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Application of red onion (*Allium ascalonicum*) and turmeric (*Curcuma* longa) rhizome extract in feed of black tiger shrimp (*Penaeus monodon*) and white leg shrimp (*Litopenaeus vannamei*) aquaculture

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Abstract

Red onion (*Allium ascalonicum*) bulb and turmeric (*Curcuma* longa) rhizome are important crops with high economic value. The present research aimed to evaluate the application of red onion (*Allium ascalonicum*) extract (6, 9, 12, 15, 18 g/kg diet) combined with turmeric (*Curcuma* longa) rhizome extract (2, 4, 6, 8, 10 g/kg diet) in a basal diet on growth performance, survival rate and feed utilization of black tiger shrimp (*Penaeus monodon*) and white leg shrimp (*Litopenaeus vannamei*). A total of 240 kg of black tiger shrimp (initial weight 150±10 g) and 240 kg of white leg shrimp (initial weight 50±5 g) were reared separately in two groups, each group including 16 indoor shrimp farming tanks (120 × 60 × 50 cm) (length × width × height) with continuous aeration. Results showed that red onion extract 12 g/kg diet or turmeric rhizome extract 8 g/kg significantly improved growth performance, survival rate and feed utilization of black tiger shrimp and white leg shrimp. In 5 different formulas in a combination of red onion and turmeric rhizome extract (7 g onion + 3 g turmeric/ kg diet, 6 g onion + 4 g turmeric/ kg diet, 5 g onion + 5 g turmeric/kg diet, 4 g onion + 6 g turmeric/ kg diet, 3 g onion + 7 g turmeric/ kg diet), we found that 6 g onion + 4 g turmeric/ kg diet resulted to the best growth performance, survival rate and feed utilization in aquaculture of these shrimps. It is suggested that red onion combined with turmeric rhizome extract would be considered an effective phyto-additive incorporated into feed during aquaculture farming.

1. Introduction

Red onion (*Allium ascalonicum*) is a perennial vegetable popularly distributed in Vinh Chau district, Soc Trang Province, Vietnam (Nguyen, 2019). Isoalliin, allicin and S-propenyl-cysteine are the main sulfur substances in red onion. It also contains saponin, sapogenine, ajoene and flavonoid contributing to antibacterial and anticancer properties (Fattorusso *et al*., 2002). Antibacterial and anticancer characteristics of red onion mainly originated from an active element called quercetin. Red onion is also a good source of bioactive compounds such as antioxidants and dietary fiber (Benitez *et al.,* 2011; Choi *et al*., 2015). Its inhibitory effect was more effective on Gram [-] than the Gram [+] bacteria (Mozin *et al*., 2015). It strongly inhibits both pathogenic and non-pathogenic bacteria (Amin and Kapadnis, 2005). Red onion extract is effective in controlling microorganisms in the small intestine, promoting the performance and improving the health of the host.

Turmeric rhizome is widely cultivated in the world. Extract of turmeric rhizome contains curcumin as an active component with different biological properties such as antioxidant, anti-inflammatory and antiproliferative. Turmeric is also highly appreciated for its hepatoprotective effect (Mesa *et al*., 2000). There was much literature mentioned the utilization of onion or turmeric in aquaculture farming (Bello *et al*., 2012; Apines-Amar *et al*., 2012; Talpur and Ikhwanuddin, 2012; Kalyankar *et al*., 2013; Thanikachalam *et al*., 2010; Farahi *et al*., 2010; Kittima *et al*., 2010; Supamattaya *et al*., 2004; Supamattaya *et al*., 2005; Vanichkul *et al*., 2007; Jennifer *et al*., 2012) but they were used alone without any combination to verify if there was any synergistic effect when these ingredients mixed.

Black tiger shrimp (*Penaeus monodon*) and white leg shrimp (*Litopenaeus vannamei*) are important aquaculture species in Vietnam. According to the report of the Vietnamese Directorate of Fisheries, in 2021, the farming area of black tiger shrimp was 630 thousand ha,

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and the area of white leg shrimp farming was 110 thousand ha. Shrimp production in 2021 reached black tiger shrimp 277.5 thousand tons, white leg shrimp 642.5 thousand tons. Shrimp export turnover for the whole year 2021 was estimated at 3.8 billion USD. In aquaculture, phyto-ingredients could be used to stimulate nonspecific immunity (Ardo *et al*., 2008). Antibiotics have been prohibited recently due to potential bacteria resistance, human health risks and the environment (Sudagar and Hajibeglou, 2010). Consumers prefer organic green seafood cultivated with natural active herbs. By incorporating phyto-ingredients into the diet, shrimp and fish can easily overcome stress, render antimicrobial capacity, and initiate the nonspecific immune system (Chansue *et al*., 2000; Immanuel *et al*., 2010). This herbal extract is beneficial as a useful nutrient and promoter in aquaculture farming due to its excellent power even in trace amounts (Logamble *et al*., 2000; Jeney *et al*., 2009). Its biodegradability in shrimp tissue without residue is appreciated. Plant extract can be added to the feed in composing or individually (Czech *et al*., 2009). The immune responses of marine fishes and shellfish against pathogens were elevated by feeding with plant extract (Maqsood *et al*., 2011). The main objective of our study was to examine the influence of red onion (*Allium ascalonicum*) and turmeric (*Curcuma* longa) rhizome extract alone or combination in at different levels on growth performance, survival rate and feed utilization of black tiger shrimp and white leg shrimp in aquaculture.

2. Materials and methods

2.1 Materials

Red onion tubers and turmeric rhizomes were supplied from a local market, Soc Trang province, Vietnam. They were cleaned thoroughly underwater to remove foreign matter. They were separately pressed by an extruder and macerated in 70% ethanol (1/1 w/v) to collect the extract.

2.2 Researching method

Diets were formulated as control diet *al*ong with 15 other diets, including 5 levels of red onion extract, 5 levels of turmeric rhizome extract and 5 levels of red onion + turmeric rhizome extract. These formulas of respected ingredients were mixed thoroughly, pressed in a feed extruder, dried at 45^{o}C to 18% moisture content, and kept in a plastic bag at ambient conditions ready for aquaculture. Two hundred and four kilograms of black tiger shrimp (initial weight 150±10 g) and 240 kg of white leg shrimp (initial weight 50±5 g) were reared separately in two groups, each group including 16 indoor shrimp farming tanks (120 × 60 × 50 cm) (length × width × height) with continuous aeration. Water in these tanks was filtered daily by siphoning to remove excretion. During the experiment, all conditions of temperature, pH, dissolved oxygen ammonia and alkalinity in culture tanks were strictly monitored in 3 hour-interval. The experiments of diets were fixed at 8 am and 4 pm daily for 10 weeks. At the end of the experiments, the growth performance, survival rate and feed utilization of shrimp were evaluated accordingly.

Experiment #1: Effect of red onion extract (6, 9, 12, 15, 18 g/kg diet) on growth performance, survival rate and feed utilization of shrimp

Experiment #2: Effect of turmeric extract (2, 4, 6, 8, 10 g/kg diet) on growth performance, survival rate and feed utilization of shrimp

Experiment #3: Effect of red onion incorporated with turmeric extract (7 g onion + 3 g turmeric/ kg diet, 6 g onion + 4 g turmeric/ kg diet, 5 g onion + 5 g turmeric/ kg diet, 4 g onion + 6 g turmeric/ kg diet, 3 g onion + 7 g turmeric/ kg diet) on growth performance, survival rate and feed utilization of shrimp.

2.3 Physicochemical evaluation

$$\text{Weight gain (\%)} = \frac{\text{final shrimp weight (g) - initial shrimp weight (g)}}{\text{initial shrimp weight (g)}} \text{ x } 100$$

$$\text{Feed utilization} = \frac{\text{feed (g)}}{\text{weight gain (g)}}$$

The survival rate (%) was estimated by an arc-sine transformation method (Sokal and Rohlf, 1981).

2.4 Statistical summary

The demonstrations were prepared as 3 replicates for various sample groups. The values were expressed as mean ± standard deviation (SD). Statistical summary was done using Statgraphics version XVI.

3. Results and discussion

3.1 Effect of red onion extract on growth performance, survival rate and feed utilization of shrimp

The effect of red onion extract (6, 9, 12, 15, 18 g/kg diet) on growth performance, survival rate and feed utilization of black tiger shrimp and white leg shrimp was shown in Table 1 and Table 2. Results showed that red onion extract 12 g/kg diet resulted in the highest weight gain percentage, survival rate and the lowest feed conversion ratio. Values of these indicators were 724.64±1.79%, 98.76±1.63%, 1.25±0.02 for black tiger shrimp and 722.54±1.42%, 96.23±1.79%, 1.29±0.01 for white leg shrimp. Onion bulb based diet resulted in an improvement in body weight in catfish and grouper (Bello *et al*., 2012; Apines-Amar *et al*., 2012). The

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Table 1. Effect of red onion extract on growth performance, survival rate and feed utilization of black tiger shrimp

Red onion extract (g/kg diet)	Percentage of weight gain (%)	Feed conversion ratio	Survival rate (%)
Control	419.19±2.31^{d}	1.85±0.06^{a}	84.53±1.34^{d}
6	625.38±1.83^{c}	1.49±0.05^{b}	92.41±1.18^{c}
9	654.13±1.25^{bc}	1.41±0.07^{bc}	93.15±2.01^{bc}
12	724.64±1.79^{a}	1.25±0.02^{d}	98.76±1.63^{a}
15	703.09±3.64^{ab}	1.31±0.04^{cd}	96.24±0.96^{ab}
18	688.17±2.30^{b}	1.36±0.03^{c}	94.82±2.05^{b}

Values are presented as mean±SD of three replications. Values with different superscripts within the same row are statistically significantly different (α = 0.05).

Table 2. Effect of red onion extract on growth performance, survival rate and feed utilization of white leg shrimp

Red onion extract (g/kg diet)	Percentage of weight gain (%)	Feed conversion ratio	Survival rate (%)
Control	421.05±3.07^{d}	1.94±0.04^{a}	82.68±1.24^{d}
6	623.94±1.45^{c}	1.53±0.01^{b}	90.52±1.31^{c}
9	649.17±1.16^{bc}	1.47±0.03^{bc}	92.89±2.12^{bc}
12	722.54±1.42^{a}	1.29±0.01^{d}	96.23±1.79^{a}
15	706.15±2.07^{ab}	1.35±0.05^{cd}	95.07±0.80^{ab}
18	684.23±1.89^{b}	1.41±0.02^{c}	94.19±2.26^{b}

Values are presented as mean±SD of three replications. Values with different superscripts within the same row are statistically significantly different (α = 0.05).

survival rate of sea bass, Swordtail, catfish, rainbow trout, and grouper was enhanced by onion extract incorporated into their diet (Talpur and Ikhwanuddin, 2012; Kalyankar *et al*., 2013; Thanikachalam *et al*., 2010; Farahi *et al*., 2010; Apines-Amar *et al*., 2012). Cysteine sulfoxide and methyl sulfonate methane in red onion contributed to its therapeutic properties (Keusgen *et al*., 2002, Ostrowska *et al*., 2004; Amar and Faisan, 2011). Moreover, the health-improving characteristics of red onion might be due to flavonoids and organosulfur substances (Griffiths *et al*., 2002). The growth performance of white leg shrimp was greatly enhanced by feeding with onion extract twice a week (Waode *et al*., 2019). Dietary onion powder administrated at 10 g/ kg greatly enhanced the survival rate, growth performance and feed utilization of sea bass fry (Norhan *et al*., 2015).

3.2 Effect of turmeric rhizome extract on growth performance, survival rate and feed utilization of shrimp

The effect of turmeric rhizome extract (2, 4, 6, 8, 10 g/kg diet) on growth performance, survival rate and feed utilization of black tiger shrimp and white leg shrimp was shown in Table 3 and Table 4. It was noticed that among 5 levels of turmeric rhizome extract (2, 4, 6, 8, 10 g/kg diet), turmeric rhizome extract 8 g/kg diet resulted in the highest weight gain percentage, survival rate and the lowest feed conversion ratio. Values of these indicators were 703.09±1.42%, 97.73±1.16%, 1.36±0.01 for black tiger shrimp and 654.65±1.24%, 97.18±1.22% 1.36±0.02 for white leg shrimp. Resistance to vibriosis, immuno improvement, and bactericidal activity in white leg shrimp intestines was noticed clearly by feeding with 25 and 50 mg/kg diet of turmeric extract (Kittima *et al*., 2010). Feed supplemented with 5 and 25 mg/kg turmeric extract improved the survival rate of black tiger shrimps infected by *Vibrio harveyi* (Supamattaya *et al*., 2004). Resistance to vibriosis in black tiger shrimp was reported when diet was added with turmeric extract (Vanichkul *et al*., 2007). Incorporation of turmeric extract into diet enhanced survival rate of shrimp infected by bacterial pathogen (Jennifer *et al*., 2012). Bioactive phytonutrient from turmeric supplemented into diet of giant prawn contributed t feed efficacy (Salini and Thomas, 2017).

3.3 Impact of red onion incorporated with turmeric extract on growth performance, survival rate and feed utilization of shrimp

Effect of red onion incorporated with turmeric extract (7 g onion + 3 g turmeric/ kg diet, 6 g onion + 4 g turmeric/ kg diet, 5 g onion + 5 g turmeric/kg diet, 4 g onion + 6 g turmeric/ kg diet, 3 g onion + 7 g turmeric/ kg diet) on growth performance, survival rate and feed utilization of shrimp was expressed in Table 5 and Table 6. It was clearly realized that red onion incorporated with turmeric extract had a synergistic effect in improving growth performance, survival rate and feed utilization of shrimp. 6 g onion + 4 g turmeric/ kg diet resulted to the best weight gain percentage, survival rate and the lowest feed conversion ratio. Values of these indicators were 809.31±1.03%, 99.45±1.06%, 1.19±0.03 for black tiger shrimp and 736.89±1.02%, 98.75±1.04 %, 1.15±0.00 for white leg shrimp. Turmeric extract supplemented into black tiger shrimp diet at 25 mg/kg effectively retarded *V. harveyi* and *Vibrio* spp. (Supamattaya *et al*., 2005). Excellent bactericidal activity was found on shrimp fed

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Table 3. Effect of turmeric rhizome extract on growth performance, survival rate and feed utilization of black tiger shrimp.

Turmeric rhizome extract (g/kg diet)	Percentage of weight gain (%)	Feed conversion ratio	Survival rate (%)
Control	419.19±2.31^{c}	1.85±0.06^{a}	84.53±1.34^{c}
2	639.75±1.65^{b}	1.52±0.03^{b}	93.14±1.27^{b}
4	659.84±1.71^{ab}	1.47±0.02^{bc}	94.35±2.03^{ab}
6	687.12±2.09^{ab}	1.41±0.05^{bc}	95.61±1.75^{ab}
8	703.09±1.42^{a}	1.36±0.01^{c}	97.73±1.16^{a}
10	705.24±2.27^{a}	1.35±0.04^{c}	98.01±1.64^{a}

Values are presented as mean±SD of three replications. Values with different superscripts within the same row are statistically significantly different (α = 0.05).

Table 4. Effect of turmeric rhizome extract on growth performance, survival rate and feed utilization of white leg shrimp.

Turmeric rhizome extract (g/kg diet)	Percentage of weight gain (%)	Feed conversion ratio	Survival rate (%)
Control	421.05±3.07^{c}	1.94±0.04^{a}	82.68±1.24^{c}
2	626.70±1.24^{b}	1.59±0.01^{b}	91.24±1.15^{b}
4	631.05±1.65^{ab}	1.50±0.06^{bc}	93.37±2.37^{ab}
6	638.27±2.19^{ab}	1.43±0.03^{bc}	95.06±1.04^{ab}
8	654.65±1.24^{a}	1.36±0.02^{c}	97.18±1.22^{a}
10	655.39±1.87^{a}	1.34±0.01^{c}	97.62±1.40^{a}

Values are presented as mean±SD of three replications. Values with different superscripts within the same row are statistically significantly different (α = 0.05).

Table 5. Effect of red onion incorporated with turmeric on growth performance, survival rate and feed utilization of black tiger shrimp.

Red oninon + turmeric extract (g/kg diet)	Percentage of weight gain (%)	Feed conversion ratio	Survival rate (%)
Control	419.19±2.31^{c}	1.85±0.06^{a}	84.53±1.34^{c}
7 g onion + 3 g turmeric/ kg diet	807.65±1.29^{a}	1.20±0.07^{c}	99.51±1.23^{a}
6 g onion + 4 g turmeric/ kg diet	809.31±1.03^{a}	1.19±0.03^{c}	99.45±1.06^{a}
5 g onion + 5 g turmeric/kg diet	765.48±1.16^{ab}	1.25±0.05^{bc}	94.63±1.17^{ab}
4 g onion + 6 g turmeric/ kg diet	739.52±2.01^{ab}	1.29±0.02^{bc}	91.66±1.34^{ab}
3 g onion + 7 g turmeric/ kg diet	701.66±1.83^{b}	1.34±0.04^{b}	89.45±1.09^{b}

Values are presented as mean±SD of three replications. Values with different superscripts within the same row are statistically significantly different (α = 0.05).

Table 5. Effect of red onion incorporated with turmeric on growth performance, survival rate and feed utilization of white leg shrimp.

Red oninon + turmeric extract (g/kg diet)	Percentage of weight gain (%)	Feed conversion ratio	Survival rate (%)
Control	421.05±3.07^{c}	1.94±0.04^{a}	82.68±1.24^{c}
7 g onion + 3 g turmeric/ kg diet	737.08±1.24^{a}	1.14±0.02^{c}	98.81±1.18^{a}
6 g onion + 4 g turmeric/ kg diet	736.89±1.02^{a}	1.15±0.00^{c}	98.75±1.04^{a}
5 g onion + 5 g turmeric/kg diet	730.32±1.37^{ab}	1.19±0.03^{bc}	96.43±1.24^{ab}
4 g onion + 6 g turmeric/ kg diet	724.07±2.19^{ab}	1.23±0.02^{bc}	94.29±1.35^{ab}
3 g onion + 7 g turmeric/ kg diet	719.36±1.73^{b}	1.29±0.04^{b}	92.77±1.02^{b}

Values are presented as mean±SD of three replications. Values with different superscripts within the same row are statistically significantly different (α = 0.05).

by diet added turmeric extract (Vidhya and Maria, 2013). Shrimp fed with polyherbal 300 mg/100 g feed had better growth performance (Chandran *et al*., 2016). A mixture of plant extracts induced a higher weight gain in *P. indicus (*Olmedo Sanchez *et al*., 2009*).* Black tiger shrimp fed with *Zingiber officinalis* had a better feed conversion ratio (Venketaramalingam and Chirstopher, 2007). White leg shrimp fed with ginger had better weight gain and feed conversion ratio (Chang *et al*., 2012). White leg shrimp fed with a mixture of garlic, echinacea, ginger, and basil extracts had a better survival rate (Fierro-Coronado *et al*., 2019).

4. Conclusion

Antibiotic is not allowed in aquaculture owing to the accumulated residue and bacterial resistance harmful to human health. Herbal extract mixed into feed can be considered as an alternative to achieve a better growth

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performance in aquaculture. Our findings showed that red onion extract combined with turmeric rhizome extract would be a promising alternative to modulate the survival rate, growth performance and feed utilization of black tiger shrimp and white leg shrimp in aquaculture. Weight gain percentage, survival rate and feed conversion ratio were 809.31±1.03%, 99.45±1.06%, 119±3% for black tiger shrimp and 736.89±1.02%, 98.75±1.04%, 1.15±0.00 for white leg shrimp. Utilization of natural phyto-ingredients will be an upcoming approach leading to sustainable, organic aquaculture.

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