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Effect of wild yam root preparation on physiochemical properties of ready-to-use wild yam flour

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ABSTRACT

Asiatic bitter yam (*Dioscorea hispida* Dennst.) or kloy kao niaw (KKN) is a food plant of people in the tropics, but certain wild varieties are edible after detoxified. Detoxified of KKN are delicious food ingredients. Thus, the effects of the preparation method on the physicochemical quality of ready to used KKN flour were investigated. The KKN tubers were taken from Mae-Tha, Lampang, Thailand. The KKN was cleaned, peeled, and sliced to 0.1 mm before soaked in salt solution at 0, 10, 20, 30, 40, and 50% for 12 hours. Each treatment was washed every day for eight days or until the sliced Kloy has white color. The ready to used KKN flour was produced with three methods; soaked in 2% salt solution for 10 min, boiling for 10 min, and steaming for 30 min prior drying in tray dried at 60 °C for four h then ground through 80 mesh screen and packed in an aluminum foil bag. The ready-to-use KKN flour was analyzed on % production yield, moisture content, color value, gelatinization temperature, starch granule by SEM, and pasting behaviors. Research revealed that the treatment on soaked slice KKN in 20% salt prior steam for 30 min had the highest production yield (26.8%), 7.70% moisture content. The color L* a* b* value were 92.98, 0.15, 7.42 respectively. The selected ready to use KKN flour had low gelatinization temperature, swollen starch granules, and lowest peak viscosity, and easily soluble in water than the other two treatments.

Keywords: table salt solution, detoxified, gelatinization temperature, viscosity behaviors

INTRODUCTION

Asiatic bitter Thai yam (*Dioscorea hispida* Dennst. var. hispida), is locally known as kloy kao niaw (KKN) and kloy kao choa (KKC). The tuber is poisonous because of high content of the alkaloid dioscorine and diosgenin. The toxic alkaloid, dioscorine, and diosgenin are poisonous to the central nervous system hence the danger to consumers (Kang et al., 2012; Hudzari et al., 2011). Traditional Thai dishes from KKN and KKC were taken time to prepare for food. The traditional processing is done by slicing the tuber very thinly and soaking it in brine for at least three days then, in flowing water or river for an additional four days until the yam slide had white color. After this, the yam chips are boiled or steamed before eaten, similar to other root crops. The drying process involving chopping, washing, and drying of the tuber starch also reduces some toxins (Kresnadipayana and Waty, 2019). In the case of highly toxic *Aconitum carmichaelii* Debeaux traditionally eaten by the locals of Qinling Mountains (China), detoxification of the root vegetable requires drying and long hours of boiling up to 8-10. Recently, the DNA barcoding strategy could be used to accurately identify the plant in the wild, which could be labeled with appropriate warnings together with preparation guides to avoid incidences of plant food poisoning (Buenavista et al., 2021). Previously studied by Jayakody et al. (2009) on the ratios of KKN to salt at 1:10 2:10 3:10 4:10 and 5:10 at room temperature for three days. The control was unsalted KKN. Each treatment was rinsed six times per day at 4 hours intervals and dried in an oven at 60 °C for 24 hrs. The dried KKN was diluted with distilled water to 10 100 200 300 and 400 g/L and mixed in water the keep ten tilapia at room temperature for 96 hours. They found that the KKN provided the lowest toxicity to tilapia with 96 h-LD50=204.54 and 214.29 g/L, respectively. For 400 g/L concentration, detoxified KKN with 4:10 and 5:10 ratios showed an accumulated mortality rate of 6.66±3.33 and 3.33±3.33%, respectively. They also reported the approximate composition of the KKN and KKC tuber per 100 g edible portion is: water 78 g, protein 1.81 g, fat 1.6 g, carbohydrates 18 g, fiber 0.9 g, and ash 0.7 g. On a dry weight basis, the tuber also contains 0.2-0.7% diosgenin and 0.044% dioscorine; these poisons can cause paralysis of the central nervous system. Commercial starch extracted from the tubers contains 88.34%

starch, 5.28% protein, 5.33% fiber, 0.23% fat, 0.66% ash, and various phenolic compounds (Kresnadipayana and Waty, 2019; Irfa et al., 2019). Furthermore, Anuntagool et al. (2006) proposed that the Starch from Thai yam *Dioscorea hispida* Dennst; locally known as kloy kao niaw (KKN), was hydrothermally modified (HM) at moisture contents (MC) between 13 and 30 g water/100 g starch (wb) at 90 °C for ten h. All treatments caused a decrease in swelling power and amylose leaching and an increase in gelatinization temperature of the starch, indicating a strengthened network within the starch granule. They also report that KKN starch granule's crystalline structure changed from B to C-type when modified at 13 g water/100 g starch (wb) and stayed unchanged when modified at 18 to 30 g water/100 g starch (wb). Thus, the objective of this study was to investigate the effects of the preparation method on the physicochemical quality of ready to used KKN flour in various food products.

MATERIALS AND METHODS

Kloy kao niaw (KKN) (*Dioscorea hispida* Dennst.) tubers were obtained from Mae-Tha, Lampang Thailand. The KKN roots were stored at room temperature for two days before produce ready to used KKN flour. Table salt was purchased from a local market in Muang Lampang province, Thailand. The chemicals used were all analytical grade from Merck, Germany. All equipment used from the Food Innovation Center, Agricultural Research Institute and Department of Argo Industry, Faculty of Science and Agricultural, Rajamagala University of Technology.

De-toxic of KKN tuber: The toxic alkaloid, dioscorine, and diosgenin were removed following the method from (Pamutha and Kansarn, 2014) with a slight modification. The raw KKN tubers were cleaned under running tap water to removed dirt and soil residues. The cleaned KKN tuber was peeled and sliced to 0.1 mm. The slices KKN were washing and soaked in salt solution at 0, 10, 20, 30, 40, and 50% for 24 hours at room temperature. The treatment was washed three times, and change the salted solution every day until the KKN sliced became white color, and the soaked water had total soluble solid less than 0.05 °Brix and pH within 5-7. Each of the treatments was repeated with the same salted solution for eight days. The drained de-toxic KKN slice was dried at 50 °C for 4 hours before analysis on moisture content (%), production yield (%), and color value.

KKN flour preparation: The ready-to-use KKN flour was produced following Anuntagool et al. (2006), modified using the de-toxic KKN sliced. The KKN flour was prepared by 1) soaked of the de-toxic KKN sliced in 2% salt solution for 10 min, 2) boiling de-toxic KKN sliced for 10 min, and 3) steaming of de-toxic KKN sliced for 30 min. The three preheated de-toxic KKN chips were drying in a tray drier at 60 °C for four h. The dried KKN chips were ground through 80 mesh screens in a Cycotex sample mill (Foss, German) and packed in air-tight aluminum foil bags for future physicochemical analysis as follows.

KKN flour yield: The production yield of the KKN flour was calculated by dividing the original mass of the rough KKN tuber (g) before processing to KKN flour weight (g) and multiple by 100. Moisture content (%) was measure in the Direct Heating Method (AOAC, 2002). Color values of KKN flour samples were measured in triplicate by reflectance using a colorimeter (Color Quest, Hunter Lab). Color value was measured following three parameters: lightness /brightness or whiteness, (L*) in which black is no reflection and white is perfect diffuse reflection; greenness to redness (a*), in which negative values indicate green and positive values indicated red and blueness-yellowness (b*), in which negative values indicate blue and positive values indicate yellow.

Granule morphology: Each KKN flour sample was sprinkled on the masking tape. The images of the KKF starch granules mounted on a stub and gold-coated were recorded using a Scanning electron microscope (JEOL model JSM-6400, Tokyo, Japan) operating at 20 kV with 5,000x magnification following Egerton (2000) with modification.

Pasting properties of KKN flour: The pasting properties of the 3 KKN flours was measure by the Rapid Visco Analyzer Series 4 (RVA-4) Newport Scientific Pty. Ltd., Australia) according to the procedure described by Approved Method 26-21A (AACC, 1999). Briefly, 3 g (12% moisture content) of each sample was mixed with 25 mL of distilled water. Each sample then underwent controlled heating and cooling cycles with constant shear, where it was held at 50 °C for 1 min, heated from 50 to 95 °C at a rate of 6 °C/min, then held at 50 °C for 5 min. The rotation speed was maintained at 75 rpm. The pasting properties, including peak viscosity (PV), hold strength (HS), breakdown (BD = PV-HS), final viscosity (FV), and setback (SB = FV-PV) of all samples were tested in triplicates.

Statistical Analysis: Completely randomized design (CRD) was used to evaluate the means of the physicochemical analysis of kloy samples. The data obtained were subjected to analysis of variance (ANOVA), followed by Duncan's multiple range test procedures for differences between treatments using Minitab for Windows Release 16.1.

RESULTS AND DISCUSSION

Physicochemical properties of the de-toxic KKN chips

Physicochemical properties of the de-toxic KKN chips that were soaked in salt solution at 0, 10, 20, 30, 40, and 50% for 24 h for eight days are shown in Table 1. Results revealed that the production yield of the de-toxic KKN chips treatment with 20% salted solution had the highest production yield (25 %), which was 10.33% moisture content. In addition, the color value of the de-toxic KKN chip had the whiteness (L*) value were in the range of 91.8 to 93.4, which was increased by the higher salt concentration. While redness (a*) value were decreased up on higher % salt solution, which was 0.36 reduced to -0.51. Furthermore, the b*value also decreased from 7.70 to 6.04. This due to the alkaloid dioscorine and diosgenin was dissolved in the salted solution that became a yellowish color during washing every day within eight days. Thus, the detoxing of KKN tuber sliced with brine (40% salt solution) and follow by watching every day was increased on L*value of the detoxined KKN chips, which was higher (93.04) than the other treatments. However, for the confidence on the KKN flour poisonous, the author will continue to study the toxin contaminated in the KKN flour by a study on DNA barcoding technique that which was proved to be useful in the accurate and correct identification of *Dioscorea hispida* Dennst as investigated by (Buenavista et al. (2021).

Table1. Physicochemical properties of de-toxic KKN chips soaked in a salt solution for eight days

De-toxic KKN properties	De-toxic KKN					
	0% salt	**10% salt**	**20% salt**	**30% salt**	**40% salt**	**50% salt**
Yield (%)	19±0.10^{b}	14±0.40^{d}	25±0.24^{a}	18±0.24^{b}	16±0.60^{c}	13±0.60^{e}
Moisture (%)	11.6±0.1^{a}	10.63±0.1^{b}	10.33±0.3^{b}	9.81±0.1^{bc}	10.63±0.2^{c}	10.89±0.5^{b}
Color value L*	92.60±0.5^{a}	91.98±0.17^{c}	92.98±0.18^{a}	92.92±0.04^{a}	93.04±0.21^{a}	92.46±0.2^{b}
a*	0.36±0.01^{a}	0.28±0.03^{a}	0.15±0.01^{c}	0.22±0.00^{b}	0.13±0.02^{c}	-0.51±0.02^{e}
b*	7.70±0.09^{a}	7.40±0.14^{b}	6.41±0.14^{c}	6.43±0.09^{c}	6.50±0.25^{c}	6.04±0.08^{d}

$^{a, b}$ Values are mean ± standard deviation. Different superscripts in columns differ significantly ($P < 0.05$)

^{ns} Values are mean ± standard deviation in columns not significantly ($P > 0.05$)

Physicochemical properties of KKN flour

Analysis results on flour yield, moisture content, color value, granule morphology, pasting behaviors are presented in Table 2 and Figure 1 – 2. Results KKN flour yield revealed that the 2% salt-soaked had the highest percent yield, moisture content, a* value, pasting time, and gelatinization temperature, 28.15%, 9.88 %, 0.23 a*, 6.45 b*, 5.25 min, and 89.90 °C, respectively. In addition, the 30 minutes steamed KKN flour was the lowest value of moisture content, a* and b* value, pasting time, and gelatinization temperature as 26.86%, 7.70%, -0.54 a*, 6.14 b*, 4.00 min, and 64.53 °C, respectively.

The pasting time and temperatures of raw KKN flour prepared by soaked in 2% salt for 10 min observed by RVA were 5.25 min and 89.90 °C. These results are higher than the previous study, about 78.4-79.6 °C (Naksriarporn et al., 2005). These results indicate that a hard granular structure of raw KKN flour compared to the boil and steamed KKN chip was 66.43 and 64.53 °C. Thus, the 30 minutes steamed KKN flour had good properties for ready to used KKN flour in various food products such as bakery, snack, and breakfast cereal products.

Table2. Physicochemical properties of ready to used KKN flour with three preparation methods.

Physicochemical properties	Preparation methods		
	10 minutes 2% salt-soaked	10 minutes boiled	30 minutes steamed
KKN flour yield (%)	28.15 ±0.10[a]	26.74±0.12[b]	26.86±0.62[b]
Moisture content (%)	9.88±0.01[a]	8.32±0.02[b]	7.70±0.02[c]
Color value L*	92.92±0.53[ns]	92.86±0.01	92.27±1.15
a*	0.23±0.00[a]	0.15±0.04[a]	-0.54±0.06[b]
b*	6.45±0.01[ns]	6.78±0.03	6.14±0.02
Pasting time (min)	5.25±0.26[a]	4.50±0.24[b]	4.00±0.12[b]
Gelatinization temp (°C)	89.90±1.51[a]	66.43±0.49[b]	64.53±0.80[c]

[a, b] Values are mean ± standard deviation. Different superscripts in rows differ significantly ($P < 0.05$)
[ns] Values are mean ± standard deviation in columns not significantly ($P > 0.05$)

Granule morphology of KKN flour

Figure 2 shows the images of ready to used KKN flour granule viewed at 5,000 x g magnification viewed under SEM. It was evident that the 2% salt-soaked had granules are mainly polyhedral in shapes with a smooth surface of 1-6 µm. Their shapes and sizes are averages of 3 to 8 µm, and these results are in agreement with a previous study by Santhanee et al. (2014). The smooth surface of the granules of these starches indicated that the treatment with the 2% table salt solution used in this study did not damage the starch granules. While the 10 minutes boiled KKN flour was partially gelatinized starch granule, which was swelled starch granule. In addition, the 30 minutes steamed KKN flour was partially gelatinized without starch granules shape. Thus, the shared morphological properties of the 30 minutes steamed KKN flour indicated that the steamed process was affected the overall structure of KKN starches. Furthermore, it has been reported that the appearance of starch granule may affect its physicochemical properties, such as gelatinization, pasting, enzyme susceptibility, crystallinity, and solubility of the flour and starch Lindeboom et al. (2004).

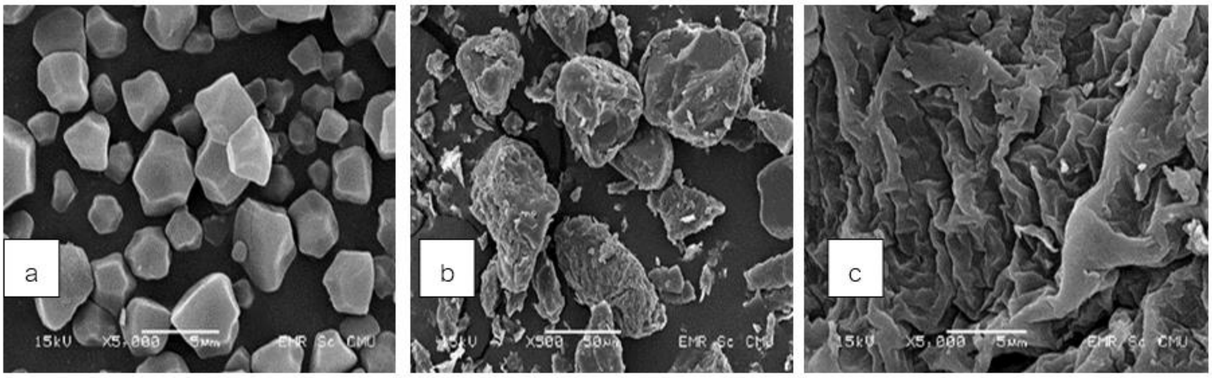

Figure 1. KKN starch granules observed under a scanning electron microscope (a) 2% salt-soaked, (b) 10 min boiled, and (c) 10 min steamed of raw de-toxin KNN tuber.

Pasting behaviors

The pasting behavior on peak viscosity, hold strength, final viscosity, setback, and pasting temperature is shown in Figure 2. The pasting properties of ready to used KKN flour prepared by 2% salt-soaked, 10 min boiled and 10 min steamed of raw de-toxin KNN slice tuber. The pasting curves reflect the behavior of KKN flour during cooking (Mishra and Rai, 2006). The KKN flour prepared from 10 min steamed of raw de-toxin KNN slice tuber GBR was the first to swell and gelatinize due to water uptake at 66.00 °C, followed by 10 min boiled at 82.30 °C and finally, 2% salt-soaked at 89.87 °C with a statistically significant difference between the three treatments. The 10 min steamed KKN flour had the lowest peak viscosity (87.30 RVU), while the 2% salt-soaked KKN flour showed the highest (392.04 RVU) with 10 min boiled of KKN flour somewhere in the middle (376.09 RVU), which were all significantly different. Our study, therefore, suggests that partially gelatinized KKN flour decreases peak viscosity. Additionally, setback value is defined as the degree of re-association between the starch molecules, is the secondary increase in viscosity during cooling, which eventually determines retrogradation of flour and starch.

The 2% salt-soaked KKN flour had the highest setback (50.10 cp) and was followed by the 10 min boiled of KKN flour (40.0 cp). While the10 min steamed, KKN flour was the lowest (4.0 cp). This phenomenon is thought to be related to the gelatinization temperature and dispersion of the amylose chain in starch polymers. Mishra and Rai (2006) also suggested that setbacks may largely be determined by the degree of amylose polymerization. From this study, partially gelatinized affected setback, though this cannot be related to the amylose content since the amylose content of KKN flour was significantly different in setback value. Similarly, the breakdown of the different KKN flour preparation revealed that they were significantly different with the same pattern as viscosity. 2% salt-soaked and 10 min boiled KKN flour had a higher breakdown (92.0 and 85.0 cp) than the 10 min steamed KKN flour (26.30 cp). The degree of gelatinization of KKN flour can be determined using an RVA, based on a calibration curve obtained by proportional mixing of raw and fully gelatinized starch. The best indicator was found to be peak viscosity which decreased with an increase in the degree of gelatinization. A 10 min steamed of raw KKN chips was sufficient to produce completely gelatinized KKN flour. This finding could bring about the application of KKN flour as a ready-to-cook flour and thickening agent in retort foods or foods that require heat-stable viscosity.

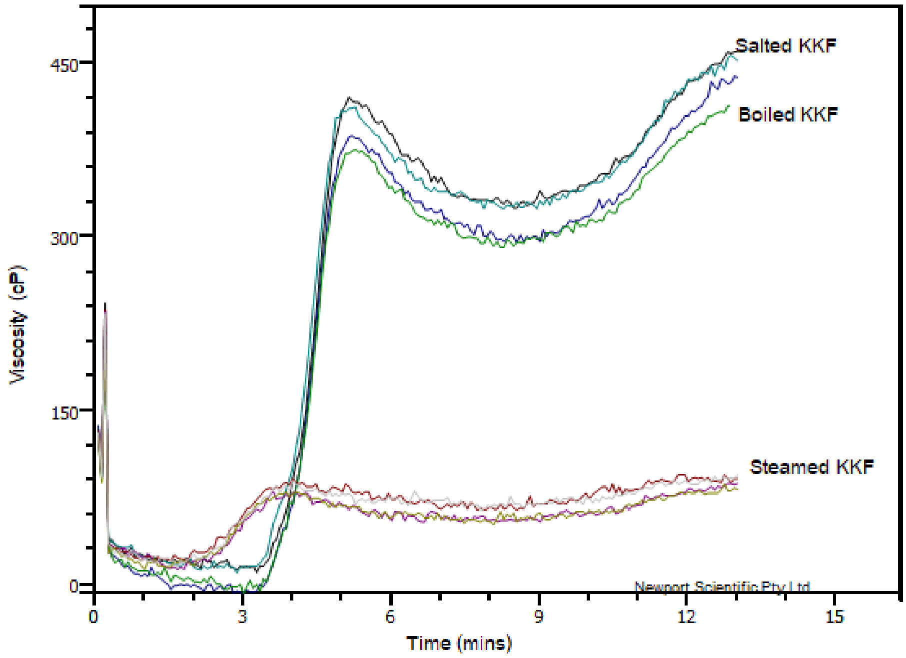

Figure 2. Pasting behaviors of the three treatments of KKN flour production as observed by Rapid Visco Analyzer

CONCLUSIONS

This study showed that the physiochemical of the ready to used KKN flour could be distinguished based on their processing. The quality of the KKN flour of the three treatments even varies the preheated types noticeably. As reported in previous studies by other authors, the shape of starch granules in uncooked KKN flour (*D. hispida*) is dominantly polyhedral and becomes gelatinized with cooking types. The pasting behaviors of the steamed KKN flour could be recommended as a source of ready-to-cooked food industrial raw materials in various products.

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