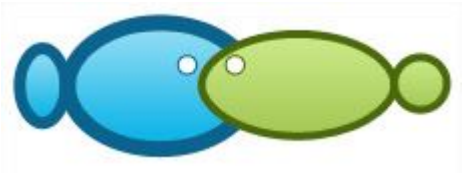

Effects of dietary supplemented with flesh ripe fruit of local cultivated banana CV. Kluai Namwa on growth performance and meat quality of Nile tilapia

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Abstract. The effects of dietary supplementation with flesh ripe fruit of Thai local cultivated banana CV. Kluai Namwa (ripe fruit of banana, RFB) on Nile tilapia growth performance and meat quality were focused in this study. Fishes with average initial weight 58.75±2.08 g were divided into 4 groups and fed for 15 weeks with feeding diet containing the RFB at 0% (control), 1%, 5%, and 10% kg^{-1} diet. Significant increases in growth parameters such as average weight, weight gain, average daily growth and specific growth rate were apparently gained up to 13.33-16.28%, 16.09-19.65%, 15.93-19.63% and 7.14-8.33%, respectively, by these RFB supplementary. Moreover, better feed conversion rate could be obtained with the ratio 1.54-1.57 when compared to the ratio 1.68 of unsupplemented control. Meanwhile, there was no difference in yield percentage and survival rate of the fish in all experiments. Although the meat quality measured by fillet hardness value in raw fish showed non significantly difference, but an improving of its texture was found in steamed fillets of RFB-supplement fed fishes with the value of 1.06-1.10 in comparison to the value 1.57 of the control one. Sensory preference by consumer was also evaluated by the meat appearance, color, odor, taste, texture and overall preferences of steamed fillets. The best values at 7, 6.9, 6.94, 7.18, 7.14, and 7.22, respectively, were revealed from those of the 10% RFB supplemented trial. In addition, neither variegated effect nor mortality caused by RFB supplementation to liver and intestine of experimental fishes was signified by a thorough histological investigation.

Key Words: cultivated banana CV. Kluai Namwa, flesh ripe fruit, Nile tilapia, growth, meat quality.

Introduction. Nile tilapia (*Oreochromis niloticus*) is one the main cultured freshwater fish species worldwide including Thailand, accounting to its valuable source of protein and essential nutrients. Extensive culture has grown rapidly since the last decade to meet a continuous increasing of customer's demand. Currently, the Nile tilapia has been cultured under intensive system as mass production with a crowded density and surplus expensive diet feed. This closed system has threatened the fish's health which concomitantly leads to undesirable outcomes such as physiological stresses, immunosuppression, disease outbreak, and finally loss of production (Diegane et al 2007). Accumulation of spoilage residues and fish belonging waste also causes environmental pollution. Recently, the utilization of plant originated natural product has gained superlative attention as an attractive choice to recover a virtue culturing condition. Several studies attesting the impact of plant products on fish culture have been reviewed concerning to their naturally antioxidants as well as growth and immune stimulants (Harikrishnan et al 2011; 2018).

Successful improvement in both fish growth and health after nourishing with plant product supplementing diets has been illustrated, for example, the use of lupin (*Lupinus perennis*), mango (*Mangifera indica*) and stinging nettle (*Urtica dioica*) in rainbow trout (*Oncorhynchus mykiss*) (Awad & Austin 2010; Amar et al 2012) and the use of fenugreek (*Trigonella foenum graecum*) in gilthead sea bream (*Sparus aurata*) (Awad et al 2015).

Banana is an eminent fruit in the world consumptive market owning to its distinctive flavorsome and health benefits that can serve as both refreshment and staple food. It is considered the world's fifth feed trade after coffee, cereals, sugarcane and cacao (Aurore et al 2009). Various banana fruit varieties are derived from the plant genus *Musa* of Musaceae family which mostly grown in the tropical and subtropical areas especially Southeast Asia (Nakasone & Paull 1999). In this present work, the ripe fruit of local cultivated banana CV. Kluai Namwa is our first choice for its feasible utilization in Nile tilapia culture. This type of banana, formerly named as *M. sapientum* Linn., but recently, is classified a hybrid one among cultivars evolved from *M. acuminata* and *M. balbisiana* as a result of human intervention (Lebot et al 1993). The Kluai Namwa banana has been domestically planted throughout Thailand all seasons and can be eaten favorably both raw and cooked or processed aliments. Its ripe fruits display pleasant taste enriching precious nutritional value. It has been reported on a superiority in nutrition facts of the ripe fruits from Kluai Namwa banana in comparison to that from another two important popular dessert cultivars such as the Lady Finger of *M. acuminata* type and the Kluai Hom of Cavendish hybrid cultivars group in most aspects including carbohydrate, protein, amino acid, vitamin and fiber (Suthanukool et al 2015).

Several beneficial bioactive compounds such as phenolic, flavonoids especially rutin, carotene and other antioxidants have also been declared higher in the ripe Kluai Namwa than in those other two varieties (Siriamornpun & Nares 2009). Moreover, the important tryptophan amino acid and its consequent neurotransmitter hormones, serotonin and melatonin are also found dominantly in this variety's ripe fruit (Sae-Teaw et al 2013). Prior to our study, the nutritional components within the flesh of this ripe fruits were roughly determined as shown in Table 1.

Table 1

Nutritional components of ripe Kluai Namwa banana's flesh in 100 g dry weight analysis

Nutrient - proximate composition	*Amount*
Protein	1.07 g
Fat	0.1 g
Carbohydrate	30.71 g
Ash	0.78 g
Moisture	67.34 g
Fibre	0.64 g
Energy	128.02 kcal
Calcium	9.55 mg
Iron	0.47 mg
Magnesium	30.54 mg
Phosphorus	32.39 mg
Potassium	349.2 mg
Vitamin A (β-Carotene)	0 mg
Vitamin B6 (Pyridoxine)	0.11 mg
Vitamin C	0.11 mg
Vitamin E (α-Tocopherol)	Not detected

Despite the recognized virtue of this Kluai Namwa banana to our knowledge, none the less regarding its application in aquaculture has been reported. The most relative study is the case using hot water extract of *M. acuminata* banana fruit's peel in a consecutive investigation of critical effects such as antibacterial activity, anti-hypothermal stress, immunity, disease resistance and growth enhancing performance on the giant freshwater prawn (*Macrobrachium resenbergii*) (Rattanavichai & Cheng 2014; 2015), however, it might not the case taken into account. Thus, this current study aims to examine the fundamental effects of the ripe Kluai Namwa banana fruit as a feed supplementary on growth performance and meat quality of Nile tilapia in the traditional intensive culture system. Histology of the Nile tilapia liver and intestine after cultured was also inspected to ensure a reliable utilization.

Material and Method

Experimental fish. Sex reversed Nile tilapia (*O. niloticus*) with an average initial weight of 58.75±2.08 g body weight, were provided by commercially available Tula Farm, Khon Kaen Province. Three hundred sixty fishes were randomly distributed into twelve experimental 0.8 × 1.2 × 1.2 meter cement ponds (30 fishes per pond), with three replicates for each treatment group. The fishes were acclimatized for 2 weeks and fed with commercial pellet diet at 3% of body weight before being used for experimentation. Fifty percent exchange of fresh water was done weekly throughout the experiment that was operated during May to August 2018.

Preparation of experimental diets. The banana fruits were proceeded to ripen naturally at room temperature for 5 days. These ripe fruits were then peeled off, brought only the part of ripe banana flesh to dice into small pieces and grinded thoroughly with a blender at a speed of 12,000 rpm for 1 minute, until the banana's flesh was homogeneously and sticky. The commercial pellet diet CP 9910 containing 30% crude protein was purchased from Charoen Pokphand Food PCL. CPF, Thailand. The ready homogenate banana's flesh was subsequently mixed with this basal pellet diets at the level of 0% (control), 1%, 5%, and 10% kg^{-1} diet. All the prepared diets were dried at room temperature for 2 h, and then stored in plastic bage at 4°C until use. Proximate composition of experimental diet was determined by standard procedures according to A.O.A.C (2000) method. Experimental diets contained the proximate analysis composition as shown in Table 2. These experimental diets were freshly prepared every 2 days. Experimental fishes were fed twice daily at 8.00 h and 16.00 h for 15 weeks.

Table 2

Proximate analysis composition of the experimental diets supplemented with specified percentage of ripe Kluai Namwa banana's flesh

Proximate composition	*Ripe Kluai Namwa banana levels (%)(WW^{-1})*			
	0	*1*	*5*	*10*
Protein (%)	30.42	30.16	28.89	27.92
Fat (%)	8.21	8.11	7.94	7.45
Nitrogen free extract (%)	40.28	40.20	39.48	38.68
Ash (%)	9.02	8.96	8.75	8.27
Moisture (%)	8.61	9.13	11.56	14.48
Fibre (%)	3.46	3.44	3.38	3.20
Digestible energy, DE (kcal/100g)	273.71	271.72	264.17	254.72
Gross energy, GE (kcal/100g)	414.67	411.85	400.20	386.72

Growth performance and feed conversion ratio. All fishes were weighted every week to calculate growth performance throughout the experiment of 15 weeks. Growth performance and feed utilization were assessed in terms of average weight, weight gain (Iwama & Taut 1981), average daily growth (Jantrarotai et al 1994), specific growth rate (Iwama & Taut 1981) and feed conversion ratio (Dupree & Sneed 1966). Calculation was conducted using the following formulae:

Average weight (AW) (g) = total final body weight/number of fish;
Weight gain (WG) (g) = FW – IW;
Average daily growth (ADG) (g day^{-1}) = (FW – IW)/t;
Specific growth rate (SGR) (% day^{-1}) = 100[(lnFW – lnIW)/t];
Feed conversion ratio (FCR) (g) = total feed supplied (g)/WG

Where FW is final weight (g), IW is initial weight (g), t is the feeding trial period (days).

Percent (%) yield evaluation. After 15 weeks, 10 fishes per pond (30 fish per experiment group) were randomly collected for % yield examined. The fishes were euthanized using cool water and slaughtered with ice. Each whole body was weighted and recorded separately. The fish fillets were done by a thorough skin removal. Both the whole fish and its fillet were analysed for % yield following the method modified from Iaconisi et al (2017):

$$\% \text{ Yield} = 100[\text{total fillet weight/total body weight fish}] \text{ (g)}$$

Survival rate. The fish's survival was expressed in percentage. The amount of mortality in each experimental group was noted daily throughout the 15 weeks experimental period according to the Nankervis et al (2000) method.

$$\text{Survival rate (\%)} = 100[\text{Number of survived fish/Initial number of fish}]$$

Flesh texture evaluation. After 15 weeks, 30 fishes per experiment group were randomly collected for the evaluation of their texture profile and meat quality. For fillet texture studies, both raw and steam fillet textures were determined. The skin was removed and assayed immediately after collection. The fillets were cut into pieces of approximate 10 mm thickness. Its texture was analyzed with TA. XT. plus Texture Analyser (Stable Micro System Ltd, UK) equipped with a 1 Kg load cell and the texture data analysis software Texture Exponent (Stable Micro Systems). A texture profile analysis was made using a flat-ended cylindrical compression detector probe with a 35 mm diameter. Samples were single compressed at constant speed with penetration depth of 3.0 mms^{-1} and 10.0 mm and the initial force at 0.1 Newton hardness was selected for the determination. Steamed fillets samples were prepared and cooked in steam oven for 15 min at 115°C, packed in lidded aluminum boxes, then the texture variables hardness was calculated as described by Bourne (1978).

Sensory preference. After the feeding period of 15 weeks, 30 fishes per experimental group were collected. Fillets used for sensory evaluation were skinned, and fillets kept at 4°C for 6 h until sensory test were carried out. These fillets were cooked by steam oven at 115°C for 15 min prior to sensory preference evaluation. A descriptive profile test was performed following six main characteristics such as appearance, color, odor, taste, texture and overall preference, using the hedonic 1-9 point scale for acceptance test by at least 50 investigating testers (Meilgaard et al 1999). The resultant scores were averaged and subsequently used for statistical analyses.

Histopathology. Liver and intestinal samples were collected from 10 fishes per pond (30 fishes per experimental group) at the end of the experimental trial for 15 weeks, preserved in 10% phosphate buffer formalin (PBF) at room temperature. The sample tissues were cut into 2 cm pieces. After serial dehydration steps in ethanol and embedded in paraffin, the transversal sections of 5 µm thickness were prepared from these embedded blocks and subsequently stained with haematoxylin and eosin (HE) for histological analysis (Humason 1976). Slides were analysed by a light microscope (Leica 6000B), and images were acquired with a Leica DFC280 digital camera.

Statistical analysis. Values were expressed as mean±standard error (SE). Growth performance, survival rate, percentage of yield, hardness and sensory preference parameters were statistically evaluated for their comparative mean values at 5% level of significance concerning the one way Anova and Duncan's multiple rang test by an aid of IBM SPSS Statistics (version 23, 2015, SPSS Inc.) software program. A relative increasing performance in percentage of each parameter was also calculated via the equation % increasing = 100 [(Value gained from supplemented trial – Value gained from control)/Value gained from control].

Results

Growth performance and fish survival. The effects of ripe fruit of the banana CV. Kluai Namwa supplementing diet on growth performance including the fish's yield and survival rate are as shown in Table 3. A clear cut difference values ($p < 0.05$) between the banana supplementary group and the control could be seen in growth parameters. Measurements on average weight, weight gain, average daily growth and specific growth rate has placed the control's performance to the least while the highest values of 397.78, 339.03, 3.23 and 1.82 with the relative increasing of 16.28, 19.65, 19.63 and 8.33%, respectively, are from Nile tilapia fed with 5% Kluai Namwa supplementing diet. However, differences among the supplementary level (1, 5, and 10%) are not statistically significant. Better value on feed conversion ratio is shown up following the supplemented diet feeding as well. Although the best value at 1.54 from 5% supplementation has apparently gained, but the values is not significantly different from another levels. Yield percentage of every trial was obtained in a not significant range around 30.94 to 31.15, and simultaneously, the survival rate of all was 100%.

Flesh texture. Assessment of fish's flesh texture based on hardness parameter provided the values illustrated in Table 4. No significant difference in hardness values among raw flesh fillets from the control and fishes fed with ripe Kluai Namwa supplemented diet, although the values 17.16±1.71 of the raw control was apparently highest. Nevertheless, significant reduction in the flesh's hardness was attained in steamed fillets of the supplementary diets feeding fishes. Their lower hardness values at 1.10±0.19, 1.08±0.12 and 1.06±0.11 could be considered not significant ($p < 0.05$).

Table 4

Hardness value of raw and steamed fillets of the Nile tilapia fed with diets supplemented at 3 levels of ripe Kluai Namwa banana compared with control after 15 weeks cultured

Hardness parameter	*Ripe Kluai Namwa banana Levels (%)(WW^{-1})*			
	0	*1*	*5*	*10*
Raw fish (N)	$17.16±1.71^{A}$	$15.87±1.87^{A}$	$15.02±1.57^{A}$	$14.80±0.10^{A}$
Steamed fish (N)	$1.57±0.08^{A}$	$1.10±0.19^{B}$	$1.08±0.12^{B}$	$1.06±0.11^{B}$

Values representing means±SD in the same row with different subscripts are significantly different ($p < 0.05$).

Sensory preference. Table 5 presents the results of sensory preference evaluation which the best values in all parameters measured are arisen from steamed fillets the fishes fed with ripe Kluai Namwa supplementary at 10% level. Their values of 7.00±1.37, 6.90±1.46, 6.94±1.33, 7.18±1.29, 7.14±1.51, and 7.22±1.40, represent the preference degree of appearance, color, odor, taste, texture and overall preferences, respectively. However, statistically, notable insignificant difference in some parameters as appearance, odor, and taste of the steamed fillets were indicated between the banana supplementary at 5% and those at 10% trial.

Table 3

Growth parameters of Nile tilapia fed with diets supplemented at 3 levels of ripe Kluai Namwa banana compared with control after 15 weeks cultured

Growth parameters	*Ripe Kluai Namwa banana level (%)(WW^{-1})*			
	0	*1.0*	*5.0*	*10.0*
Average weight (g)	342.09±14.72^{B}	392.54±9.45^{A} (14.75%)	397.78±10.72^{A} (16.28%)	387.69±13.64^{A} (13.33%)
Weight gain (g)	283.34±14.72^{B}	333.79±9.45^{A} (17.81%)	339.03±10.72^{A} (19.65%)	328.94±13.64^{A} (16.09%)
Average daily growth (g day^{-1})	2.70±0.14^{B}	3.18±0.09^{A} (17.78%)	3.23±0.10^{A} (19.63%)	3.13±0.13^{A} (15.93%)
Specific growth rate (% day^{-1})	1.68±0.04^{B}	1.81±0.02^{A} (7.74%)	1.82±0.03^{A} (8.33%)	1.80±0.03^{A} (7.14%)
Feed conversion ratio (FCR)	1.68±0.10^{A}	1.56±0.02^{B}	1.54±0.03^{B}	1.57±0.03^{B}
Yield (%)	30.94±0.15^{A}	31.04±0.83^{A}	31.15±0.30^{A}	30.97±0.18^{A}
Survival rate (%)	100.00±0.00^{A}	100.00±0.00^{A}	100.00±0.00^{A}	100.00±0.00^{A}

Values representing means±SD in the same row with different subscripts are significantly different ($p < 0.05$). Data in bracket are the corresponding relative increasing performance in percentage.

Table 5

Sensory preference test parameters evaluation on steamed fillets of the Nile tilapia fed with diets supplemented at 3 levels of ripe Kluai Namwa banana compared with control after 15 weeks cultured

Parameters	*Ripe Kluai Namwa banana levels (%)(WW^{-1})*			
	0	*1.0*	*5.0*	*10.0*
Appearance	6.02±1.39^{B}	6.52±1.33^{AB} (8.31%)	6.68±1.38^{A} (10.96%)	7.00±1.37^{A} (16.28%)
Color	6.00±1.34^{C}	6.26±1.31^{BC} (4.33%)	6.66±1.42^{AB} (11.0%)	6.90±1.46^{A} (15.0%)
Odor	5.90±1.57^{B}	6.26±1.41^{B} (6.10%)	6.86±1.37^{A} (16.27%)	6.94±1.33^{A} (17.63%)
Taste	6.06±1.57^{B}	6.22±1.27^{B} (2.64%)	7.04±1.25^{A} (16.17%)	7.18±1.29^{A} (18.48%)
Texture	6.04±1.48^{C}	6.46±1.27^{BC} (6.95%)	6.90±1.25^{AB} (14.24%)	7.14±1.51^{A} (18.21%)
Overall preferences	6.54±1.23^{B}	6.68±1.13^{B} (2.14%)	7.06±1.28^{AB} (7.95%)	7.22±1.40^{A} (10.40%)

Values representing means±SD in the same row with different subscripts are significantly different ($p < 0.05$). Data in bracket are the corresponding relative increasing performance in percentage.

Histological structure

Histological structure of liver. Normal characteristics of structural hepatocytes were similarly revealed following observation of Nile tilapia liver tissue in both the banana supplementary diet trials and the control after 15 weeks cultured as display in Figure 1. The figure demonstrated a round purple hematoxylin staining nucleus embedded with pink eosin staining cytoplasm of this hepatic cell altogether with surrounding sinusoids and exocrine pancreas (Figure 1A-E, G-H) Existence of central vein along with its leukocyte could also be seen obviously (Figure 1F).

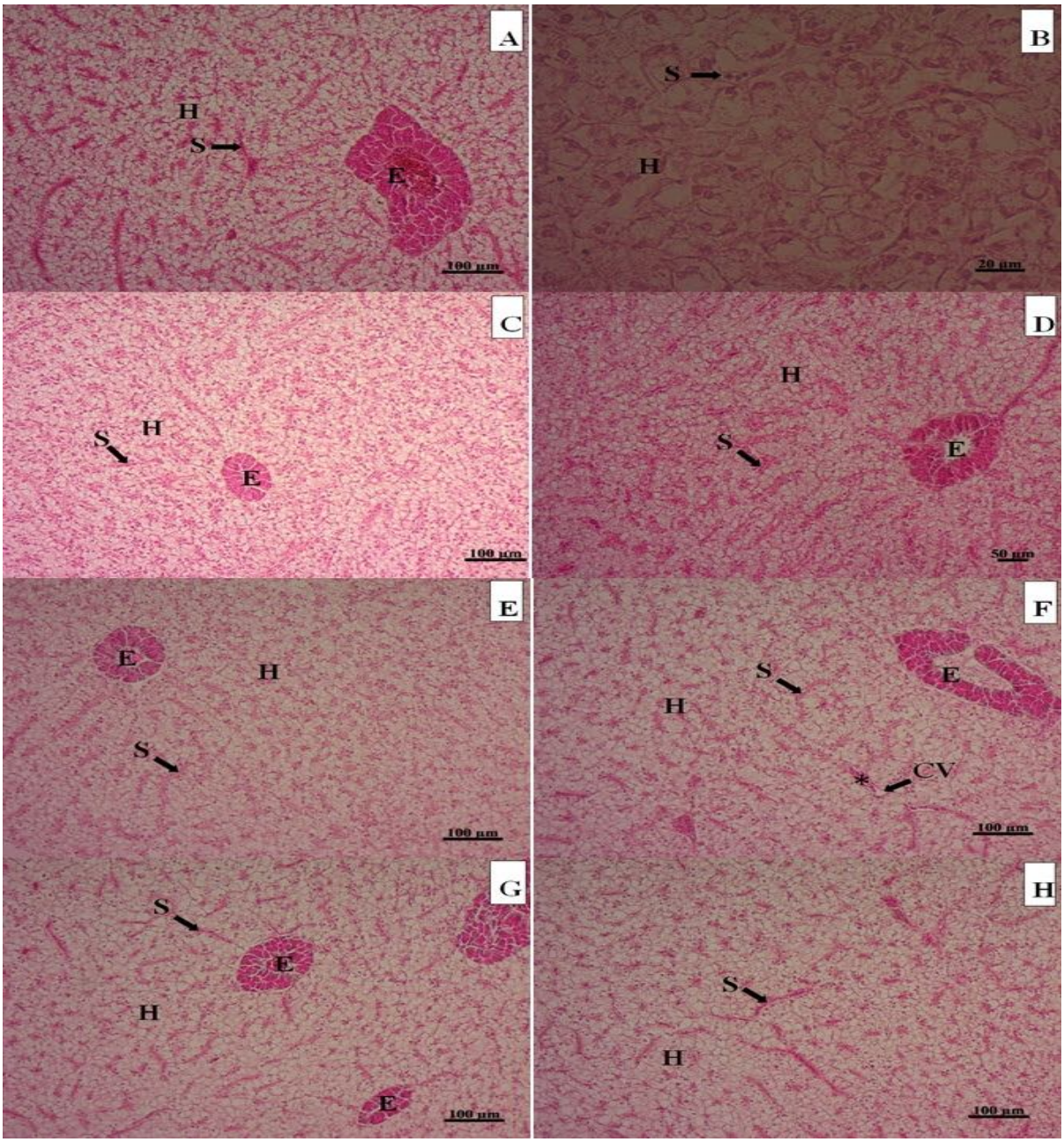

Figure 1. Histological micrographs of Nile tilapia liver cross sections stained with eosin and hematoxylin. (A) after 15 weeks feeding with unsupplementary diet control (x40), (B) magnified micrographs following the (A) observation (x400), (C) after 15 weeks feeding the diet supplemented with ripe Kluai Namwa at 1% level (x40), (D) magnified micrographs following the (C) observation (x100), (E) after 15 weeks feeding the diet supplemented with ripe Kluai Namwa at 5% level, (F) higher magnification of (E) showing central vein and its leukocyte*, (G) and (H) after 15 weeks feeding the diet supplemented with ripe Kluai Namwa at 10% level. H: hepatocyte; S: sinusoid; E: exocrine pancreas; CV: central vein.

Histological structure of intestine. Microscopic inspection of Nile tilapia intestine tissue section illustrated a regular feature in both from those fed with control diet (Figure 2A) and with ripe Kluai Namwa supplementary diets for 15 weeks (Figure 2B-D). Their structural morphology included four layers from the lumen consisting of the mucosa which is a simple columnar epithelium in combination with a burial goblet cells, the submucosa with embedding leukocytes, the muscularis composing dense lateral alignment inner smooth muscle and longitudinal aligned outer smooth muscle, and the exterior serosa comprising a single thin row epithelium.

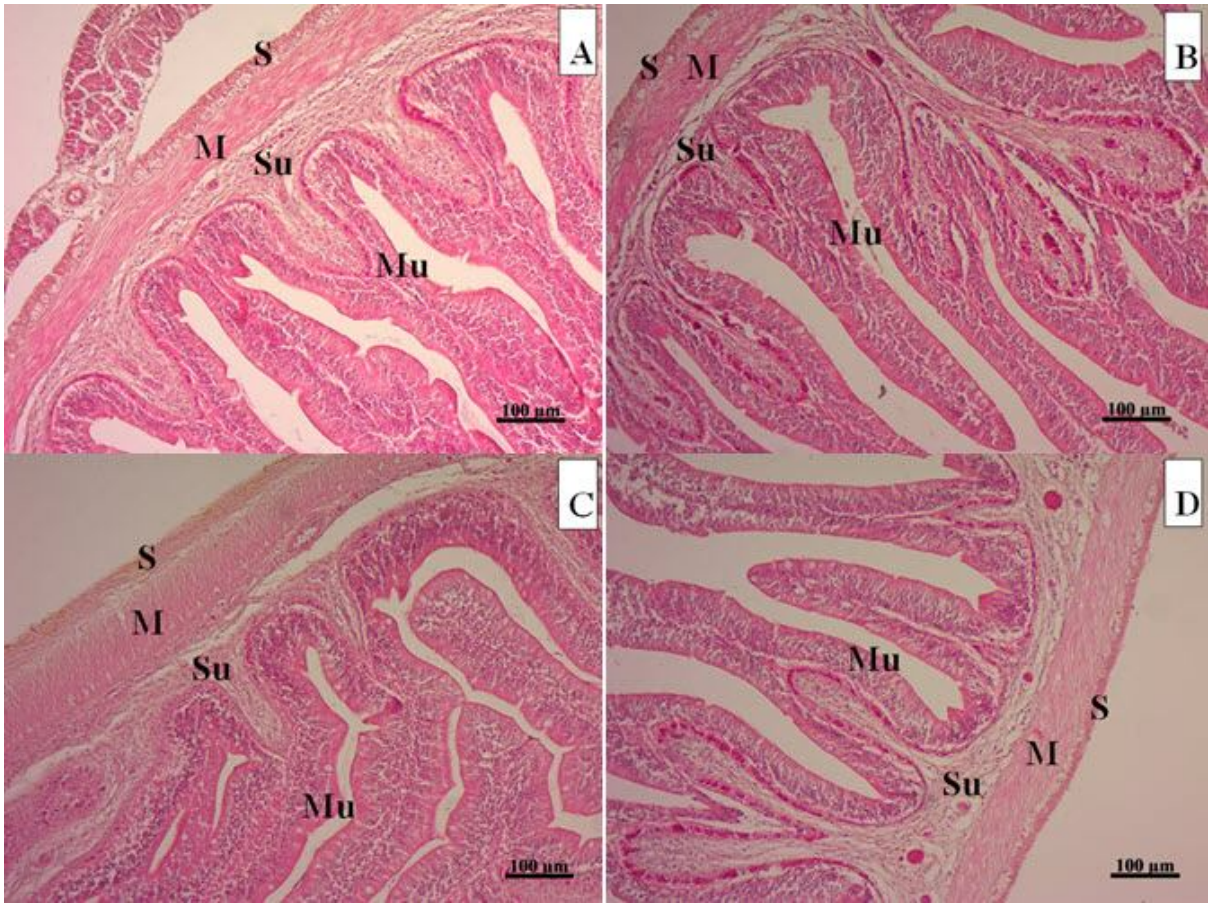

Figure 2. Histological micrographs (x40) of Nile tilapia intestine cross section stained with eosin and hematoxylin show in structurally normal (A) after 15 weeks feeding with unsupplementary diet control, (B) after 15 weeks feeding with the diet supplemented with ripe Kluai Namwa at 1%, (C) after 15 weeks feeding with the diet supplemented with ripe Kluai Namwa at 5%, (D) after 15 weeks feeding with the diet supplemented with ripe Kluai Namwa at 10%. Mu: mucosa; Su: submucosa; M: muscularis; S: serosa. Bars: 100 µm.

Discussion. Banana is well-known as a most affordable fruit in the world consumption and a good source of precious nutrients including bioactive compounds essential for good health. It is considered as super food due to its supreme combination of energy value, tissue-building elements, protein, vitamins, minerals, and numerous antioxidants. Especially in the case of ripe fruit from Thai local cultivated “Kluai Namwa” that possesses a superb quality on its higher iron, calcium, potassium, vitamins and important delightful neurotransmitters such as serotonin and melanin than fruits from other cultivars (Sae-Teaw et al 2013). The main sugar containing in this type of banana fruit is a ready energy converting monosaccharide such as glucose and fructose which makes it different from the other (Jongjaitesh 2014). Regarding to the banana’s excellent attributes, not only for human serving, but it has also been extensively applied as livestock feeds for long (Babatunde 1992; Singh et al 2018). Therefore, an effective utilization of the banana should be enabled in aquaculture industry as well. Considerably attention on the ripe choice has paid due to the facts involving a higher increasing in most of the banana’s

capacities such as soluble sugar, protein, lipid and antioxidants following the fruit maturation (Emaga et al 2008). Our study was encouraged to examine the efficacy of experimental diet supplementing with the ripe Kluai Namwa banana on growth performance and meat quality of Nile tilapia, an important economical Thai fishery.

The results gained in this current study obviously confirm a positive impact of our postulation in almost of the indicative parameters. Enhancement in Nile tilapia average weight, weight gain, average daily growth and specific growth rate was significantly appeared after feeding with the ripe Kluai Namwa banana supplementing diet at all the levels testing as 1, 5, and 10%. Their feed conversion rate records have also informed better feeding efficiency than that from the control trials without any disturbance in their yield and survival after 15 weeks of culture. These pleasing performances could be ascribed by various valuable components integration in the banana's flesh such as a high digestibility, appetite and pleasure stimulant including nutritional balance. Up to the present searching, there is scarcely available earlier report concerning the diet supplementation of crude ripe banana in fish culture. However, extensive studies on the ripe banana feeding have been successfully carried out for livestock in Latin American countries and some Asian countries that produce bananas in very large quantities (Babatunde 1992). Among the species investigated, the most ensuring case is the pig that preferably consumes banana as energy source and grow well if those banana are sufficiently ripe (Calles et al 1970; Clavijo & Maner 1975). Moreover, the study on gestation sow using the banana plus protein supplement diet showed better growth performance than those of the control with significant gaining weight during gestation and producing heavier piglets at birth (Clavijo et al 1971), and recently, the work performed by Renaudeau et al (2014) has confirmed that banana meal is a valuable energy source for feeding pig as well. Utilization of ripe and unripe banana in the diet of hybrid catfish Heteroclarias (*Heterobranchus longifilis* × *Clarias gariepinus*) has been demonstrated lately as a representative aquaculture example that similarly claimed an improvement effect on growth, nutrient and hematological performance of this fish species (Aderolu et al 2011). In Nile tilapia culture, previous study using fruits of Cavendish banana CV Kluai Hom Thong (*Musa* AAA group) at 10% complementary in diet also reported the gaining in fish's average weight and better feed conversion rate with non significant survival percentage to the control one (Haemasaton & Pisuttharachai 2016). The latest investigation on the use of banana fruit in fish culture was done as one among prebiotic supplementary feeds on growth performances, feed utilization, and survival of climbing perch (*Anabas testudineus*) which displayed a significant higher feed utilization and survival rate in the fish fed with banana powder supplementation (Pimpimon et al 2018). Comparing to those studies, a correlative finding in our experiment has demonstrated satisfied application specifying the advantages of ripe "Kluai Namwa" banana as well.

Physical texture property especially the hardness is considered imperative routine index for evaluation of fish's flesh quality (Periago et al 2005). In the present study, although there was no significant difference of the hardness between raw fillets from the ripe Kluai Namwa banana supplementary feeding and from the control fishes, but an existence in its difference was distinct in the flesh after steaming (Table 4). Several other studies also reported a non apparent effect of the tested supplementary diets feeding on raw fillet texture in many fish species including sea bream, rainbow trout and red hybrid tilapia even though with an additive dietary oils (Ng & Bahurmiz 2009; Castro et al 2015; Trullas et al 2017). It is believed that various factors such as feeding diet and condition, body pH, lipid oxidation of the flesh, body fat and water content can dominate the flesh textural character of the fish (Carbonell et al 2003). However it seemed that the direct effects accompanied these factors were quite obscured regarding to a similarity of raw fillet hardness results in those mentioned studies and this current case. On the other hand, fillets of the fishes fed with the banana supplemented diets of all levels were noticeably softened after steamed cooking which could be implied for a better improvement of the meat quality. In general a softening of the flesh is normally associated with the retained lipid, water content and fiber structures in fillets (Lie 2001). Meanwhile the other study found no significant difference between the hardness degree

in cooked fillet sensory texture of brown trout despite the clear differences in lipid content and fatty acid profile (Turchini et al 2003). Collagen level and its stability are other important features that affected on the flesh's hardness (Moreno et al 2012). It has been stated that collagen is responsible for maintaining the softening structure of the fillets through a gelatinization by thermal action and the changes of connective tissue constituents has caused by integration of collagen rather than mycofibrillar protein (Castro et al 2015). Due to the lack of more effective parameters in this current investigation, a more concrete experiment for determining the most direct antecedent will be managed in the next study.

Simultaneously, assessment on the flesh quality respecting the perception of consumer preference and acceptance is also compulsory (Borresen 1992). Sensory preferences in five important categories such as appearance, color, odor, taste, texture and overall preference were determined in steamed fillets derived from the experimental Nile tilapia. The best rating in all of these attitudes were denoted from steamed fillets of the fishes fed with ripe Kluai Namwa banana supplementation at 10% level (Table 5) suggesting a proper applicable ration. As feeding composition has been claimed influencing several quality parameters of the fishes and its products (Lie 2001), a significant pleasing sensory resulting in this case, therefore, should be arisen from many beneficial effects of the ripe Kluai Namwa banana. Addition of different ingredients from bioactive compounds rich vegetable sources had been reported referring their profitable effects on overall appearances and preferences of the fish and its flesh for examples, the supplementation of dried algae *Schizochytrium* sp. that improved sensory quality of channel catfish *Ictalurus punctatus* (Li et al 2009), the dietary inclusion of red seaweed *Gracilaria vermiculophylla* that modulated rainbow trout's flesh quality (Valente et al 2015). The natural pigments, vitamins, minerals and other valuable bioactive constitutes have thus been assumed responsible for these preference effects. Besides, the body lipid and collagen content are often considered main factors associating appreciable flesh characteristics especially the appearance, odor, taste and texture. Changes in dietary feeding have been proposed as stimulant for a differentiation in both fatty acid and collagen profile and hence altering the sensory performance (Mills et al 1993). The apparent improvement found in this current study is likely due to various superlative natural compounds containing in the ripe fruits of 'Kluai Namwa' banana particularly carotenoids and riboflavin which affect the fillet's color and appearance, potassium and pectin which help in cell development and body's water balance regulation, magnesium which helps relaxing muscles, and vitamin C which essentially helps in collagen configuration (Singh et al 2016; Singh et al 2018).

Liver and intestine are meaningful organs conducting various vital body functions to keep health balance. The liver directs functions such as detoxification of harmful substances, storage of vitamins, metabolism of carbohydrate, fat and protein, manipulation of blood consistency and formation of urea. While the intestine pursues functions mainly nutritional digestion, absorption and osmoregulation. Aberration occurring in these anatomical structures would strikingly interrupt a proper physiological function and growth of the fish (Blaxhall 1972). Investigation on histological morphology of the liver after feeding the fishes with plants or plant extracts supplementary diets has been reported noticeably in the studies on sea bream fed a mixture of vegetable protein concentrates (Baeza-Areno et al 2014) and fenugreek seeds supplementation which showed similarly indifference from typical liver characteristics. Whereas the effects of feeding with herbal supplemented dietaries on histological structure of the fishes as Nile tilapia in the culture using alginic acid polysaccharide of brown algae (Merrifield et al 2011) and the case of culturing with polysaccharide product of *Astragalus membranaceus* (Zahran et al 2014) have been described. A normal histology of the Nile tilapia intestine in experimental and control groups were revealed in both cases which implied for a safe utility of these natural compounds. Correlatively, our current observation on Nile tilapia liver and intestine histology declared a customary appearance without incurring harm or damage following the ripe 'Kluai Namwa' banana supplementary feeding at all the tested levels of 1, 5, and 10% experimentation. This affirmative information thus infers its capability and secure utilization.

Conclusions. This is the first report concerning an effective utilization of ripe banana's flesh as dietary supplementation for Nile tilapia culture. The present study demonstrated that this banana supplemented diet at 1, 5 and 10%, each, has assured pleasant effects in enhancing growth and feed conversion efficiency of the fish. Significant improvement in texture quality was obviously gained in their steamed fillets with much lower hardness value parameter. Evaluation based on consumer's sensory preferences of the steamed fillets indicated the best score from fish fed with ripe Kluai Namwa banana adding at 10%, suggesting a suitable level for supplementation. The trials caused no harm to the fish survival, likewise, neither queer effect nor mortality to liver and intestine was shown up following a histological determination. It is worth considering the exploitation of local cultivated banana CV. Kluai Namwa in consensus to its nutritious, economical readily available, easy handling and ecofriendly performance.

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