CHARACTERISTICS OF KWETIAU MATERIAL OF FORMULATION RICE FLOUR AND UWI FLOUR, TARO FLOUR AND KIMPUL FLOUR MODIFIED BY HEAT MOISTURE TREATMENT (HMT)

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Abstract

The purpose of this study is to determine the effect of substitution uwi flour, taro flour, and kimpul flour modified on rice flour that can produce the best characteristics of high resistant starch kwetiau. HMT modification on the uwi/ keribang/ coconut yam (*Dioscorea alata*) flour, taro (*Colocasia esculenta* (L) Schott) flour and kimpul/ sarawak taro/ belitung taro (*Xanthosoma sagittifolium* (L) Schott) flour characteristics can be applied to the manufacture of kwetiau . The nature of the lack of appropriate natural starch is expected to be improved by modification of starch is by Heat Moisture Treatment (HMT). HMT treatment is 20% and 30% water content with heating time 4, 6, 8, 10 hours at 80 ° C. The results showed HMT modification effect on the water content and crystallinity of uwi flour, taro flour and kimpul flour.

Keywords: Heat MoistureTreatment, Kimpul, Resistant Starch, Taro, Uwi.

1. Introduction

Uwi tuber (*Dioscorea alata*), taro (*Colocasia esculenta* (L) Schott) and kimpul (*Xanthosoma sagittifolium* (L) Schott) is part of the tubers are used as food plants in West Kalimantan. One of the benefits of tuber development effort that is by processing the tubers into flour. Tubers flour are expected to replace the rice flour, that is replacing rice flour in the manufacture of kwetiau. Rice flour in the manufacture of kwetiau containing moderate to high amylose (Cham and Suwannaporn, 2010; Phothiset and Charoenrein, 2006), making it susceptible to retrogradation (Wattanachant et al., 2002). Retrogradation required in kwetiau texture formation during cooling. Making kwetiau of rice flour have been studied by Thomas et al. (2014) and (Cham and Suwannaporn (2010), but has not been much research kwetiau from tubers flour. Rice with low to medium amylose content does not have the potential for the manufacture of rice noodles (Jayakody and Hoover, 2008). The use of tubers flour are not expected to produce good kwetiau so it is necessary to modify them with Heat Moisture Treatment (HMT).

HMT modification is a physical modification by heating above the starch gelatinization temperature (80-120 ° C) but with a limited water content (<35%) (Collado et al., 2001). HMT has been done on uwi, taro, kimpul, cassava and potato starch (Gunaratne and Hoover, 2001). HMT can improve the characteristics of sago starch vermicelli (Herawati, 2009), improve the characteristics of rice flour noodles (Cham and Suwannaporn, 2010), led to a decrease in the crystalline regions in the starch of corn, peas and lentils thereby increasing levels of resistant starch (rs) (Chung et al., 2009), but HMT modified has not been much done on tubers flour. This research will result flour of uwi, taro and kimpul modified by HMT is expected to improve the characteristics of the flour so that it can be applied to the manufacture of kwetiau.

2. Materials and Nethods

The materials used are uwi tubers, taro tubers, kimpul tubers obtained from Pontianak Morning Market, a standard glucose, KCl-HCl buffer solution, α-amylase. Making flour is done by cleaning the bulbs from the soil, the tubers are washed, peeled, and sliced 2 mm thick, dried in a drying oven for 12 hours at 50 ° C, in order to obtain a dry tuber slices. Dried tuber slices are ground and sieved with a 100 mesh sieve. HMT is done with a combination of treated water content (20 and 30%) and time (4, 6, 8 and 10 hours). Modification method refers to the method used Herawati (2009).

Analysis of modified flour of uwi, taro and kimpul that has been modified are: analysis of water content (thermogravimetri method, AOAC, 1999), swelling power and solubility (Collado et al., 2001), the nature of amilografi. The crystallinity area test is using FTIR, calculated as the ratio between the absorbance at wave number 1045 cm^{-1} to the absorbance at 1022 cm^{-1}.

3. Results and Discussions

Tubers flour material of uwi, taro and kimpul has been analyzed: water content analysis, amylose content, swelling power and solubility. They are presented in Table 1. The water content analyzes was conducted to determine the amount of water added, whereas changes starch crystallinity due to HMT modifications is observed by FTIR are presented in table 6.

Table 1. Average of Water Content, Amylose Content, Swelling Power and Flour Solubility

Material	Water Content (%)	Amylose Content (%)	Swelling Power (%)	Solubility (%)
Uwi flour	8,74	28,37	5,5582	3,58
Taro flour	9,36	13,28	5,3223	6,05
Kimpul flour	9,46	24,24	4,8737	4,99

On drying, the heat will be given covering the surface of the material and raise the pressure of vapor water at the material surface. Amylose content contained in the flour is influenced by the type of plants, the environment grows, ages and varieties.

The Water Content.

Results of analysis of variance showed water content treatment and prolonged heating at flour of uwi, taro and kimpul has real effect and there is interaction between the treatment of the water content. The average water content of flour of uwi, taro and kimpul under the influence of water content and heating times are presented in Table 2.

In the treatment of 20% water content, water content of flour of taro and uwi decreased with prolonged heating, except uwi flour on prolonged heating 6 hours, this is due to the longer heating the water removed more. On prolonged heating kimpul flour showed no significant difference except on treatment longer than 4 hours heating.

In the treatment of 30% water content, water content of flour of taro, uwi and kimpul increased with increasing heating times, except on prolonged heating taro flour 10 hours. The heat energy at HMT absorbed by granules used for the arrangement or the formation of new bonds between the molecules in addition to form the double helix unfolded amylopectin (Siregar et al., 2012), new bonds between the molecules in starch granules can cause water to enter and tied. According to Meyer and Parker (2003), molecules of water into the starch granule and trapped in the molecular structure - amylose and amylopectin molecules.

Table 2. Average of water content of flour of uwi , taro and kimpul due to the influence of water content and treatment of HMT heating time

Treatment	Water Content (%)		
	Uwi Flour	Taro Flour	Kimpul Flour
Water Content 20%, Heating Time 4 H	17,34 c	13,60 c	12,02 a
Water Content 20%, Heating Time 6 H	20,56 f	14,09 c	13,62 b
Water Content 20%, Heating Time 8 H	17,35 c	12,91 b	13,66 b
Water Content 20%, Heating Time 10 H	10,65 a	11,61 a	14,19 b
Water Content 30%, Heating Time 4 H	13,43 b	17,62 e	15,73 c
Water Content 30%, Heating Time 6 H	19,03 d	20,45 f	16,28 cd
Water Content 30%, Heating Time 8 H	20,00 e	17,46 e	16,90 d
Water Content 30%, Heating Time 10 H	20,63 f	16,50 d	17,20 d

Note: Averages figures are followed by the same letter in the same column are not significantly different at α 0.05 Duncan test

Flour type also affects the difference in water content of flour after HMT modification. Amylose content also reported affects the role of water in the process of HMT modification. According to Franco et al. (1995), an increase in the water content HMT improve the heat stability of normal corn starch paste but not significant for waxy corn starch paste. According to Herawati (2009), imbibition of water into the starch granules due to the high temperatures that can break the hydrogen bonds between molecules of amylose-amylose, amylose-amylopectin, and amylopectin-amylopectin. Hydrogen bonds between molecules are then replaced by hydrogen bonding with water. Therefore, water content and temperature applied during the modification will likely interact to influence the characteristics of the resulting modified starch.

Amylose content.

Results of analysis of variance showed water content treatment and prolonged heating at uwi flour, taro and kimpul real effect on amylose content and there was no interaction between treatments. The mean amylose content of flour uwi, taro and kimpul due to the influence of water content and duration of heating are presented in Table 3.

Table 3. The Average of amylose content of flour uwi, taro and kimpul due to the influence of water content and longer heating HMT

Treatment	Amylose Content (%)		
	Uwi Flour	Taro Flour	Kimpul Flour
Water Content 20%, Heating Time 4 H	20,30 b	13,94 g	23,38 a
Water Content 20%, Heating Time 6 H	24,56 c	13,15 de	27,72 e
Water Content 20%, Heating Time 8 H	19,86 b	13,83 fg	26,24 c
Water Content 20%, Heating Time 10 H	17,67 a	12,60 bc	27,03 d
Water Content 30%, Heating Time 4 H	29,61 d	13,45 ef	26,32 c
Water Content 30%, Heating Time 6 H	29,62 d	12,96 cd	24,44 b
Water Content 30%, Heating Time 8 H	28,98 d	12,28 b	23,73 a
Water Content 30%, Heating Time 10 H	36,17 e	11,56 a	26,57 cd

Note: average figures are followed by the same letter in the same column are not significantly different at $\alpha = 0.05$ Duncan test

In the treatment uwi flour 20% water content the longer the heating will lower amylose content, in contrast to 30% water content, the longer the heating will raise the levels of amylose. The water content of 20% showed lower amylose content compared with treatment water content of 30% at the same time heating. In both taro flour at levels of 20 and 30% water content the longer heating the amylose content decreases. At 20% water content of amylose content higher than 30% water content at the same time heating. In the treatment of the water content of 20% by prolonged heating 4 hours showed the highest amylose content, while the smallest amylose content is the treatment of the water content of 30% and heating time 10 hours. In the kimpul flour treatment water content and heating times did not show a regular pattern.

Increased levels of amylose in uwi flour treated water content of 30% with the longer heating of HMT, in addition to the existing derived from amylose, also caused by the formation of a new amylose molecules which shorter than the result of depolymerization of amylose and amylopectin. In taro flour amylose content decrease with the longer heating the water content of 20% and 30%, not too large compared to the uwi flour. This is due to the amylose content of taro starch has amylose content less than uwi flour. According to Lewandowicz et al. (1997) Starch with high amylose content (21% amylose potato starch) showed greater changes than the physicochemical characteristics of starch than low amylose content (17% amylose tapioca starch). Donovan et al. (1983) which states that the association of amylose in the amorphous zones tend to experience greater changes than changing the association of amylopectin in crystalline zone during the heating process takes place.

Crystallinity.

FTIR was used to determine the level of the helical arrangement of starch to see starch changes due to the process of starch gelatinization, retrogradation or storage (Faridah, 2011). Polysaccharides like starch can be absorbed at wave number 800 - 1200 cm^{-1} which is the fingerprint of the conformation and hydration of starch (Savenou et al., 2002). The increase in the ratio of 1045/1022 indicates upregulated crystalline regions (Chung et al., 2009), whereas the increase in the ratio of 1022/955 showed an increase in the composition of amorphous regions (Htoon *et al.* 2009). The changing of amorphous and crystalline regions of starch at different treatment based on the results of the analysis of the curve FTIR can be seen in Table 4. As explained before, the value of 1022/995 ratio is the value that shows the structure of the amorphous regions of the starch granules. All treatments flour increases the amorphous regions compared to the original flour.

Swelling Power.

The results of analysis of variance showed water content treatment and prolonged heating at uwi flour, taro and kimpul real effect on swelling power and there was no interaction between treatments. The mean amylose content of flour uwi, taro and kimpul due to the influence of water content and duration of heating are presented in Table 5.

Table 4. Changes in amorphous and crystalline regions of flour of uwi, taro and kimpul and treatment of water content and heating times based on measurements by FTIR

Treatment	Absorbance ratio	
	A1045 /A1022	**A1022 /A955**
Uwi Flour	0,9128	1,0105
Water Content 20%, Heating Time 4 H	0,8498	2,6565
Water Content 20%, Heating Time 6 H	0,8716	2,4317
Water Content 20%, Heating Time 8 H	0,8843	2,2656
Water Content 20%, Heating Time 10 H	0,9075	1,0094
Water Content 30%, Heating Time 4 H	0,8940	1,0152
Water Content 30%, Heating Time 6 H	0,8653	2,4461
Water Content 30%, Heating Time 8 H	0,8802	2,3129
Water Content 30%, Heating Time 10 H	0,8866	1,0082
Taro Flour	0,7685	3,4393
Water Content 20%, Heating Time 4 H	0,7501	3,9488
Water Content 20%, Heating Time 6 H	0,7598	3,9289
Water Content 20%, Heating Time 8 H	0,7290	4,2515
Water Content 20%, Heating Time 10 H	0,7738	3,3894
Water Content 30%, Heating Time 4 H	0,7411	4,0111
Water Content 30%, Heating Time 6 H	0,7818	3,5236
Water Content 30%, Heating Time 8 H	0,7775	3,5897
Water Content 30%, Heating Time 10 H	0,7744	3,5957
Kimpul Flour	0,8149	3,0621
Water Content 20%, Heating Time 4 H	0,8181	3,1086
Water Content 20%, Heating Time 6 H	0,8143	3,0009
Water Content 20%, Heating Time 8 H	0,7865	3,7408
Water Content 20%, Heating Time 10 H	0,8148	3,3100
Water Content 30%, Heating Time 4 H	0,7953	3,3198
Water Content 30%, Heating Time 6 H	0,8201	3,3320
Water Content 30%, Heating Time 8 H	0,9078	3,2411
Water Content 30%, Heating Time 10 H	0,8139	3,1805

Table 5. The mean swelling power of flour uwi, taro and kimpul due to the influence of water content and longer heating HMT

Treatment	Swelling Power (%)		
	Uwi Flour	Taro Flour	Kimpul Flour
Water Content 20%, Heating Time 4 H	20,30 b	4,43 c	4,42 b
Water Content 20%, Heating Time 6 H	24,56 c	3,32 b	6,49 c
Water Content 20%, Heating Time 8 H	19,86 b	3,30 b	3,67 a
Water Content 20%, Heating Time 10 H	17,67 a	2,51 a	4,58 b
Water Content 30%, Heating Time 4 H	29,61 d	5,55 d	4,67 b
Water Content 30%, Heating Time 6 H	29,62 d	4,26 c	3,90 a
Water Content 30%, Heating Time 8 H	28,98 d	3,42 b	3,71 a
Water Content 30%, Heating Time 10 H	36,17 e	2,49 a	3,93 a

Note: The averages figures are followed by the same letter in the same column are not significantly different at $\alpha = 0.05$ Duncan test

The mechanism of development due to the hydrogen bonds linking the molecules of amylose and amylopectin become weaker with increasing heating temperature, thereby disrupting the cohesiveness of starch granules. The increase in temperature causes the water molecules have higher kinetic energy so it can easily penetrate the starch granule. In the treatment of 20% water content uwi flour swelling power is smaller than the water content of 30% at the same time heating. In all kinds of flour have the same swelling power patterns that the longer the heating, swelling power of flour uwi, taro and kimpul the lower.

The decrease swelling caused by the rearrangement of molecules in starch granules and a decrease in crystalline regions and amorphous regions rise. According to Eerlingen et al. (1993) a decrease in swelling power caused by the transformation of amorphous amylose into a helical shape, increased interaction between amylose chains, and changes in the interaction between the crystalline and amorphous. The decrease swelling power due to rearrangement of molecular chains, so that the more rigid structure of starch after HMT. The decrease swelling power related to the amount of amylose, the uwi flour HMT treatment led to an increase in the amount of amylose, where the greater amylose content would decrease power development. According to

Lii at al. (1998) swelling power depends on the levels of amylose and amylopectin, amylose as an inhibitor of swelling, especially if lipids bound. If there is branching in polymers such as amylopectin starch will limit hydrogen bonds between the polymer so can increase the interaction with water and amylopectin is more easily hydrated.

Table 6. The average solubility flour of uwi, taro and kimpul due to the influence of water content and longer heating HMT

Treatment	Solubility (%)		
	Uwi Flour	Taro Flour	Kimpul Flour
Water Content 20%, Heating Time 4 H	20,30 b	4,66 a	3,37 c
Water Content 20%, Heating Time 6 H	24,56 c	11,91 f	2,44 b
Water Content 20%, Heating Time 8 H	19,86 b	7,27 c	4,54 d
Water Content 20%, Heating Time 10 H	17,67 a	5,28 b	6,48 e
Water Content 30%, Heating Time 4 H	29,61 d	11,52 f	4,73 d
Water Content 30%, Heating Time 6 H	29,62 d	9,58 e	4,51 d
Water Content 30%, Heating Time 8 H	28,98 d	8,89 d	1,75 a
Water Content 30%, Heating Time 10 H	36,17 e	4,64 a	3,59 c

Note: Figures are averages followed by the same letter in the same column are not significantly different at α = 0.05 Duncan test

Solubility.

Results of analysis of variance showed water content treatment and prolonged heating at flour of uwi, taro and kimpul significantly affect the solubility and there is interaction between the treatments. The mean amylose content of flour uwi, taro and kimpul due to the influence of water content and duration of heating are presented in Table 6.

Solubility changes in general tend to be the same as the swelling power, so that the starch with swelling power or high swelling volume of starch pastes have a high solubility is also described by a Herawati (2009). The data show the solubility is not always the same as the swelling power, it is alleged in uwi flour, taro and kimpul contains components that have a high solubility for example mucus and soluble fiber. Solubility is also affected by the amylose content and granule development occurs when the granules are heated together with water and hydrogen bonds that stabilize the structure.

Uwi flour at 20% water content, the longer the heating, the solubility will decrease, which showed the same pattern of swelling power. This is because the low solubility will limit the hydration of water into the starch granule swelling power that is also low. Solubility and swelling power is also affected by the amylose leaching, Amylose is out (leaching) will increase the solubility of the starch. Uwi flour at 30% water content, the longer the heating solubility increases, which shows a different pattern than the swelling power decreased with the longer heating. At 30% water content is more affected by increased levels of amylose and amylose occurs more powerful arrangement that reduces amylose leaching.

Amilografi nature.

In taro flour and kimpul peak viscosity, breakdown viscosity, setback and final viscosity higher than that of natural ingredients with starch after HMT treatment. In the uwi flour final viscosity of flour naturally higher than flour after HMT treatment. This is because the swelling power of HMT modified flour limited so that the viscosity is lower than natural flour.

Taro flour at 20% water content and 30% and 30% kimpul flour showed the same pattern that is the longer the heating, the solubility will decrease, except at water content of 20% by heating 4 hours that have low solubility. Solubility pattern tend to similar to the pattern of swelling and amylose content were getting down to the longer heating. Kimpul flour at 20% water content increased solubility with the longer he.

Selection of Best Treatment.

Determining the best treatment using the effective index method. This method is performed on flour of uwi, taro and kimpul with parameters of water content, amylose content, swelling power, solubility, gelatinization temperature and peak viscosity. The best combination treatment of uwi flour has been obtained from the uwi combination treatment water content of 30% and a 4 hour long treatment. The best combination treatment of taro flour has been obtained from the uwi combination treatment water content of 20% and a 4 hour long treatment. The best combination treatment of kimpul flour has been obtained from the uwi combination treatment water content of 30% and a 10 hour long treatment.

4. Conclusions

The best combination treatment of uwi flour obtained from the combination treatment of water content of 30% and a 4 hour long treatment. The best combination treatment of taro flour obtained from the combination treatment taro water content of 20% and a 4 hour long treatment. The best combination treatment of kimpul flour obtained from the combination treatment kimpul water content of 30% and a 10 hour long treatment.

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