on CRS concentration results to the better improvement of texture and decrease of brightness. In addition, higher sensory value is given by the panelists to the *dawet* gel sample with the addition of 2.5% CRS. These results indicate that CRS is possibly potential to be used to improve

food product's quality (*dawet* gel). Essential mineral contains, in particular, might be applicable to overcome mineral deficiency issues in Indonesia. Therefore, further study is required in order to explore its potential to improve the quality of food products as well as its mineral contents bioavailability.

### **References**

- AACC International. (1999) *Approved Methods of Analysis, 11th Ed. Method 76-21.01. General pasting methods for wheat or rye flour or starch using the rapid visco analyzer*. St. Paul, MN: AACC International.
- AOAC. (1993) *AOAC official method number 990.08 metals in solid wastes by ICP*. Gaithersburg, MD: AOAC International.
- AOAC. (2000) *AOAC Official Method 999.11 determination of lead, cadmium, copper, iron, and zinc in foods*. Gaithersburg, MD: AOAC International
- CNN. (2021) *50 of the worlds's best desserts* [online]. Available at <https://edition.cnn.com/travel/article/world-50-best-desserts/index.html> (Accessed: 14 March 2021)
- Chuang, L., Panyoyai, N., Shanks, R., and Kasapis, S. (2015) 'Effect of sodium chloride on the glass transition of condensed starch systems', *Food Chemistry*, 184, pp. 65-71
- Dobermann, A., and Fairhurs, T.H. (2002) 'Rice straw management', *Better Crops International Special Supplement*, 16, pp. 7-11
- Edun, A. A., Olatunde, G. O., Shittu, T. A., and Adeogun, A. I. (2018) 'Flour, dough and bread properties of wheat flour substituted with orange-fleshed sweetpotato flour', *Journal of Culinary Science & Technology*, 17(35), pp 1-22

- FAOstat. (2020) *Rice, paddy production quantity, Indonesia* [online]. Available at <http://www.fao.org/faostat/en/#data/QC> (Accessed: 14 March 2020)
- Gropper, S. S., Smith, J. L., and Groff, J. L. (2009). *Advanced nutrition and human metabolism. Fifth Edition*. California: Wadsworth.
- Hsu, C. K., and Chiang, B. H. (2002) 'Effects of water, oil, starch, calcium carbonate and titanium dioxide on the colour and texture of threadfin and hairtail surimi gels', *International Journal of Food Science & Technology*, 37(4), pp. 387-393
- Jenkins, B. M., Baxter, L. L., Miles Jr. T. R., and Miles, T. R. (1998) 'Combustion properties of biomass', *Fuel Processing Technology*, 54, pp 17-46
- Kanokkanjana, K., and Garivait, S. (2013) 'Alternative rice straw management practices to reduce field open burning in Thailand', *International Journal of Environmental Science and Development*, 4(2), pp.119-123
- Karim, A. A., Pei-Lang Tie, A., Manan, D.,M.,A., and Zaidul, I. S.,M. (2008) 'Starch from the Sago (*Metroxylon sago*) palm tree—properties, prospects, and challenges as a new industrial source for food and other uses', *Comprehensive Reviews in Food Science and Food Safety*, 7, pp. 215-228
- Liu, N., Ma, S., Li, L., and Wang, X. (2019) 'Study on the effect of wheat bran dietary fiber on the rheological properties of dough', *Grain and Oil Science Technology*, 2, pp. 1-5
- Mierczynska, J., Cybulska, J., Solowiej, B., and Zdunek, A. (2015) 'The Effect of Ca<sup>2+</sup>, Fe<sup>2+</sup> and Mg<sup>2+</sup> on rheological properties of new food matrix made of modified cell wall polysaccharides from apple', *Carbohydrate Polymers*, 133, pp. 547-555
- Miller, D. D. (2008) 'Minerals' in Damodaran S., Parkin K. L., and Fennema, O. R. (eds) *Food Chemistry 4<sup>th</sup> Edition*. New York: CRC Press, pp. 523-570
- Murtini, E. S., and Lorenzsa, C. S. (2020) 'Characteristics of sago noodles as affected by varied concentration of carbonized rice straw-based liquid colorant', 5th International Conference on Food, Agriculture and Natural Resources (FANRes 2019), *Advances in Engineering Research*, 194, pp. 237-240
- Murtini, E.S., Yuwono, S. S., and Setyawan, H. S. (2018) 'The mineral composition and the effect of particle size of carbonized rice straw as colorant of a traditional cake kue jongkong Surabaya', *IOP Conf. Series: Earth and Environmental Science*, 131, pp. 1-6
- Murtini, E.S., Yuwono, S.S., and Setyawan, H.S. (2019) 'Comparison of characteristics of carbonized rice straw from various rice varieties and parts of rice straws as a source for natural black colorant', *IOP Conf. Series: Earth and Environmental Science*, 230, pp. 1-7
- Niu, M., Hou, G., Lee, B., and Chen, Z. (2014) 'Effects of fine grinding of millfeeds on the quality attributes of reconstituted whole-wheat flour and its raw noodle products', *LWT - Food Science and Technology*, 57 (1), pp. 58-64
- Prasad, K., Singh, Y., and Anil, A. (2012) 'Effects of grinding methods on the characteristics of Pusa 1121 rice flour', *Journal of Tropical Agriculture and Food Science*, 40(2), pp. 193-201
- Salinas, M.V., and Puppo, M.C. (2013) 'Effect of organic calcium salts-inulin system on hydration and thermal properties of wheat flour', *Food Research International*, 50, pp. 298-306
- Singh, R., Srivastava, M., and Shukla, A. (2016) 'Environmental sustainability of bioethanol production from rice straw in India: A review', *Renewable and Sustainable Energy Reviews*, 54, pp. 202-216
- Srijunthongsiri, S., Pradipasena, P., and Tulyathan, V. (2016) 'Influence of heat-moisture modification in the presence of calcium compound on physicochemical properties of pigeon pea (*Cajanus cajan*) starch', *Food Hydrocolloids*, 53, pp. 192-198
- Vadiveloo, J. (2000) 'Nutritional properties of the leaf and stem of rice straw', *Animal Feed Science and Technology*, 83(1), pp. 57-65
- Yang, N., Luan, J., Ashton, J., Gorczyca E., and Kasapis, S. (2014) 'Effect of calcium chloride on the structure and in vitro hydrolysis of heat induced whey protein and wheat starch composite gels', *Food Hydrocolloids*, 42(2), pp. 260-268