The possibility of sweet potato (*Ipomoea batatas*) addition as feed for white leg shrimp (*Litopenaeus vannamei*) under biofloc rearing condition

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Abstract- The aim of the study is to determine the possibility of sweet potato (*Ipomoea batatas*) addition as feed for white leg shrimp (*Litopenaeus vannamei*) under biofloc rearing condition. The experiment was randomly set up with four feeding treatments including (i) 100% commercial pellet without sweet potato addition (control), (ii) commercial pellet in combination with 10% sweet potato addition, (iii) 20% sweet potato addition, and (iv) 30% sweet potato addition. Shrimps (0.76±0.15 g; 4.4±0.6 cm) were cultured in biofloc system (C: N = 15: 1) at stocking density of 150 shrimp/m^3 and water salinity of 15‰. After 90 days of culture, the increase sweet potato addition increased shrimp weight. The final shrimp weight (25.7 and 25.8 g/ shrimp) of treatments of 20% and 30% sweet potato addition were significantly higher than those of control treatment (23.8 g/shrimp). The final shrimp weight of 10% sweet potato addition treatment was not significant difference compared to control treatment. The survival rate (61.5-66.7%) and shrimp biomass (2.3 – 2.6 kg/m^3) were not significant difference between treatments. The increase in addition of sweet potato increased shrimp sensory property, especially shrimp color. Also, the increase in addition of sweet potato increased feeding cost, however, there was no significant difference in feeding cost between control treatment and treatment of 10% sweet potato addition. In short, addition of 10% sweet potato as feed for white leg shrimp did not effect on survival rate, shrimp growth performance, shrimp biomass, feeding cost but enhanced the shrimp sensory properties.

Index Terms- addition, biofloc, Litopenaeus vannamei, sensory property, sweet potato, white leg shrimp

I. INTRODUCTION

In recent years, marine aquaculture of Vietnam has been concerned and developed. According to Ministry of Agriculture and Rural Development (2016), the total area of marine shrimp culture was 683,422 ha with the production of 680,000 tons. Among that, white leg shrimp aquaculture widely promoted as its high growth rate in high density condition (Brigg *et al.*, 2005). During culture period, the most concerned problem of farmer is input cost, among that, feed cost accounted for the highest portion, more than 50 % of total cost. Liao and Chien (2011) stated that white leg shrimp showed more advantages in growth rate, culture density, low protein demand and capable of utilizing vegetable protein compared with black tiger shrimp. Therefore, utilizing plant original feed as additional feed to increase shrimp immune system, reduce feed conversion rate (FCR) and reduce environment pollution is currently concerned. Cruz *et al.* (2009) stated that 3.3% addition of *Enteromorpha* algea in white leg shrimp culture resulted in faster growth rate, low FCR and improved marketable shrimp color compared with no *Enteromorpha* algea addition. In addition, the growth rate and feed utilizing efficiency were improved if replacing soybean powder with *Enteromorpha* sp. and *Chadophoraceae* algea powder at the ratio of 20 and 40% (Anh *et al*., 2014a). The results of Bang *et al*. (2016) showed that 10% addition of pumpkin as feed in white leg shrimp biofloc culture resulted in higher growth rate, reduced feed cost and improved shrimp color. Sweet potato *(Ipomoea batatas)* could be a source of additional feed in white leg shrimp culture as its high micro and macro-mineral element and high amount of beta carotene and vitamins which increased growth rate and immune system (Pandey *et al*., 2003). However, there has been no study on using sweet potato as a source of feed addition in white leg shrimp culture, thus, the study "The possibility of sweet potato (*Ipomoea batatas*) addition as feed for white leg shrimp (*Litopenaeus vannamei*) under biofloc rearing condition" was carried out to determine the optimal ratio of sweet potato addition for reducing feed cost, improving color and quality of cultured shrimp.

II. METHODS

2.1 Experiment design

Experiment was conducted in 0.5 m^3 tanks contained 0.3 m^3 of saline water 15‰. The experiment was randomly designed and included 4 treatments i.e. control treatment (use commercial feed only), 10%, 20% and 30% of sweet potato supplementation.

Each treatment was triplicated. The stocking density was 150 individuals/ m^3. The initial shrimp weight was 4.4±0.6 cm in length and 0.76±0.15 g in weight. The experiment lasted for 90 days.

2.2 Experiment management

Feeding rhythm was four times a day at 7:00 AM, 10:30 AM, 2:00 PM and 5:30 PM. The feed of first three times was commercial feed which purchased from Grobest (40% of crude protein, 6% crude lipid) and the last feeding was sweet potato purchased from local market. The sweet potato composed 80.5% of moisture, 1.38% crude protein, 0.08% crude lipid, 0.77% total ash and 17.2% carbohydrate. The sweet potato was washed with water, cut into species of 1x1 cm and put into experiment tanks at the last feeding. The amount of feed was calculated according to the formulation introduced by Wyk *el al.* (2001); $Y = 13,391 W^{-0,5558}$, where Y is the feed amount and W is the weight of shrimp.

The water was not exchanged during experiment, alkalinity was measured every 15 days and maintained at 142 mg $CaCO_3$/L. Rice powder was added into tanks every four days based on the amount of feed in order to obtain 15:1 of C:N ratio (Phuong *et al*., 2014a). Rice powder contained carbohydrate 73.4% and crude protein 0.26%. The rice powder was mixed with water with the ratio of 1 part of rice powder and 3 parts of water and incubated for 48 hours before fertilized into tanks.

2.3 Evaluation parameters

Temperature and pH were measured twice a day at 7:00 AM and 2:00 PM by pH meter (HANA, USA). Every 15 days, nitrite, alkalinity and TAN were measured at 7:00 AM by test kits (Sera, Germany). Light intensity was measured every 15 days at 6:00 AM, 9:00 AM, 12:00 PM, 3:00 PM and 6:00 PM by photometer (Extech 401025, USA).

Biofloc parameters including Floc value index (FVI) and floc size were measured every 15 days. The length and wide of floc were calculated by measuring 30 flocs under microscope with eyepiece micrometer, the floc volume was measured by taking 1 L water into Floc measurement tool, deposited and measured the volume of sediment. Shrimp growth performance was assessed at the end of the trial, all shrimps in each tank were collected, weighed and measured the total length. Growth performance was evaluated through the following formulas:

Daily weight gain: DWG (g/day) = $(W_2-W_1)/T$

Special growth rate of weight: SGR(%/day)=$100*(LnW_2-LnW_1)/T$

Daily length gain: DLG (cm/day)=$(L_2-L_1)/T$

Special growth rate of length: SGR (%/day)= $100*(LnL_2-LnL_1)/T$

(where W_1 is initial weight (g), W_2 is final weight (g), L_1 is initial length (cm), L_2 is final length, T is culture period (day).

Survival rate (%)= (number of harvest shrimp/ number of stocking)*100

Biomass is the total weight of harvest shrimp per a water unit (Kg/m^3)

The shrimp sensory properties were evaluated following the method described in the study of Meilgaard *et al*. (1999). Nine shrimps in each tank were used for evaluation sensory properties in fresh (uncooked) and steamed (cooked) samples using sensory panel by nine trained inspectors. The color and odor of fresh shrimp and color, odor and flavor of cooked shrimp was scored from 1 to 9 with the increase of intensity. The other nine shrimps were peeled for analysis of toughness and chemical compositions. The toughness was measured by TA.XTplus Texture Analyzer (Stable Micro Systems, YL, UK) with P5/S probe. Chemical compositions (crude protein, crude lipid, total ash and moisture) was then analyzed following the method of AOAC (2016).

2.4 Data analysis

Mean and standard deviation of collected data was calculated with Microsoft Excel 2010. The difference between treatments was determined according to one way ANOVA and DUNCAN test using SPSS 16.0, significant difference was set at 95%.

III. RESULTS AND DISCUSSION

3.1 Environmental parameters

3.1.1 Light intensity

There was no significant difference of light intensity between treatments (Table 1).

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Lowest light intensity was 18 – 20 Lux at 6:00 PM and the highest was 3500 – 3756 Lux at 12:00 PM. Guo *et al*. (2012) stated that the light intensity of 300 – 5,100 Lux was optimal for growth and peeling of shrimp. The color of shrimp was also depended on light intensity; the color of shrimp was faded if cultured in light intensity lower than 1,000 Lux (Tseng *et al*., 1998). Shrimp color was defined by carotenoid (mainly astaxanthin), the astaxanthin of natural shrimp was higher than shrimp which is in-house culture (Chien and Shiau, 2005; You et al., 2005). Besides, the shrimp color was also affected by feed,

the more carotenoid in feed the higher color of cultured shrimp (Parisenti *et al*., 2011). The non-significance effects of light intensity between treatments presented no effect of light intensity on experimental cultured shrimp. Therefore, in this experiment, shrimp color may influence mostly from feeding different amount of sweet potato addition, presented in the section 3.4.

3.1.2 Temperature and pH

Morning and afternoon temperature of treatments were 26.3 to 26.4 and 28.5 to 28.6°C, respectively (Table 2). Generally, the difference of temperature between morning and afternoon was not high and in the optimal range for the development of white leg shrimp. According to My (2009), the optimal temperature of white leg shrimp was 26 to 32°C. Temperature showed high effect on growth, feed conversion rate; and, the suitable temperature for shrimp development should be 27 – 30°C (Wyban and Sweeney, 1995). Similar to temperature, the fluctuation of pH between morning and afternoon was low (<0.5) and in the range of 7.85 and 7.96. Wasielesky *et al.* (2006) stated that the optimal pH for white leg shrimp development is from 7.5 to 8.5 (on-day vary lower than 0.5) and according Yuniasari and Ekasari (2010), pH should be in 7.3 – 7.9. The results showed that temperature and pH was suitable for shrimp in this experiment.

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3.1.3 TAN, nitrite and alkalinity

The results showed that TAN, nitrite and alkalinity of treatments were 0.05 – 0.14 mg/L, 2.97 – 3.58 mg/L and 127 – 139 mg$CaCO_3$/L, respectively (Table 3). Whetstone *et al.* (2002) stated that safe amount of TAN for shrimp growth was lower than 2 mg/L. However, in shrimp – tilapia integration culture under biofloc condition, the nitrite concentration of 3.23 mg/L showed no effect on shrimp growth (Viet *et al.*, 2015). The low amount of TAN indicated that biofloc reduced free ammonia in water by the mean of using ammonia as a source for protein synthesis due to bacterial activity of biofloc (Hopkins *et al*., 1993; Chamberlain and Hopkins, 1994). The optimal alkalinity for shrimp growth should be between 120 – 160 mg$CaCO_3$/L, in the case of low alkalinity (<40 mg$CaCO_3$/L), the shrimp shell was soft and difficult to peel (Charantchakool, 2003; Ebeling *et al.*, 2006; My, 2009). The results indicated that TAN, nitrite and alkalinity was in suitable ranges for shrimp growth.

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3.1.4 Biofloc parameters

After 15 days of experiment, the length and width of flocs among treatments were 0.52 – 0.57 mm and 0.15 – 0.19 mm, respectively (Table 4).

The floc size increased gradually and reached the length of 1.00 – 1.05 mm and the width of 0.2 – 0.56 mm at the day 60. In the day 75, the size of floc decreased shortly at the length of 0.98 – 1.15 mm and the width of 0.39 – 0.40 mm, but the floc size then continuously increased to 1.03 – 1.06 mm in length and 0.39 – 0.43 mm in width at the day 90. Avnimelech (1999) stated that the suitable size of floc for aquaculture was 0.1 – 1.0 mm. The floc size was depended on floc bacterial density and the density of plankton, the faster growth of bacteria and plankton the higher size of biofloc and vice versa (Phuong *et al.*, 2014b). Besides, the floc size was also affected by density and biomass of cultured shrimp, the higher density and biomass of shrimp the smaller size of biofloc (Viet *et al.*, 2015).

The results showed that the biofloc volume of treatments increased during experiment. There was no significant difference of biofloc volume (FVI) among treatments during sampling times ($p>0.05$). After 15 days, the FVI were 1.43 – 1.90 mL/L and then increased to 29.3 – 33.0 mL/L in the day 90. That could be explained that the amount of feed and shrimp waste were low at the beginning, so the nutrition content of water low, and bacteria and plankton were still not significantly developed. According to Avnimelech (2012), biofloc included many kinds of microorganisms e.g. filamentary bacteria, bacteria, algae, protozoa, fragment of organic matter (e.g. remaining feed, waste of shrimp, and gel micro-pellet). Hargreaves (2013) stated that the optimal biofloc volume for aquaculture was 3 – 20 mL/L. The FVI increased during white leg shrimp culture period and varied from 8.2 to 116.3 mL/L, but the shrimp still grow normally (Bang *et al.*, 2016).

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3.2 Growth performance of white leg shrimp between treatments

3.2.1 Growth rate in length

The length of shrimps was not significantly different between treatments ($p>0.05$), but slightly increased according to the increase of sweet potato addition rate. After 90 days rearing, the shrimp length and the daily growth in length varied from 12.8 to 13.1 cm and from 0.09 to 0.10 cm/day (1.21 – 1.24%/day), respectively (Table 5). The shrimp growth rate in length of this study was higher than that of some recent studies. In the study of Khanh *et al.* (2015), white leg shrimp cultured in biofloc system at 150 ind/m^3 showed the growth rate in length of 1.02%/day after 90 days of rearing. In the shrimp – tilapia integration biofloc system, the growth rate in length was 0.08 – 0.09 cm/day (Viet *et al*., 2015). These values were 0.065 – 0.085 cm/day and 0.87 – 1.00 %/day in the case of using pumpkin as a source of feed addition (Bang *et al*., 2016).

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3.2.2 Growth rate in weight

After 90 days rearing, shrimp weight varied from 23.8 to 25.8 g/shrimp corresponding to specific growth rate of 3.83 – 3.92% (Table 6). The specific growth rate of shrimp in control treatment were low, 3.83%/day, and it was significant difference to the other treatments ($p<0.05$). However, there was no significant difference in the final shrimp weight and daily weight gain between control treatment and 10% sweet potato addition ($p>0.05$). Increase addition of potato increased shrimp growth performance. Liao and Chien (2011) reported that whiteleg shrimp require lower protein compared to other marine shrimp and they can utilize protein from plant origin effectively. Anh *et al.* (2014b) also reported that whiteleg shrimp performed higher growth when using gut weed and blanket weed in diet for whiteleg shrimp. Cruz *et al.* (2009) used gut weed *Enteromorpha* powder 3,3% in diet for whiteleg shrimp enhanced shrimp growth.

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3.3 Survival rate, biomass and feed cost

3.3.1 Survival rate and biomass

After 90 days of experiment, the survival rate of treatments varied from 61.5 to 66.7% and the biomass was 2.3 to 2.6 kg/m^3 (Table 7). There was no significant difference in survival rate and biomass of culture shrimp between treatments ($p>0.05$). It can be concluded that feeding sweet potato did not affect to shrimp survival rate. The shrimp biomass of this study was higher than that of Gam *et al.* (2014), which cultured white leg shrimp in pond with the density of 152 ind/m^2, and cultured for 90 days, the productivity of this system was 15.6 tons/ha/cycle (equal to 1.56 kg/m^3). In the study of Phuong *et al.* (2014b), white leg shrimp was cultured in tank with different densities (100, 300 and 500 ind/m^3), after 60 days, the productivity of 500 ind/m^3 treatment was highest, 1.4 kg/m^3. In the experiment of pumpkin replacement, white leg shrimp productivity was 1.4 – 2.1 kg/ m^3 after 3 months of culture (Bang *et al.*, 2016).

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3.3.2 Feed amount and feed cost for one kg of marketable shrimp

After 90 days of experiment, the amount of feed and sweet potato varied from 1.39 to 1.62 and from 0.33 to 0.91 kg, respectively (Table 8). The feed costs for 1 kg shrimp was significant difference among treatments ($p<0.05$), ranged from 53.281 to 59.492 VND. Among these treatments, there was no difference in the feed costs of control and 10% sweet potato addition treatments and the cost was significantly lower compared with other treatments. This result was also similar to that of study of Bang *et al.* (2016), stated that there was no significant difference in feed cost when adding 10 – 20% of pumpkin. In addition, adding 10% of carrot would decrease feed cost for 1 kg of black tiger shrimp (Cuong *et al.*, 2016).

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3.4 Shrimp sensory properties and chemical compositions

3.4.1 Shrimp sensory properties

Color and odor of shrimp in sweet potato addition treatments were significantly higher than control treatment, especially for the cooked shrimp (Table 9). After cooking, the color of shrimp feeding sweet potato enhanced color and sensory score in color were significantly higher than control treatment ($p<0.05$) (Fig. 1). The odor of uncooked shrimps was not different significantly from treatments and varied between 7.57 and 7.71. However, after cooking, the odor of shrimp was scored as 8.00 for the shrimp of 20% sweet potato addition treatment and it was significantly different to control treatment (7.14). Feeding sweet potato also enhanced flavor of shrimp after cooking.

The results indicated that added sweet potato as feed in white leg shrimp culture improved the color and other sensory value compared control treatment. The reason may be that sweet potato contains beta carotene (8500 µg/100g wet matter) and beta carotene is a pigment element (Pandey *et al*., 2003). According to Yu *et al.* (2003), the color of cooked white leg shrimp which cultured in high density condition presented pale color because shrimp could not synthesize enough pigment, especially astaxanthin in such condition. Similarly, addition of algae (*Enteromorpha* sp.) as feed in white leg shrimp culture resulted in deep red color in cooked shrimp compared to control treatment (Nguyen Thi Ngoc Anh *et al.*, 2014b).

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3.4.2 Chemical compositions and toughness of harvest shrimp

There was no significant difference in chemical compositions (moisture, crude protein, crude lipid and total ash) and toughness of fresh shrimp between treatments ($p>0.05$) (Table 10).

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Generally, sweet potato addition improved color of white leg shrimp, but that did not influence the quality of shrimp tissue (chemical contents and texture).

IV. CONCLUSION

Supplementation of sweet potato at level of 10% as feed for white leg shrimp did not effect on growth performance, survival rate, biomass, chemical compositions or production cost, but improved the sensory properties of harvest shrimp. The trial in large scale system should be done to confirm the utilization of sweet potato in shrimp farming.

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Table 1: Light intensity (lux) between treatments

Treatments	Time				
Sweet potato additional rate (%)	6:00AM	9:00AM	12:00PM	13:00PM	6:00PM
Control (0)	59.0±5.0[a]	1430±124[a]	3530±203[a]	1879±449[a]	18.0±6.0[a]
10	54.0±6.0[a]	1585±92[a]	3500±128[a]	2058±234[a]	19.0±2.0[a]
20	58.0±8.0[a]	1396±274[a]	3756±582[a]	1942±403[a]	20.0±2.0[a]
30	60.0±6.0[a]	1384±259[a]	3594±190[a]	2166±586[a]	20.0±3.0[a]

The similar letters in the same column shows no significant difference (p>0.05)

Table 2: Temperature and pH between treatments

Treatments	Temperature (°C)		pH	
Sweet potato additional rate (%)	AM	PM	AM	PM
Control (0)	26.3±0.48	28.5±0.45	7.91±0.29	7.96±0.27
10	26.4±0.38	28.5±0.43	7.85±0.33	7.92±0.29
20	26.4±0.32	28.6±0.57	7.87±0.31	7.89±0.30
30	26.4±0.22	28.6±0.53	7.86±0.31	7.88±0.34

Table 3: TAN, nitrite and alkalinity between treatments

Treatments	TAN (mg/L)	Nitrite (mg/L)	Alkalinity (mgCaCO3/L)
Sweet potato additional rate (%)			
Control (0)	0.14±0.05	3.58±0.43	135±12.7
10	0.08±0.01	2.97±0.42	127±16.2
20	0.05±0.01	3.25±0.85	139±16.4
30	0.03±0.01	3.28±0.69	127±13.1

Table 4: Biofloc sizes between treatments

Duration (day)	Treatments			
	Sweet potato additional rate (%)			
	Control (0)	10	20	30
	Length (mm)			
15	0.52±0.01[a]	0.54±0.01[a]	0.56±0.02[a]	0.57±0.05[a]
30	0.68±0.20[a]	0.80±0.05[a]	0.81±0.05[a]	0.87±0.01[a]
45	0.86±0.08[a]	0.86±0.10[a]	0.82±0.06[a]	0.81±0.08[a]
60	1.05±0.02[a]	1.02±0.02[a]	1.00±0.04[a]	1.04±0.04[a]
75	1.03±0.04[a]	0.97±0.14[a]	1.15±0.08[a]	0.98±0.11[a]
90	1.04±0.01[a]	1.04±0.01[a]	1.03±0.01[a]	1.06±0.06[a]
	Width (mm)			
15	0.15±0.02[a]	0.17±0.02[a]	0.16±0.01[a]	0.19±0.04[a]
30	0.34±0.11[a]	0.39±0.03[a]	0.29±0.06[a]	0.30±0.11[a]
45	0.49±0.04[a]	0.49±0.04[a]	0.47±0.04[a]	0.46±0.02[a]
60	0.53±0.04[a]	0.56±0.01[a]	0.52±0.02[a]	0.54±0.03[a]
75	0.39±0.03[a]	0.40±0.04[a]	0.39±0.04[a]	0.40±0.01[a]
90	0.43±0.03[a]	0.39±0.04[a]	0.39±0.02[a]	0.40±0.01[a]

The similar letters in the same row shows no significant difference (p>0.05)

Table 5: Growth rate in length of shrimp after 90 days of experiment

Treatments Sweet potato additional rate (%)	L_i (cm)	L_f (cm)	DLG (cm/day)	SGR_L (%/day)
Control (0)	4.31±0.59	12.75±0.27[a]	0.09±0.00[a]	1.21±0.01[a]
10	4.31±0.59	12.93±0.31[a]	0.10±0.01[a]	1.23±0.03[a]
20	4.31±0.59	12.90±0.46[a]	0.10±0.01[a]	1.22±0.04[a]
30	4.31±0.59	13.10±0.15[a]	0.10±0.00[a]	1.24±0.01[a]

L_i: initial shrimp length; L_f: final shrimp length; DLG: Daily growth rate in length; SGR_L: Specific growth rate in length. The similar letters in the same column shows no significant difference (p>0.05)

Table 6. Growth rate in weight of shrimp after 90 days of experiment

Treatment Sweet potato additional rate (%)	W_i (g/ind)	W_f (g/ind)	DWG (g/day)	SGR (%/day)
0 control	0.8±0.3	23.8±0.5[a]	0.26±0.00[a]	3.83±0.01[a]
10	0.8±0.3	24.9±0.7[ab]	0.27±0.01[ab]	3.88±0.03[b]
20	0.8±0.3	25.7±0.8[b]	0.28±0.01[b]	3.91±0.03[b]
30	0.8±0.3	25.8±0.3[b]	0.28±0.01[b]	3.92±0.01[b]

The similar letters in the same column shows no significant difference (p>0.05)

Table 7: Survival rate (%) and biomass of white leg shrimp (kg/m^3) after 90 days of experiment

Treatments Sweet potato additional rate (%)	Survival rate (%)	Biomass (kg/m^3)
Control (0)	63.3±2.6^a	2.3±0.4^a
10	63.0±5.6^a	2.4±0.2^a
20	61.5±5.6^a	2.4±0.2^a
30	66.7±3.2^a	2.6±0.1^a

The similar letters in the same column shows no significant difference (p>0.05)

Table 8: Feed amount and feed cost for one kg of marketable shrimp

Treatments Sweet potato additional rate (%)	Commercial feed	Sweet potato	Feed cost (VND/kg shrimp)
Control (0)	1.62±0.09	-	53.281±3.019^a
10	1.48±0.06	0.33±0.02	53.974±2.412^a
20	1.39±0.05	0.62±0.04	55.115±2.005^{ab}
30	1.39±0.03	0.91±0.03	59.492±1.283^b

The similar letters in the same column shows no significant difference (p>0.05)

Cost of commercial feed and sweet potato were 33.000 VND/kg and 15.000 VND/kg respectively.

Table 9: Sensory values of harvest shrimp

Treatments	Uncooked samples		Cooked samples		
Sweet potato additional rate (%)	Color	Odor	Color	Odor	Flavor
Control (0)	7.00±0.82^a	7.29±0.49^a	6.86±0.69^a	7.14±0.69^a	7.43±0.79^a
10	7.57±0.54^{ab}	7.71±0.49^a	7.71±0.76^b	7.29±0.49^{ab}	8.29±0.48^b
20	7.86±0.90^{ab}	7.57±0.54^a	7.86±0.69^b	8.00±0.58^b	7.86±0.69^{ab}
30	8.29±0.80^b	7.71±0.49^a	7.86±0.38^b	7.71±0.76^{ab}	8.29±0.49^b

The similar letters in the same column shows no significant difference (p>0.05)

Figure 1: Shrimp color of harvest shrimp between treatments, control, 10%, 20 and 30% adding sweet potato, left photos presented for uncooked shrimp and right photos as for cooked shrimp

Control (0%) 10% 20% 30% Control (0%) 10% 20% 30%

Table 10: Chemical compositions and toughness of harvest shrimp

Treatments Sweet potato additional rate (%)	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	Toughness (g.cm)
0 (Control)	74.4±0.1[a]	69.8±1.2[a]	3.7±0.6[a]	7.0±0.5[a]	458±77[a]
10	75.5±0.1[a]	70.3±0.9[a]	3.7±0.3[a]	7.7±0.2[a]	470±81[a]
20	74.3±0.2[a]	71.5±0.6[a]	3.3±0.3[a]	7.1±0.2[a]	517±122[a]
30	74.8±0.1[a]	71.0±1.1[a]	3.1±0.6[a]	7.3±0.5[a]	552±90[a]

The similar letters show no significant difference between data in a column ($p>0.05$)