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Appropriate Proportion of Water Meal (*Wolffia arrhiza* (L.)) and Commercial Diet in Combined Feeding for Tilapia Fingerlings Rearing

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Abstract Studying the growth performance of tilapia fingerlings fed with different proportions of dried water meal and commercial diet was carried out. The experiment consisted of 4 treatments and 3 replications that produced in 0.15 m^3 circle cement pond (50 fingerlings per unit). Fingerlings were fed commercial diet (CD) combined with dried water meal (DWM) at 100:0 (control treatment), 70:30, 50:50 and 30:70 for 75 days and the average initial weight of fish were 0.82±0.02 g, 0.85±0.05 g, 0.76±0.11 g and 0.74±0.04 g respectively which no significant difference ($p>0.05$). The results indicated that fish gradually grew throughout the experiment. The average weight gain, average daily growth and average specific growth rate of fish fed with 100:0 of CD and DWM showed significantly higher ($p<0.05$) than other treatments (10.54±1.15 g 0.14±0.01 g day^{-1} and 3.54±0.14 % day^{-1} respectively). In the parts of feed conversion ratio, fish were fed 100:0 of CD and DWM showed significantly lower ($p<0.05$) than other treatments (1.61±0.18) but no significant difference when compared with 70:30 of CD and DWM feeding (2.21±0.58). DWM might not be suitable for direct feeding however its adventage could make fat accumulation in fish body lower than fish fed with 100% of CD and revealed high protein level in their body. The combined feeding between CD and DWM at 70:30 could reduce feed cost about 12.60% and showed no contrast on feed conversion ratio when compared with 100% CD feeding that is the best choice for DWM utilization.

Keywords: water meal, tilapia, appropriate proportion

Introduction

Tilapia is important economic fish in the world, most of its production produces from Asia aquaculture. China is a major tilapia producer continual by Indonesia Philippine Thailand and Viet Nam (Josupeit, 2010; FAO, 2016). Tilapia remains a popular of whitefish species because of its inexpensive that has entered traditional whitefish market and is enabling the sector to expand subtantially by reaching new consumers. (FAO, 2016). In Thailand, tilapia is

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likely becoming the second of the most important aquaculture specices after shrimp, most of fish raise in rural ares (Bhujel, 2011) and 90 percents of products are consumed within country remained 10 percents for exportation (Pongmaneerat, 2015). Tilapia culture has extend to almost regions of Thailand namely North, South, East and Northeast, their cultured patterns contain various execution such as polyculture, semi-intensive and intensive aquaculture. However, the first aspect of problem and barrier for farmer is high production cost that feed is the main cost about 70 - 80 percents of all production cost (Pongmaneerat, 2015). In fact, farmers explore alternative to pellet feeds, they usually end up with cheap by-product that contain mainly carbohydrates. As protein is the preferred source of energy, the addition at least one of the locally available proteins will greatly enhance the quality of feeds without adding substantial cost (Bhujel, 2011).

Water meal or duckweed, *Wolffia* spp. is a genus which comprises the smallest flowering plants on the Earth. *Wolffia* species are rootless free-floating thalli, green or yellow-green and their species include up to 11 species around the world (Ivan and Katya, 2013). *Wolffia* spp. is an aquatic plant generally found throughout Thailand and the neighbor countries. In the upper northeast and the east of Thailand discover 2 species of *Wolffia* spp., *Wolffia arrhiza* (L.) and *Wolffia globosa* (L.) (Rodroil *et al.*, 2009; Rodroil *et al.*, 2012; Ruekaewma *et al.*, 2015). *Wolffia arrhiza* from the Lemnaceae genus is the smallest vascular plant which is very expansive and reproduces intensively by gemmation under condition of our climate, especially in small and shallow eutrophic reservoirs. They have atypical leaf-like body calling a frond that is a complex tissue with only little differentiation, therefore the *Wolffia arrhiza* organism resembles more the thallophytic algae than vascular plants (Czerpak and Piotrowska, 2005). Thai local name of this plant calls Khai-nam that may be literally translated as eggs of the water and suggests the oval shape (length 1.5 mm, width 1.0 mm) (Bhanthumnavin and Mcgarry, 1971). In Phetchabun province can not find Khai-nam thoughout the year particularly in dry season Khai-nam will be invisible in natural water. Nutritional values of *Wolffia arrhiza* consist of 20.15% to 20.4% protein, 2.43% to 4.63% fat and 11.6% to 14.72% fibre (Jairakphan, 1999; Chareontesprasit and Jiwyam, 2001). Their potentials can be using as the human food (Bhanthumnavin and Mcgarry, 1971; Suppadit *et al.*, 2008) included soybean meal and fish meal replacing in formulated diets as a protein source for animal food or even direct feeding to fish, all of these practices intend to reduce the food cost. (Chareontesprasit and Jiwyam, 2001; Tavares *et al*., 2008; Ariyaratne, 2010; Chantiratikul *et al.*, 2010).

Consequently, the objective of this study determines the growth performances and the appropriate proportion of water meal (*Wolffia arrhiza*

(L.)) to combine feeding with commercial diet for tilapia fingerling rearing that much benefit for farmers to further development of tilapia farming in reducing production costs.

Materials and methods

Experimental site and water meal preparation

The experiment was carried out at aquaculture unit of agriculture technology faculty, Phetchabun Rajabhat University, Thailand. Water meals were collected from natural water at Tabo district, Amphoe Mueang Phetchabun, Thailand. After gathering, water meals were rinsed with cleaned water and were dried at 60 ℃ for 72 hours by hot air oven. Dried water meals were unfinely grinded for fish feeding.

Experimental design

The completely randomized design (CRD) was planned by dividing into four treatments and three replications. Four feeding ratios as 100:0 (control treatment), 70:30, 50:50 and 30:70 of commercial diet (CD, 25% protein) and dried water meal (DWM) were tested.

Before trial, one month tilapia from freshwater aquaculture research and development center of Phetchabun were acclimated in 0.15 m^3 circle cement ponds and fed with 50:50 of CD and DWM for 2 weeks. Feeding rate was about 6-10% of body weight which always adjusted for full eaten and water quality maintenance. Fish were fed three times a day.

After 2 weeks adaptation, fish were randomized weighing and stocked 50 fish in each cement ponds. Next day, fish were fed by different feeding ratios as the plan for 75 days, once a month and the end of experiment the fish were counted and weighed. During the experiment period, feeding rate was about 6-10% of body weight and always adjusted for full eaten. Fish were fed three times a day at 09.00 A.M. 12.00 P.M. and 1500 P.M.. In the initial and the end of experiment, specimens were kept for proximate analysis that were cut off the head and gut content before drying. Containers were washed at least twice a week and water temperature, pH, DO and total ammonia nitrogen of water samples were determined by using pH meter, DO meter and phenate method respectively.

The average daily growth (ADG), specific growth rate (SGR), feed conversion ratio (FCR) and % survival rate of fish were determined according to following equations (Ariyaratne, 2010).

$$ADG\ (g\ day^{-1}) = \frac{Final\ weight\ of\ fish - Initial\ weight\ of\ fish}{days\ of\ rearing}$$

$$SGR\ (\%\ day^{-1}) = \frac{Ln\ (Final\ weight) - Ln\ (Initial\ weight)}{Experimental\ duration} \times 100$$

$$FCR = \frac{Dry\ weight\ of\ feed\ given\ (g)}{Wet\ weight\ gain\ (g)} \times 100$$

$$Survival\ rate\ (\%) = \frac{No.of\ fish\ harvested}{No.of\ fish\ stocked} \times 100$$

Statistical analysis

For all treatments, the three repetitions were analyzed means and standard deviations. Difference among treatments were tested the significance using one-way ANOVA and multiple posthoc comparisons among means were tested by the Duncan's multiple range test (DMRT) at 0.05 of significance level. Statistical analysis were performed with IBM SPSS statistics version 21.

Results

Tilapia fingerlings rearing with the different portions of CD and DWM for 75 days, the results indicated that the fish at all treatments gradually grew throughout the experiment (Fig 1 and 2). The effect of different feeding in CD and DWM ratios on growth performances of tilapia showed statistically significant differences in average weight gain ($F = 28.59$; $p<0.05$), average daily growth ($F = 28.59$; $p<0.05$), specific growth rate ($F = 31.51$; $p<0.05$) and feed conversion ratio ($F = 13.98$; $p<0.05$). In the part of survival rate showed no statistically significant differences between groups ($F = 1.20$; $p>0.05$). The average weight gain, average daily growth and specific growth rate of fish were fed 100% CD as the control treatment was significantly higher than 70:30, 50:50 and 30:70 of CD and DWM feeding (10.54 ± 1.15 g 0.14 ± 0.01 g day^{-1} and 3.54 ± 0.14 % day^{-1} respectively). When compared between 70:30 and 50:50 of CD and DWM feeding groups found that no significant different of these parameters (Table 1). The specific growth rate of fish at all treatments trended to be decrease when the rearing time expansion (Fig 3).

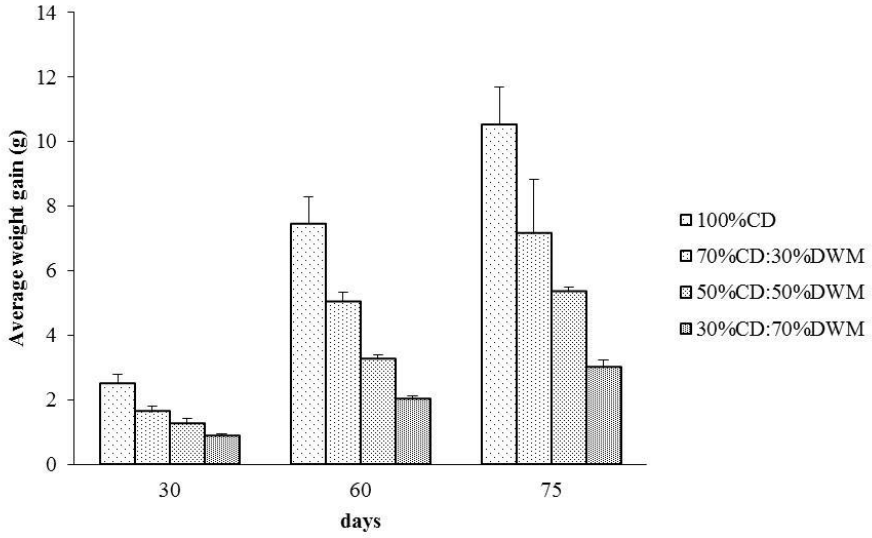

Figure 1. Average weight gain (g) of tilapia fingerlings fed with different ratios of commercial diet (CD) and dried water meal (DWM).

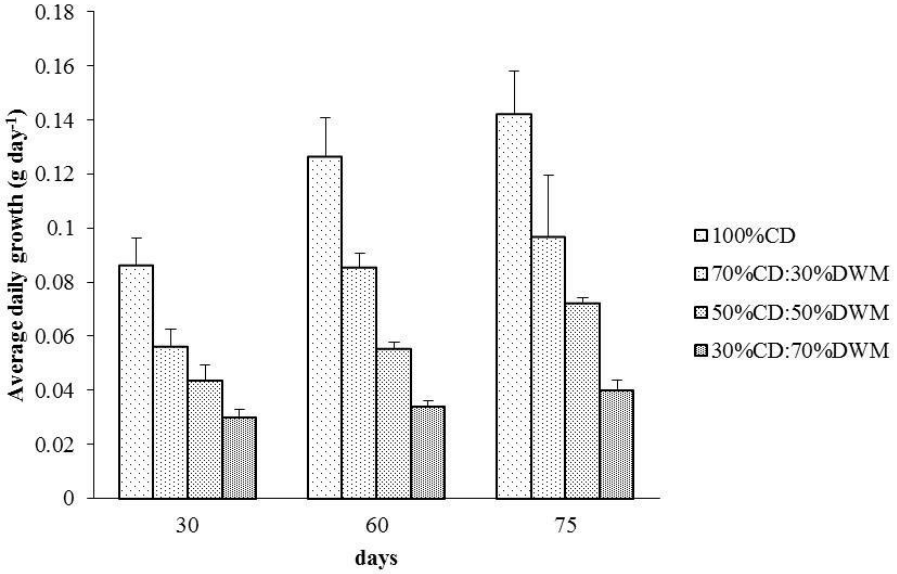

Figure 2. Average daily growth (g day^{-1}) of tilapia fingerlings fed with different ratios of commercial diet (CD) and dried water meal (DWM).

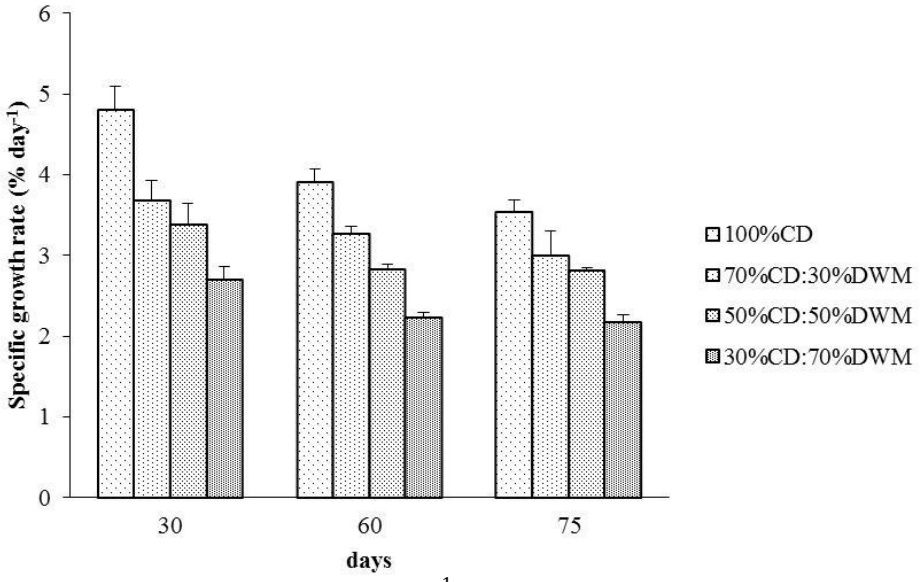

Figure 3. Specific growth rate (% day^{-1}) of tilapia fingerlings fed with different ratios of commercial diet (CD) and dried water meal (DWM).

The feed conversion ratio of fish were fed 100:0 of CD and DWM showed significantly lower than other treatments (1.61±0.18) but no significant difference when compared with 70:30 of CD and DWM feeding (2.21±0.58). The survival rates of fish at the end of experiment were about 96.66±1.15% to 99.33±1.15% and no significant difference when compared between treatments but the fish were fed 30:70 of CD and DWM was survival rate higher than other treatments (Table 1).

Table 1. Growth performances of tilapia fingerlings fed with different ratios of CD and DWM for 75 days.

	CD:DWM (%)			
Parameters	**100:0**	**70:30**	**50:50**	**30:70**
Average initial weight (g)	0.82±0.02	0.85±0.05	0.76±0.11	0.74±0.04
Average final weight (g)	11.36 ± 1.15^{a}	8.01 ± 1.68^{b}	6.12 ± 0.13^{b}	3.74 ± 0.24^{c}
Average weight gain (g)	10.54 ± 1.15^{a}	7.16 ± 1.68^{b}	5.36 ± 0.13^{b}	2.99 ± 0.24^{c}
Average daily growth (g day^{-1})	0.14 ± 0.01^{a}	0.09 ± 0.02^{b}	0.07 ± 0.001^{b}	0.04 ± 0.003^{c}
Specific growth rate (% day^{-1})	3.54 ± 0.14^{a}	3.00 ± 0.30^{b}	2.82 ± 0.02^{b}	2.18 ± 0.08^{c}
Food conversion ratio	1.61 ± 0.18^{a}	2.21 ± 0.58^{ab}	2.31 ± 0.05^{b}	3.38 ± 0.28^{c}
Survival rate (%)	97.33±3.05	97.33±1.15	96.66±1.15	99.33±1.15

Mean±S.D. in the same row carrying different superscripts were significant different ($p<0.05$).

The results on proximate analysis of DWM revealed that crude protein, crude fat, crude fibre and ash were approximately 28%, 2.8%, 13.5% and 18.19% respectively (Table 2).

Table 2. Mean value of proximate analyses on dry weight basis of water meal.

Item analysed	Means ±SD
Crude protein (%)	28.72 ±9.49
Crude fat (%)	2.81 ±0.61
Crude fibre (%)	13.54 ±1.09
Ash (%)	18.19 ±0.65
Calcium (%)	1.37 ±0.22
Phosphorus (%)	0.88 ±0.77
Gross energy (kcal Kg^{-1})	3,605.55 ±191.27

The nutritional values of fish before commencement of experiment found that crude protein, crude fat, crude fibre, ash, calcium, phosphorus and gross energy were approximately 70.06 ±0.24%, 6.16 ±0.14%, 1.24 ±0.22%, 15.74 ± 0.10%, 5.13 ±0.12%, 2.95 ±0.04% and 4303.73 ±131.19 kcal Kg^{-1} respectively. The effect of different feeding in CD and DWM ratios on nutritional values of fish at the end of experiment showed statistically significant differences in crude protein ($F = 4.25$; $p<0.05$), crude fat ($F = 19.27$; $p<0.05$), ash ($F = 7.49$; $p<0.05$), calcium ($F = 2.14$; $p<0.05$), phosphorus ($F = 10.22$; $p<0.05$) and gross energy ($F = 35.02$; $p<0.05$) but crude fibre showed no statistically significant differences between groups ($F = 1.59$; $p>0.05$) (Table 3).

Table 3. Nutritional values of tilapia fingerlings fed with different ratios of CD and DWM for 75 days

	CD : DWM (%)			
Item analysed	**100:0**	**70:30**	**50:50**	**30:70**
Crude protein (%)	67.75 ±1.21^{ab}	67.27 ±0.58^{b}	67.46 ±0.65^{b}	69.20 ±0.61^{a}
Crude fat (%)	12.30 ±1.04^{a}	11.40 ±0.73^{ab}	10.58 ±0.82^{b}	7.89 ±0.04^{c}
Crude fibre (%)	0.61 ±0.13	0.63 ±0.05	0.64 ±0.16	0.45 ±0.10
Ash (%)	13.86 ±0.12^{b}	15.25 ±0.70^{a}	15.62 ±0.42^{a}	15.75 ±0.31^{a}
Calcium (%)	4.14 ±0.26^{b}	4.56 ±0.33^{ab}	4.57 ±0.19^{ab}	4.66 ±0.10^{a}
Phosphorus (%)	2.65 ±0.01^{c}	2.79 ±0.09^{bc}	2.94 ±0.09^{ab}	3.01 ±0.06^{a}
Gross energy (kcal Kg^{-1})	4,686.85 ±74.17^{a}	4,498.63 ±49.53^{b}	4,468.30 ±23.31^{b}	4,303.76 ±15.10^{c}

Mean ±S.D. in the same row carrying different superscripts were significant different ($p<0.05$).

Crude protein content, ash, calcium and phosphorus on fish were fed 30:70 of CD and DWM showed significantly higher than other treatments (69.20 ±0.61%, 15.75 ±0.31%, 4.66 ±0.10% and 3.01 ±0.06% respectively). In the parts of fish fed with 100:0 of CD and DWM showed significantly higher than

other treatments in crude fat and gross energy (12.30±1.04% and 4,686.85 ±74.17 kcal Kg^{-1}).

During trials, water temperature ranged from 26.05±0.07 - 28.75±0.35 ℃, pH was between 7.71±0.04 – 8.42±0.01, DO was between 5.00±0.84 – 6.35± 0.63 mg L^{-1} and unionized ammonia (NH_3) ranged from 0.0013±0.026 – 0.026 ±0.495 mg L^{-1}.

Discussion

The obtained results showed that specific growth rate of fish at all treatments gradually decreased when the rearing time increasing because of specific growth rate will decline with increasing fish weight following time that the ingestion and metabolism of fish will against the body weight (Jobling, 1994). Growth performances of fish were fed much DWM tended to be lower than the fish fed with 100% CD because of the utilization pattern of DWM in this study as the grained DWM by direct feeding may be unfavorable for fish consumption. DWM had limited of water stability. The reasons of DWM conducting for utilization are shortage solution of fresh water meal which are observed in some seasons of natural water and supporting farmers to feed fish by water meal throughout the year. However, Tavares *et al.* (2008) studied the growth performance of tilapia fingerlings fed on 100% commercial feed (40% crude protein), 100% dried duckweed that was cut to a smaller size to facilitate feeding management and 50:50 of commercial feed and dried duckweed, their results indicated that the fish fed alone dried duckweek promoted the lowest weight gain and specific growth rate which are consistent with our results and they confirmed that dried duckweed can replace 50% (1:1 dry weight) tilapia fingerling 40% crude protein feed for a period of at least 50 days without reducing growth. In addition, the study of Ariyaratne (2010) on the potential of duckweed (*Wolffia arrhiza*) as fish feed in tilapia (*Oreochromis niloticus*) fry rearing, the results showed that average daily growth, final body weight and specific growth rate of fish were fed 100% fresh duckweed were lower than fish fed with 100% commercial feed. Nevertheless, *Wolffia arriza* could be use as feed for tilapia fry rearing and needed to determine the optimal amounts for feeding. Other applications of *Wolffia* or other duckweeds for tilapia rearing are mainly replacement the expensive ingredients in formulated diets (Chareon tesprasit and Jiwyam, 2001; Solomon and Okamoda, 2012; Olanniyi and Oladunjoye, 2012). Chareontesprasit and Jiwyam (2001) evaluated of Wolffia meal (*Wolffia arrhiza*) in replacing soybean meal in some formulated rations of tilapia (*Oreochromis niloticus* L.), the results revealed that the highest total production occurred in fish being fed on formulated ration containing 15%

Wolffia meal and it could be successfully used in place of soybean meal but the amount being used should not exceed 15%.

The carcesses of fish were fed 100% CD showed highest gross energy because of their bodies stored fat higher than fish in other treatments. The fish were fed 30:70 of CD and DWM had highest protein level in their bodies due to DWM contained protein higher than CD anywise fish in this group still been inadequate of non-protein energy necessary to growth (Kpogue *et al*., 2013). Therefore, fish were fed much DWM showed reduction of growth. At the initial and the end of experiment, observable crude protein of fish carcesses were very high about 67 - 70% equivalent to fish meal by reason of it was whole body proximate analysis which fish only were cut off the head and gut content before analysis. Then, the results showed quite high in crude protein, the quality fish meal will have 60 – 74% of crude protein (Jensen *et al.*, 1990; Anderson and Lall, 1994).

Tilapia fingerlings rearing with 70:30 of CD and DWM for 75 days, the fish weighed 8.01±1.68 g and the cost of CD for feeding was about 56.99 bahts Kg^{-1} when compared with control treatment, its production cost was about 65.21 bahts Kg^{-1}. In conclusion, the combined feeding between CD and DWM at 70:30 could reduce feed cost about 12.60% and showed no contrast on feed conversion ratio when compared with 100% CD feeding that is the best choice for DWM utilization.

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