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Full Paper

Use of 'Kluai Leb Mu Nang' banana peel as a dietary ingredient in feed for spotted scat (*Scatophagus argus* Linnaeus, 1766)

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Abstract: The use of banana peel as an aquatic animal feed additive has been previously demonstrated. The peel of 'Kluai Leb Mu Nang' banana is known to be rich in useful nutrients and this study investigates its use as a dietary ingredient in the culture of spotted scat (*Scatophagus argus*). Five isonitrogenous and isocaloric diets supplemented with the ripe banana peel were fed to the fish twice a day for 12 weeks. Diet 1, without banana peel, served as a control diet, whereas Diets 2, 3, 4 and 5 were experimental diets containing 5, 10, 15 and 20 % banana peel respectively. The effects of the diets were measured in terms of the final body weight (FBW), weight gain (WG), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), hapatosomatic index (HSI) and survival rate (SR) of the fish, as well as the influence on the fish whole-body composition (i.e. moisture, crude protein, crude lipid and ash percentages). At the end of the feeding period, the FBW, WG, SGR, FCR and PER of the fish fed diets containing 0, 5, 10 and 15 % banana peel were similar but those fed 20 % banana peel diet gained significantly less weight. Diets supplementated with banana peel had no effect on HSI, SR, body moisture or the crude protein content of the fish compared to control groups. Those fed 5 % peel diet had significantly higher ash content and the crude lipid content was significantly lower in the fish receiving the 15 % peel diet (all differences were significant at $p<0.05$). However, in general the levels did not deviate markedly from those obtained from the fish fed the control diet. Based on these results and the fact that the banana peel is an otherwise valueless biomass waste which is easily available, it may be of benefit as a feed additive in aquaculture.

Keywords: spotted scat, *Scatophagus argus*, Kluai Leb Mu Nang banana, Musa (AA group), banana peel, dietary supplementation

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INTRODUCTION

Spotted scat (*Scatophagus argus* Linnaeus, 1766), also known as tiger scat, argus fish and spotted butter fish, is found in many countries around the Indo-Pacific region including Thailand [1]. It lives in muddy coastal areas including estuaries, mangroves, harbours and the lower courses of rivers. In the southern part of Thailand it is commonly called 'Pla Kitang'. This fish species is popular not only among fish consumers, but also as an ornamental fish because of its attractive and varied colouration. It is tolerant of a wide range of salinity, is well adapted to fluctuations of environment conditions [2] and is omnivorous, feeding on both the small fauna and flora in its habitat [3]. Because of these interesting characteristics, it is a candidate for coastal aquaculture with the potential to generate income for farmers, and studies of its reproductive biology and breeding for mass seed production have been conducted in a number of countries [4-8]. In Thailand the Department of Fisheries has successfully bred and reared this species of fish [9].

Banana is one of the most commonly consumed fruits. It is cultivated in over 130 countries and contributes approximately 17% of the world's total fruit production [10]. Banana peel, which constitutes up to 35% of the ripe fruit, is a food waste discarded in large quantities each year [11]. However, it contains nutrients and minerals that are actually very similar to the flesh of the banana fruit [12]. Banana peel is not only rich in starch, protein, lipid, fibre, vitamins and minerals [13], but also contains antibacterial and antioxidant agents [14], which makes it a good alternative feedstuff for animals [15]. The potential for the use of various types of banana peel as a feed ingredient has been demonstrated in livestock [16,17], poultry [18,19], and aquatic animals including African catfish (*Clarias gariepinus*) [20], the giant freshwater prawn (*Macrobrachium rosenbegii*) [21], rohu fish (*Labeo rohita*) [22], pearl spot (*Etroplus suratensis*) [23] and red tilapia (*Oreochromis* sp.) [24]. However, the dietary effects of banana peel on the growth performance and nutrient utilisation of spotted scat, *Scatophagus argus*, have not previously been investigated. The spotted scat has a U-shaped stomach which affords a large surface area for food absorption and reduces the gastric emptying time [25]. Further, its digestive tract is rich in protease-amylase-, cellulase- and lipase-producing bacteria [26]. Taken together, these facts suggest that this fish species may be able to utilise banana peel as a nutrient source.

Musa (AA group) banana variety, or 'Kluai Leb Mu Nang' in Thai, is a diploid cultivar of the seeded banana *Musa acuminate,* which is native to Southeast Asia. In Thailand it is well known as an economic crop and large planting areas are found in the southern provinces, especially Chumphon and Nakhon Sri Thammarat. Besides being consumed fresh, the 'Kluai Leb Mu Nang' banana can be processed into several kinds of banana products. As a result, a large volume of peel is produced as a household and industrial food waste in this region, which could potentially be used as an animal feedstuff. Because food is one of the most expensive inputs in aquaculture, reducing the cost of feedstuff would lead to an increase in profitability. The use of banana peel as an alternative feedstuff is a promising approach since it can be easily obtained at a low cost. In order to explore the feasibility of utilising this fruit waste as a feed additive in aquaculture, this paper investigates the effects of using 'Kluai Leb Mu Nang' banana peel as a dietary supplement on the growth performance, feed utilisation and body composition of spotted scat.

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MATERIALS AND METHODS

Preparation of Banana Peel

The peel of ripe 'Kluai Leb Mu Nang' banana was collected from the Agricultural Products Processing Group in Chumphon province, Thailand. It was washed with fresh water and dried in a hot air oven at 70°C for 48 h. The dried samples were milled using a herb grinder and the ground material was kept in air-tight plastic bottles at 4 °C until use.

Experimental Fish

Juvenile spotted scat (*Scatophagus argus*) was obtained from the marine fish hatchery at Coastal Aquaculture Research and Development Regional Centre 6, Songkhla, Thailand. The fish were conditioned in two 500-L seawater tanks and acclimated to the local conditions for a period of 7 days. During this adaptation period, the fish were fed a commercial diet. At the beginning of the experiments, the fish (initial mean body weight 0.64 g) were divided randomly into five groups (Diet 1, Diet 2, Diet 3, Diet 4 and Diet 5) in three replicates of 20 fish for each group per aquarium. Each aquarium (90 x 40 x 45 cm) was filled with 140 L of seawater and supplied with continuous aeration. The salinity, water temperature and dissolved oxygen were maintained at 5%, 27-30°C and 5.62-6.91 mg/L respectively. The fish were fed to apparent satiation twice a day at 08.30 and 16.00. Every day before feeding, faeces and pellet residues were removed by siphoning and half the water in each aquarium was changed. The fish were weighed at the beginning of the experiment and then biweekly for 12 weeks. Before weighing, they were starved for 24 h, allowing the gut to empty. A pooled sample of 30 fish from the initial group and five fish per aquarium at the end of the trial were sacrificed and frozen for subsequent carcass analysis. All the fish were handled with care throughout the study and were killed following the guidelines of the Animals for Scientific Purpose Act 2015 and the National Research Council of Thailand.

Experimental Diets

Five experimental diets with between 0-20% banana peel were formulated as shown in Table 1. For their preparation, all the ingredients were ground, mixed and pelleted in a pellet making machine (La Minerva, Italy) through a 1.5-mm sieve. The diet pellets were dried in a hot-air oven at 70°C and subsequently stored at 4°C.

Proximate Analysis

Samples of all the diets were dried at 70°C for 72 h before analysis. Analytic methods of AOAC [27] were employed. Moisture content was determined by oven drying at 105±1°C for 24 h, crude protein by micro-Kjeldahl method, crude lipid by petroleum ether extraction at 40-60°C in a Soxhlet apparatus, crude fibre by extraction with 0.5M of H_2SO_4, and ash by using a muffle furnace at 600°C for 15 h. Gross energy was measured by ballistic bomb calorimetric method [28].

To establish the mineral content of banana peel, the analytic methods of AOAC [27] were employed. Calcium and magnesium were determined by atomic absorption spectrophotometric method [19], sodium and potassium by flame photometric method [27] and phosphorus by spectrophotometric method [27].

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Table 1. Ingredients of experimental diets

Ingredient	(% of dry weight)				
	Diet 1	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**
Fish meal	45	45	45	45	45
Squid meal	4	4	4	4	4
Soybean meal	16	16	16	16	16
Broken rice	10	19	15	9	4
Wheat flour	16	2	1	2	2
Banana peel	0	5	10	15	20
Live fish oil	5	5	5	5	5
Soybean oil	3	3	3	3	3
Mineral mix[a]	0.5	0.5	0.5	0.5	0.5
Vitamin mix[b]	0.3	0.3	0.3	0.3	0.3
Vitamin C	0.1	0.1	0.1	0.1	0.1
BHT[c]	0.1	0.1	0.1	0.1	0.1

[a] Per kg of mineral mixture: iron 12,000 mg; copper 12,000 mg; zinc 15,000 mg; manganese 6,000 mg; iodine 200 mg; selenium 25mg; magnesium 50,000 mg; calcium 100,000mg; phosphorus 80,000 mg
[b] Per kg of vitamin mixture: vitamin A 600,000 IU; vitamin D3 200,000 IU; vitamin E 6,000 IU; vitamin K 1,200 mg; vitamin B1 5,000 mg; vitamin B2 6,000 IU; vitamin B6 5,000 mg; vitamin B12 6 mg; niacin 20,000 mg; pantothenic acid 16,000 mg; folic acid 1,000 mg; biotin 200 mg; Endox Dry (synergistic anti-oxidative mixture) 20,000 mg
[c] Butylated hydroxytoluene

Total Phenol Content

The total phenol content (TPC) in each diet was quantified based on the method of Velioglu et al. [29]. Briefly, 200 mg of each diet was extracted for 2 h with 2 mL of water at room temperature on an orbital shaker. The mixture was then centrifuged at 1,000 x g for 15 min. and the supernatant was collected and mixed with 0.75 mL of 10% Folin-Ciocalteu's reagent (Sigma-Aldrich) dissolved in water. The mixture was allowed to stand for 5 min. before addition of 0.75 mL of 10% (w/v) Na_2CO_3. After mixing, it was left at room temperature for 90 min. and TPC was determined at 725 nm using tannic acid as standard. Each value was expressed as tannic acid equivalent in mg/g dry weight.

Growth Performance and Feed Utilisation

Growth performance and feed utilisation were estimated in terms of mean weight gain (WG), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), hepatosomatic index (HSI) and survival rate (SR). These indices were calculated as follows:

WG: [final body weight (g) - initial body weight (g)] x 100/initial body weight (g)

SGR: [Ln final body weight (g) - Ln initial body weight (g)] x 100/experimental period

FCR: feed intake (g)/weight gain (g)
PER: weight gain (g)/protein intake (g)
HSI: [liver weight (g)/fish weight (g)] x 100
SR: [final fish quantity/initial fish quantity] x 100

Statistical Analysis

All data were expressed as mean ± standard deviation (SD) and analysed using one-way ANOVA with differences between mean values being compared using Duncan's new multiple range test [30]. Differences were considered as being significant at $p<0.05$.

RESULTS AND DISCUSSION

Composition of Diets

Based on the findings of this study shown in Table 2, 'Kluai Leb Mu Nang' banana peel is a potential source of alternative feedstuff for animals**.** It was rather high in protein but low in fibre compared to the peel of other bananas. For instance, the moisture, ash, protein, crude lipid and crude fibre of *Musa sapientum* peel from Nigeria are 6.70 ± 2.22**,** 8.50 ± 1.52**,** 0.90 ± 0.25, 1.70 ± 0.10 and 31.70 ± 0.25 % respectively [12] and the elemental composition of Musa AAA and AAB groups from India for calcium, potassium and sodium were 19.2 ± 0.00, 78.12 ± 0.14, and 24.3 ± 0.12 mg/100g respectively [15]. The dietary fibre in banana peel consists of insoluble and soluble fractions [31]. The latter is well known to have beneficial health properties [32, 33] and an increase in such fibre upon ripening has been previously reported in the peel of the genus *Musa* [31, 34].

Table 2. Proximate composition and mineral content of 'Kluai Leb Mu Nang' banana peel

Composition (%)	
Moisture	9.54±0.13
Ash	17.45±0.11
Crude protein	9.77±0.21
Crude lipid	5.10±0.07
Crude fiber	11.41±0.11
Calcium	0.47 ± 0.00
Phosphorus	0.22 ± 0.14
Potassium	5.56 ± 0.02
Magnesium	0.18 ± 0.01
Sodium (mg kg^{-1})	17.77 ± 1.15

Note: Values are the mean ± SD of three replications.

The results obtained from composition analysis of the experimental diets (Table 3) show that all are isonitrogenous and isocaloric. However, the fibre and ash content increases with the amount of banana peel included in the feed ration.

The TPC of the experimental diets is presented in Table 3. There is a significant increase in TPC ($p<0.05$) from Diet 2 to Diet 5 in proportion with the amount of banana peel added (5-20% by weight). Banana peel is a rich source of phenolic compounds such as flavonoids, tannins, alkaloids, anthocyanins and terpenoids, which have been reported to exert various biological and pharmacological effects [35]. Therefore, the presence of these bioactive phytochemicals in the diets suggests that they may have valuable medicinal properties when fed to animals.

Table 3. Composition of experimental diets

Composition	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Moisture (%)	1.30±0.05[a]	1.57±0.17[b]	1.64±0.17[b]	1.59±0.05[b]	1.69±0.05[b]
Ash(%)	15.79±0.29[a]	16.47±0.07[b]	17.11±0.20[c]	17.68±0.12[d]	18.43±0.01[e]
Crude protein(%)	34.66±0.25[b]	33.01±0.39[a]	33.08±0.31[a]	33.47±0.44[a]	33.41±0.44[a]
Crude lipid (%)	7.92±1.04	7.32±0.02	8.16±0.40	7.60±0.26	8.39±0.41
Crude fiber (%)	2.05±0.30[a]	2.88±0.34[b]	3.62±.0.26[c]	4.41±0.39[d]	5.16±0.37[e]
Gross energy [1]	398.05±1.87[ab]	399.28±3.45[ab]	411.17±2.81[c]	402.44±1.69[b]	397.54±2.23[a]
TPC [2]	23.80±0.36[a]	25.22±0.42[a]	27.49±4.59[b]	31.16±0.61[c]	34.28±1.81[d]

Note: Values are mean ± SD of three replications.
Means within each row not sharing a common superscript are significantly different (p<0.05).
[1] kCal/100g
[2] mg/g tannic acid equivalent

Growth Performance, Feed Utilisation, Hepatosomatic Index and Survival Rate

Data on the growth performance (WG and SGR), feed utilisation (FCR and PER), HSI and SR of the fish fed the five experimental diets for 12 weeks are summarised in Table 4**.** Feeding with the diet containing up to 15% banana peel did not produce results which were significantly different from those for the control group (Diet 1). However, the fish fed Diet 5 containing 20% peel gained significantly less weight (WG) than those fed all the other diets. As a result, significantly lower SGR and PER values and a higher FCR (p<0.05) were obtained. These findings thus suggest that the supplementation level of 'Kluai Leb Mu Nang' banana peel in the fish diet should not exceed 15%.

Further, the significant reduction in WG among the fish on the diet containing 20% peel and the value of FCR and PER indicates that the fish utilised the dietary nutrients less efficiently (Table 4), which may be a result of the greatly increased level of tannins in the diet as represented by the TPC (Table 3). In banana peel, levels of tannins ranging between 1.99-7.36% have been reported [18]. Tannins are known to be a nutritional inhibitor [36] which reduces nutrient absorption. The ability of tannins to lower the digestibility of protein and the metabolisability of energy has been demonstrated in chicken, pigs and rats [37]. This can have an adverse effect on body growth. It seems that the phenolic groups of tannins bind to enzymes and other proteins via hydrogen bonds and hydrophobic interactions and form insoluble tannin-protein complexes resistant to digestive enzymes [38]. In addition, tannins can bind with gastrointestinal mucosa protein to form insoluble complexes on the intestinal mucosal surface. This can damage the intestinal wall and interfere with the absorption of some minerals such as calcium, iron and zinc ions, as well as form deposits and complexes with vitamin B12, which reduces the food utilisation rate [39].

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Table 4. Growth performance, feed utilisation, hepatosomatic index and survival rate of spotted scat fed the experimental diets for 12 weeks

Parameter	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
IBW (g)	0.67 ± 0.01^{a}	0.63 ± 0.01^{a}	0.62 ± 0.03^{a}	0.63 ± 0.02^{a}	0.64 ± 0.05^{a}
FBW (g)	7.87 ± 0.54^{b}	8.16 ± 0.93^{b}	7.53 ± 0.14^{b}	7.71 ± 0.49^{b}	6.09 ± 1.29^{a}
WG (%)	$1{,}071.80\pm73.03^{b}$	$1{,}195.80\pm119.78^{b}$	$1{,}119.34\pm43.62^{b}$	$1{,}119.38\pm35.13^{b}$	863.07 ± 98.79^{a}
SGR (%)	2.93 ± 0.07^{b}	3.05 ± 0.10^{b}	2.98 ± 0.04^{b}	2.98 ± 0.03^{b}	2.66 ± 0.18^{a}
FCR	2.82 ± 0.13^{a}	2.91 ± 0.09^{ab}	3.23 ± 0.24^{ab}	2.85 ± 0.14^{a}	3.51 ± 0.65^{b}
PER	0.94 ± 0.04^{b}	0.95 ± 0.02^{b}	0.86 ± 0.06^{ab}	0.96 ± 0.05^{b}	0.77 ± 0.14^{a}
HSI (%)	3.87 ± 0.42^{a}	4.14 ± 0.29^{a}	4.00 ± 0.23^{a}	3.95 ± 0.36^{a}	3.61 ± 0.53^{a}
SR (%)	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}	98.33 ± 2.89^{a}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}

Note: All values are mean ± SD of three replications.
Means within each row not sharing a common superscript are significantly different (p<0.05).
IBW = Initial body weight, FBW = Final body weight

It is also observed that of the five test diets, the TPC of Diet 2 containing 5% banana peel, was not significantty different from that of the control diet (Table 3) and this diet (Diet 2) showed the best growth performance as represented by the highest WG and SGR values (Table 4). The findings that the diet with 20% banana peel significantly decreased growth performance and feed utilisation (WG, SGR, FCR and PER) in the fish are in agreement with those of Lawal et al. [20], who fed diets containing 5, 10 and 15 % banana peel to catfish, and those of Giri et al. [22], who fed a diet containing 7% banana (*Musa acuminata*) peel flour to rohu fish.

In this study there were no significant differences in the HSI and SR among the treatments, indicating that banana peel does not negatively affect the accumulation of food in the liver nor the survival of fish. The banana peel can therefore be used as a food source for fish, although the amount used may affect its growth.

Body Composition of Fish

The whole body composition of the spotted scat fed the experimental diets is shown in Table 5. There was no significant difference in moisture and crude protein content in all treatments. The lowest crude lipid content was found in the fish fed the diet with 15% peel (Diet 4) and the ash content was highest in the fish fed 5% peel diet (Diet 2) and both these values were significantly different from all the other values (p<0.05). However, other than these two differences, there were no significant variations among the fish fed on the experimental diets (Diets 2-5) and the control diet (Diet 1). In particular, these results demonstrate that the use of 'Kluai Leb Mu Nang' banana peel meal caused no significant alteration in the fish crude protein content nor in its moisture content under the conditions of this study. The results do, however, suggest that the fish fed the diet containing 20% peel grew at a slower rate than the others, leading to a lower WG as shown in Table 5.

Table5. Composition of whole-body fish fed experimental diets for 12 weeks

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Moisture (% wet weight)	65.75±0.02[a]	65.58±0.04[a]	65.35±1.09[a]	64.74±0.52[a]	64.97±0.57[a]
(% dry weight)	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Crude protein	44.40±0.81[a]	44.97±0.45[a]	45.05±1.39[a]	46.06±0.14[a]	44.72±1.14[a]
Crude lipid	36.36±2.43[b]	36.47±0.39[b]	35.92±0.84[b]	31.93±0.59[a]	34.38±0.73[b]
Ash	14.98±0.13[a]	16.19±0.51[b]	14.71±0.51[a]	14.20±0.70[a]	14.81±0.78[a]

Note: Values are mean ± SD of three replications.
Means within each row not sharing a common superscript are significantly different (p<0.05).

CONCLUSIONS

The peel of ripe 'Kluai Leb Mu Nang' bananas has the potential to be used as an alternative feed ingredient in marine fish culture. The use of this waste product as an ingredient in fish food would be economically beneficial since it would lead to a reduction in food costs. The inclusion of up to 15% peel in the diet seems to have no adverse effect on the growth performance of the fish, nor was there any major effect on their whole-body composition, their feed utilisation, HSI or their SR. The use of this cheap and readily-available food source as a feed additive seems to be appropriate since not only would this employ an otherwise valueless waste product, but it would also lead to a reduction in the cost of feedstuff, thus lowering operating costs in the culture of spotted scat and potentially other varieties of fish.

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