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Nutritional values and cooking quality of defatted Kenaf seeds yellow (DKSY) noodles

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Abstract

Kenaf (*Hibiscus cannabinus*) seeds have always being wasted as agricultural waste. Recent studies revealed that the seeds contain high fiber. The purpose of this study is to develop defatted kenaf seeds yellow noodles (DKSY) and assess the nutritional and physicohemical properties of the noodles. Defatted kenaf flour at 25% and 75% were used to make DKSY noodles and compared to wheat yellow noodles (Control). Fresh DKSY noodles were analyzed for their nutritional and physiochemical properties. The ash and fiber contents increased in order of Control > 25% DKSY > 75% DKSY noodles. While total phenolic contents (TPC) was found to be higher in 75% DKSY noodles (138.30 ± 1.63 mg GAE/100 g) than Control noodles. Colour (L, b) and hardness decreased in order of Control > 25% DKSY > 75% DKSY indicating that DKSY noodles developed less quality than Control noodles. However, cooking loss values were found to be in the same order while cooking values exist in the opposite order indicating that. DKSY noodles have better noodle cooking quality. In conclusion, nutritional properties and noodle cooking quality of yellow noodles increased with higher concentration of defatted kenaf flour but the physicochemical properties were compromised. More research needs to be done in order to develop a formulation that can increase all of the attributes studied.

Introduction

Kenaf (*Hibiscus cannabinus* L.) is a cordage plant, whose stem and stalk 47 have been widely used for the production of high quality paper, bio composites, fiber boards and bio plastics. In Malaysia, the National Kenaf Research and Development Program has been formed in an effort to develop kenaf as a possible new industrial crop for Malaysia. Residues of kenaf processing mainly comprised of leaves and seeds. Recently, more attention has been focused on the utilization of food processing byproducts and wastes, as well as underutilized agricultural products. Kenaf seed contains 9.6% moisture, 6.4% ash, 20.4% oil, 21.4% nitrogenous matter and 12.9% crude fiber. Palmitic, oleic, and linoleic acids were reported as major fatty acid. Kenaf's relatively high oil content and its similarity to cottonseed oil suggest that the seed oil may be used as a source of edible oil (Mohamed *et al.*, 1995). However, defatted kenaf seeds, the byproduct of oil extraction were underutilized. Previous studies done by Chan and colleagues (2013), had found higher contents of total phenolic, flavonoid contents, protein, carbohydrate and ash than non-defatted kenaf seeds. High antioxidative flours could effectively improve the nutritive values, shelf life and sensory quality of the final food products (Bilek and Turhan, 2009; Ozvural and Vural, 2011).

Noodles in various contents, formulations, and shapes have been the staple foods for many Asian countries since ancient time. Despite their ancient origins, noodles have undergone considerable evolution and migration, as the products become increasingly globalized (Hatcher, 2001; Hou, 2001). The modification of formulation and processing is necessary due to regional eating habits, taste preference, advances in technology and to enhance health benefits. Therefore, there is a need of enhancement of the nutritional quality of the noodle to increase these health benefits to consumers. Traditional noodle is made from simple ingredients (wheat flour, water and salt) and is claimed to lack other essential nutritional components, such as dietary fiber, vitamins and minerals, which are lost during wheat flour refinement (Maberly, 2003).

To date, studies on the nutritional quality evaluation and application of defatted kenaf seeds as functional food ingredient are scarce. This study will investigate the effects of incorporating defatted kenaf seeds flour to the common yellow noodles recipe on nutritional contents, physicochemical and cooking

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properties of the final product.

Materials and Methods

Source of materials

Kenaf seeds were obtained from Institute of Bioscience, University Putra Malaysia Serdang, Selangor. The seeds had undergone milling process first at Food Engineering laboratory, Food 3 Faculty of Food Science and Technology. The other materials of noodle making such as wheat flour (Sauh brand), corn flour, eggs, xanthan gum, salt, and oil were purchased at the mini market of Sri Serdang, Selangor. All chemicals and solvents used were bought from BDH Laboratories (Poole, England) and Merck (Darmstadt, Germany).

Milling process and extraction of oil from kenaf seeds

In order to make the kenaf noodle, kenaf flour was produced. Kenaf seeds were washed under running water to remove all impurities present. Then the kenaf seeds were air dried for 12hours in a smoke dryer at 60˚C until constant weight of seeds were achieved. The seeds were then grinded finely with ultra-centrifugal mill (Retsch, DR100/75) and subsequently sieved to obtain flour particles size of 0.5 mm and under.

Once the flour was ready, defatting process were carried out. The defatting process was done according procedures reported by Chan and Ismail (2009), whom used the sonication method or conventional method assisted with solvent extraction. Following this method, kenaf flour (50 g) was homogenized with 300 ml of iso-hexane at 13500 rpm for 6 minutes. Afterwards, the mixture was sonicated in the sonicator (DELTA, DC150H) for about 10 minutes. Later, the mixture was filtered by using aspirator pump (Eyela, A3S) and filtered through filter paper Whitman No.1. Flour was oven dried at 40˚C for 12 hours before it was packed in an airtight sealed container and stored at 4˚C before use.

Noodle preparation

Yellow noodles were made using commercial noodle recipe with the 50% and 75% defatted kenaf yellow noodles ingredients modified (refer Table 1). All ingredients were measured precisely. Ingredients were weighed accordingly. All the dry ingredients such as kenaf flour, wheat flour, corn flour, xanthan gum and salt were mixed together using a mixer. While still mixing, slightly beaten eggs were added and water and were added gradually. Then, the dough was taken out from the mixing bowl and kneaded slightly before being divided into 6 portions. By using a dough roller, the dough was rolled forming a sheet of dough and then was further sheeted using the noodle maker. Folding and sheeting was repeated for several times. The smooth sheeted dough were then cut into noodle strands by applying the dough sheet to the noodle cutting roll. After that, the noodle strands were boiled in boiling water with ratio 1:8 for 1 minute and cooled down immediately under running water. A sieve was used to remove surplus water. Finally, the noodles were packed in a translucent plastic bag and sealed using the Hand Press Sealer and stored at 4˚C before use for further analysis.

Table 1. Formulation of noodle for each treatment based on 250 g flour

Ingredients	Wheat yellow noodles (Control)	25% defatted kenaf seeds yellow noodles (25% DKSY noodles)	75% defatted kenaf seeds yellow noodles (75% DKSY noodles)
Defatted kenaf flour (g)	-	83.33	166.67
Wheat flour (g)	250	83.33	-
Egg (g)	116	116	116
Corn starch (g)	-	83.33	83.33
Water (ml)	44.67	44.67	44.67
Oil (ml)	15	15	15
Xanthan gum (g)	-	10	10
Salt (g)	2.5	2.5	2.5

Nutritional analysis

Moisture content was measured by using oven drying method (AACC Method 44-15A) at a temperature of 105˚C for 7 hours.

Total ash content was measured by using dry combustion (AACC Method 08-01) temperature of 550˚C for 7-8 hours or until constant rate was reached.

Crude protein was determined by using micro Kjeldahl method (AACC, Method 46-13). The sample was placed in micro Kjeldahl test tube. Distilled water was used as blank.

Crude fat was measured by using petroleum ether extraction, (AACC, Method 30-25) for at least 8 hours. After 8 hours, petroleum ether was evaporated using rotary evaporator and weight of crude fat was calculated.

To determine the Total Phenolic content (TPC), the extraction procedures was done using methanol extraction as described by Chong and Aziz (2010). The extracted concentrated noodles (5 g) were dissolved in 5 ml of dimethyl sulfoxide (DMSO). The resulting solution (0.5 ml) was added to 1 ml of 50% Folin–Ciocalteau reagent and incubated at room temperature. Absorbance was measured at 760 nm, using a spectrophotometer, with DMSO with distilled water as blank. Results were expressed as milligrams of Gallic acid equivalents per 100 g of noodle extract (mg GAE/g extract).

Physicochemical property analysis

For colour analysis, method described by Suwaibah *et al*. (2009) was used. 10 g of noodle were weighed and tightly packed in a sealed translucent plastic bag. Prior to colour analysis, the surface of noodle packaging was wiped to remove any soil. The Hunter Lab (UltraScan PRO D65) was calibrated and set to mode RSIN. The noodle colour was determined by running the Hunter Lab.

The hardness of the noodles was determined by running compression test using a texture analyzer (TA-XT2). The compression test method was modified from the previous published method (Chin *et al*., 2012). The compression test was conducted, and eight measurements for each sample were collected. The load cell consisted of 5 kg, and the P/36R was used as probe. The heavy-duty platform was set up and used. The distance of the probe and the force were calibrated with 2 kg before starting the analysis. The distance the probe was allowed to move was set at 20 mm. The settings were as follows; mode setting was on measure force in compression; pre-test speed, test speed and post-test speed were all set to 2.0 mm/sec; the trigger force was set at 0.1 N; and strain was on 75% deformation. The eight noodle strands (around 4cm long) were rested on the heavy-duty platform one strand at one time in a straight manner. The noodle was pressed by the probe until a deformation of 75% was reached. Upon that, the curve of force/time was obtained. The hardness of the noodles was obtained from the curves.

Cooking properties

Cooking yield was determined using using a previously published method (AACC, 1976; Lim, 2006). A beaker was filled with 150 ml distilled water and heated to boil by using a hotplate. 10 g of noodle was weighed and cooked in the beaker for 10 minutes with stirred continuously. The beaker was covered with aluminium foil during cooking process to prevent evaporation of water. After 10 minute, the cooked noodles were separated from the cooking water and were cooled for 15 minute. Finally the noodle was weighted and the cooking yield was calculated. This experiment was triplicate. The cooking yield was measured by equation below:

$$\text{Cooking yield (\%)} = \frac{\text{Weight of noodles after cooking}}{\text{Weight of noodles before cooking}} \times 100$$

Cooking loss was also determined using the method used previously (AACC, 1976). The cooking water from the cooking yield method was separated from the cooked noodles and poured into 250 ml volumetric flask. Distilled water was poured into the volumetric flask until the mark and shaken to homogenize the cooking water solution. 10 ml of the solution was pipette into a dried crucible and left to dry to constant weight in oven at 105°C. Finally the solid loss during cooking was calculated. The cooking loss was measured by equation below:

$$\text{Cooking loss (\%)} = \frac{A - B}{\text{Noodle sample weight - C}} \times 25$$

where:
A = weight of crucible + dry cooked water sample
B = weight of crucible
C = noodles moisture content

Statistical analysis

For all analysis, measurements were conducted in triplicate, results were averaged and data is reported as mean ± standard deviation. Analysis of variance (ANOVA), accompanied with Tukey test were analyzed using Minitab Statistical Software (MINITAB® Release 14.12, Minitab Inc.). Significant differences among the samples were defined at $p < 0.05$.

Results and Discussions

Defatted kenaf seeds yellow noodles

In this study, we produced two different formulations of noodles (25% and 75% defatted kenaf seeds yellow (DKSY) noodles and used wheat yellow noodles as the control product (Figure 1).

Nutritional composition of defatted kenaf seeds yellow (DKSY) noodles

Table 2 indicates the nutritional composition of 25% and 75% DKSY noodles compared to Control. Significant differences were observed in the moisture content among the noodle samples, where Control noodles exhibited higher moisture content than the 25% DKSY and 75% DKSY noodles. Wheat has higher moisture content because of its hygroscopic nature (Rehman and Shah, 1999) and presence of starch. Higher water holding capacity was observed in wheat flour, therefore increasing the moisture content in the final product. In production of yellow noodles, lower moisture content is more desirable, as the gluten level will be lower and sheeting ability will be improved.

The ash contents in the 25% DKSY and 75% DKSY noodles were significantly ($p < 0.05$) higher than Control noodles. These values corresponded to higher mineral content in the noodles. According to Chan KW (2013), phosphorus (3.28%), potassium

Table 2. Nutritional composition of noodle samples

Noodles	Moisture (%)	Ash (%)	Crude fiber (%)	Protein (%)	Fat (%)	TPC (mg GAE/100 g extract)
Control	40.073 ± 0.64b	0.7767 ± 0.075b	0.087 ± 0.021b	6.665± 0.290c	0.611 ± 0.058a	107.84c ± 2.30
25% DKSY	33.692 ± 0.321a	1.8407 ± 0.067a	1.434 ± 0.614b	5.719 ± 0.168b	0.698 ± 0.244a	47.97b ± 1.01
75% DKSY	33.089 ± 0.526a	2.5190 ± 0.506a	4.805 ± 0.921a	3.396 ± 0.170a	0.969 ± 0.223a	138.30a ± 1.63

a-c: Results are obtained from means of three determinations ±standard deviation. Different alphabets within the same row indicate significant difference ($p < 0.05$)
b Crude protein = N(%) x 6.25.

Figure 1. From left, Control noodles, 25% DKSY noodles and 75% DKSY noodles

(3.21%) and magnesium (1.54%) are the major minerals present in defatted kenaf seed meal (DKSM). However, it is an advantage for the wheat flour to have lower amounts of ash, as the whitish color of flour is highly desirable and flour ash is traditionally viewed as causing noodle discoloration.

Crude fiber was also found to be significantly ($p < 0.05$) higher in the 75% DKSY and 25% DKSY noodles compared to Control noodles. This result was expected because the kenaf plant is a great source of fiber (Mariod *et al.*, 2010). Fiber content of 25% DKSY noodles is still higher when compared to 30% buckwheat noodles (Bilgiçli, 2008). Dietary fiber plays a very important role in the human diet. Dietary fiber in kenaf, consists of indigestible hemicellulose and lignin which provide a variety of health benefits.

Crude protein was significantly ($p < 0.05$) higher in the Control noodles than DKSY noodles with 75% DKSY noodles showing the least amount of protein. Higher amount of protein is related to higher moisture content in the Control flour compared to the defatted kenaf seed flour. Protein content is a key specification for wheat and flour purchasers since it is related to many processing properties, such as water absorption and gluten strength. The harder the wheat is, the higher the protein content. With high water absorption, the gluten content becomes higher contributing to high protein content in the wheat flour (Yaday *et al.*, 2006). However, according to Chan KW *et al.* (2013), defatted kenaf seed meal (DKSM) was found to contain high content of proteins (26.19%). Thus, the results about obtained might suggest that during noodle processing, the crude protein has been denatured.

No significance differences ($p < 0.05$) were observed among the fat content of the samples. Wheat flour has been known to have approximately about 2 to 3% of fat content (Niihara *et al.*, 1996). Moreover, fat content was decreased with formation of an amylose-lipid complex resulting from heat treatment in noodle production. Furthermore, according to the method by Chan *et al.* (2013), the resulting residue after filtration using Whitman 1 was re-extracted twice using the same procedure. The defatting process with massive extraction effectively removes most of the oil from kenaf seeds and thus, residual fat content in the DKSM was found to be less than 1% (Chan and Ismail, 2009).

Total phenolic content (TPC) was highest in the 75% DKSY noodles and lowest in the 25% DKSY noodles. Kenaf seeds were reported by Yazan *et al.* (2011) to have higher phenolic content than wheat. The higher phenolic content might be due to various active components such as tannins, saponins, and polyphenolics (Agbor *et al.*, 2005). Thus, this indicates that 75% DKSY noodles have good antioxidative value compared to Control noodles.

Physicochemical properties of defatted kenaf seeds yellow (DKSY) noodles

Table 3 indicates the colour and hardness of all of the noodles samples. There were significant differences ($p < 0.05$) in the colour of all the noodle samples. The colour of noodle sample were measured based on value of L, a and b which each representing the brightness, redness and yellowness, respectively. Asian customers prefer bright yellow, and red or dull grey noodles are considered as undesirable (Pitiporn *et al.*, 2011). Control noodles showed the highest L value and 75% DKSY noodles showed the lowest value. The brightness of the noodles decreased as the percentage of defatted kenaf seeds flour was increased. The a value which represents the redness of noodles also increased with increasing percentage of defatted kenaf seeds flour for the same reason the L value increased. The b value which represents the yellowness of the noodles decreased as the percentage of defatted kenaf seeds flour increased in the noodles.

Table 3. Colour, and texture analysis (compression) of noodle samples

Noodles	Colour			Hardness (g)
	L	a	b	
Control	67.81 ±1.23a	-1.72 ±0.03a	20.71 ± 0.13a	1492.8 ± 185.5a
25% DKSY	61.95 ± 0.52b	1.34 ± 0.03b	17.94 ± 0.23b	922.3 ± 119.5b
75% DKSY	55.76 ± 0.10 c	3.56 ± 0.13c	13.97 ± 0.03c	898.9 ± 229.6b

Mean ± standard deviation of three determinations.
Means within the columns with three different letters are significantly different at p<0.05

Table 4. Cooking yield and cooking loss of noodle samples

Noodles	Cooking Yield (%)	Cooking Loss (%)
Control	186.02 ± 0.55c	8.983 ± 0.84a
25% DKSY	191.2 ± 0.45b	3.869 ± 1.18b
75% DKSY	240.12 ± 0.17a	2.227 ± 0.14b

Mean ± standard deviation of three determinations.
Means within the columns with three different letters are significantly different at p < 0.05

In other studies, Bin and colleagues (2007) found that there is a relation between the noodles colour with the fiber content in the flour used to prepare the noodles. The fiber which can be found in the bran layer together with the action of polyphenol oxidase (ppo) enzyme in the bran resulted in the dark colour for the flour. Reungmaneepaitoon *et al.* (2006) had proved that the high fiber found in oat bran affect the colour of noodles where the L value (brightness) of the noodles with addition of oat bran decreased as the quantity of the oat bran flour incorporated into noodles increased while Hatcher *et al.* (2005) had proved that incorporating the fiber rich hull-less barley flour into noodle have decreased value of L^* (brightness) and b^* (yellowness), and increased a^* value (redness). Thus, the high fiber content in defatted kenaf seeds flour decreased the brightness and yellowness, and increased the redness of noodles with increasing percentage of defatted kenaf seed flour.

The hardness of the noodles was measured based on the peak of the compression curve. As shown in Table 3, incorporation of defatted kenaf seeds flour significantly reduced ($p < 0.05$) the hardness of the noodles compared to Control noodles with no significant difference between 25% and 75% DKSY noodles. Hardness of noodles is associated with the protein content in the noodle. High protein flour used to make noodles gave firmer and springier texture to the noodle (Hou and Kruk, 1998). It had been reported that about 80% of the total protein of wheat flour is gluten (Kovacs *et al*., 2004). Gluten proteins are composed of gliadins and glutenins, which are responsible for dough extensibility and strength. From the results obtained, 25% and 75% DKSY noodles may not possess sufficient binder ingredients thus resulted to fragility of the noodles.

Cooking properties of defatted kenaf seeds yellow (DKSY) noodles

The cooking yield of noodle was defined as the percentage of noodles weight after cooking compared to the weight of the raw noodles. The cooking yield of the three types of noodles was showed in Table 7. All three type noodles were determined to be different significantly ($p < 0.05$) in terms of the cooking yield. 75% DKSY noodles have the highest cooking yield, followed 25% DKSY and Control noodles. High cooking yield of represents the ability of the noodles to absorb water and this value should be negatively proportional to the flour protein content (Chin *et al.*, 2012). Thus, the lower protein content of defatted kenaf seeds flour has resulted in the higher cooking yield in DKSY noodles.

The cooking loss was determined by measuring the amount of solid substance lost compared to the amount of cooking water (Pitiporn *et al.*, 2011). The cooking loss represented the particles that diffused out from the noodles into the cooking water (Chin *et al*., 2012). Table 4 above shows that there was significantly ($p < 0.05$) higher cooking loss in Control noodles compared to DKSY noodles. Incorporation of defatted kenaf flour into noodle gave small value of cooking loss at which this described the quality of noodles. High cooking loss resulted in high starch content in the cooking water and confirms that the noodles had low cooking tolerance (Chin *et al*., 2012). In addition, high cooking loss is undesirable as it indicates high solubility of starch, resulting in turbid cooking water, low cooking and sticky mouth feel (Bhattacharya *et al*., 1999). Thus, the cooking properties of DKSY noodles were found to be better when compared to Control noodles.

Conclusions

The incorporation of defatted kenaf seeds flour had significantly change the nutritional and physicochemical properties of normal yellow noodles. Nutritional values were generally increased as 25% and 75% DKSY noodles were found to have higher mineral, fiber and total phenolic content. These nutrients are essential and are sometimes missing from the total daily food intake of normal people. Although it has been observed that DKSY noodles contain lower amount of protein which can contribute to different quality of yellow noodles, the health benefits of the DKSY noodles should be highlighted to consumers in order for this product to be accepted. Moreover, the different colour and hardness quality of DKSY noodles compared to normal yellow noodles might also be a challenge in introducing this product to the market. In terms of cooking properties, DKSY noodles were found perform better than the normal yellow noodles. This will give better taste to the cooking where the noodles will be used.

Throughout the experiment, 75% DKSY has been found to have the higher nutritional properties but lower physicochemical and cooking properties than 25% DKSY noodles. Thus, more experiments need to be done using a wide percentage of defatted kenaf seeds flour in order to find the best composition that can increase the nutritional, physicochemical and cooking properties of the DKSY noodles that will be accepted by the consumers.

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