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Submission date: 23-Apr-2022 08:11AM (UTC+0700)
Submission ID: 1817769905
File name: chmawati_2018_IOP_Conf._Ser.__Earth_Environ._Sci._137_012027.pdf (535.21K)
Word count: 6163
Character count: 30091

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To cite this article: D Rachmawati and I Samidjan 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **137** 012027

IOP Conf. Series: Earth and Environmental Science **137** (2018) 012027 doi:10.1088/1755-1315/137/1/012027

Performance efficiency of feed utilization, relative growth rate, and survival rate of common carp (*Cyprinus carpio*) through the addition of phytase in the feed

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Abstract. The purpose of this study was to determine the effect of adding phytase enzyme in the feed on digestibility of feed, efficiency of feed utilization, relative growth rate and survival rate of Common carp (*Cyprinus carpio*). Fish samples in this research were Common carp with an average - weight of 3.34 ± 0,16 g/fish. The treatments were adding the phytase enzyme in the feed with the different level of doses. Those were A (0 U kg^{-1} feed), B (500 U kg^{-1} feed), C (1.000 U kg^{-1} feed g) and D (1.500 U kg^{-1} feed). Observation was conducted on digestibility of protein (ADC_P), digestibility of phosphor (ADC_F), efficiency of feed utilization (EFU), relative growth rate (RGR), protein efficiency ratio (PER), feed conversion ratio (FCR), survival rate (SR) and water quality parameters. The results show that the addition of phytase enzyme significantly (P<0.01) affected on ADC_P, ADC_F, EFU, RGR, FCR, and PER, on the other hand it insignificantly (P>0.05) affected on SR of common carp. Based on results, it was concluded that optimum doses of phytase enzyme feed in terms of digestibility of feed, efficiency utilization of Feed and growth rate of Common carp ranges from 943 to 1100 U kg^{-1} feed

1. Introduction

Intensive common carp (*Cyprinus carpio*) aquaculture needs feed that contains complete nutrients. It should also be efficient and economical. Common carp (*C. carpio*) highly needs complete feed, which contains fat, protein, carbohydrate, vitamins, and minerals. Protein is the most important element in the feed to support growth [1]. Protein in the feed can be from plant-based protein or animal-based protein. However, the use of such plant ingredients in aqua feed is limited because of the presence of wide variety of anti-nutrient compounds [2], which have deleterious effects on the physiology and morphology of the digestive tract [3, 4], thereby affecting the overall fish growth [5, 6]. Plant-based feed from soybean meal has a drawback because soybean meal contains the anti-nutrient phytic acid. Phytic acid can hinder the absorption of plant-based protein by fish. Around 80% of the available phosphor (P) is in phytic acid [7]. Phramkunthong *et al*. [9] mentioned that the content of phytic acid in soybean meal was 3.88%, with as much as 59.9% of it was phosphor [8]. Gatlin *et al*. [10] stated that most plant-based feed contained high fiber that was difficult to digest; therefore, fish cannot utilize the feed well [9]. Moreover, Masumato *et al*. [11] reported that phytic acid can reduce digestibility of protein and minerals such as K, Mg, Ca, Zn, Fe, and Cu [10]. To solve these problems the enzyme phytase can be added in the feed.

An increase in the use of plant-based feed creates another problem. It produces phosphoric pollutant in the water. According to Masumoto *et al*. [11], Cheng *et al*. [12], Depnath *et al*. [13], Rachmawati *et* *al*. [14], phosphor in plant-based feed cannot be fully utilized by the fish due to lack of the enzyme phytase that decomposes phytic acid. Moreover, Kumar *et al*. [15] explained that phytic acid bound 80% of the total phosphor available in plant-based feed. Phytic acid in the feed is excreted along with feces into the environment, then it is degraded by microbes that produce phytase and the phosphor is then released into the water. High phosphor concentration in the water will trigger eutrofication that hinders cultivation of fish [7]. Jagannathan *et al*. [16] reported that phosphor is a macro nutrient that is needed by animals including fish.

Chung [17] suggested that to add phytase to overcome the problem of phytic acid. This enzyme can hydrolyze phytic acid into inositol and phosphoric acid; in turn, it can eliminate metal-chelating character [8]. Moreover, Chung [17] mentioned that phytase increased nutrient absorption and regulated nutrient excretion, such as phosphor, nitrogen, and minerals. Some researchers studied on addition of phytase in artificial feed, such as, by [14, 18, 19, 20, 21, 22]. Husain *et al*. [18] and they found that the optimal dose of phytase on the fingerlings of *Labeo rohita* was 750 FTU kg^{-1} feed. Shapawi *et al*. [19] suggested that 30 % of soy bean meal with the addition of phytase (2000 FTU kg^{-1} feed) formed an optimal dose for *Ephinephelus fuscoguttatus* fish. Moreover, Bulbul *et al*. [20] reported that supplementing phytase in feed can increase nutrient digestibility and growth of shrimp (*Marsupenaeus japonicas*). Danwitz *et al*. [21], also mentioned that the dose of phytase at 2000 Ukg^{-1} feed could increase growth, protein digestibility, and phosphor of turbot fish (*Psetta maxima* L.). Rachmawati and Samidjan [22], also reported that the dose of phytase at 1000 FTU kg^{-1} feed increased growth of shrimp (*Penaeus monodon*). Moreover, Rachmawati *et al*. [14], stated that 1000 FTU kg^{-1} feed of phytase increased digestibility and growth of fish (*Channos channos*). Based on the above discussion, this research was aimed to study effects of phytase on digestibility of feed, efficiency of feed utilization, relative growth rate, and survival rate of common carp (*C. carpio*) through the addition of phytase in the feed and also to determine the optimal dose of phytase.

2. Methodology

Fish used in this study was fingerlings of common carp (*C. carpio*) with the average weight of 3.34 ± 0.16 g/fish. The fish was obtained from Magelang, Central Java, Indonesia. Density of fingerlings was 25 fish per m^3 [23]. The fish was selected on the base of size uniformity, health, completeness of organs, and lack of potential diseases. The selected fish was placed in to the cultivation container for 7 (seven) days in order to adapt to the environment and fed with feed without phytase. After 7 (seven) days, the fish was left to fast for one day to empty waste of its metabolism; therefore, at the beginning of the study, the fish could be weighed without any waste of metabolism in the body [14]. The sampled fish was raised for 42 days and fed at satiation 3 (three) times a day at 08:00, 12:00, and 16:00 o clock. The sampled fish was weighed every 7 (seven) days.

Containers used in the study were happas with the dimensions of 1 m x 1 m x 0.6 m. The experiment was conducted with 4 (four) treatments and 3 (three) repetitions. happas were Then put in the pond with the dimensions of 13 m x 12 m x 1 m equipped with inlet and outlet to circulate the water [23].

The study used artificial feed in the form of pellet containing 30% protein and added phytase. The doses of enzyme were A (0 U kg^{-1} feed), B (500 U kg^{-1} feed), C (1000 U kg^{-1} feed), and D (1500 U kg^{-1} feed). The enzyme doses used in this study were modified from the results of a study by Baruah *et al*. [24] that suggested phytase, as much as 750 U kg^{-1} feed was the optimum level for the growth of fingerlings *Labeo rohita*. Each feed was fed thrice daily (07.00, 12.00, and 17.00 h) to approximate satiation for 42 d. Initially, feeds were fed at 3% of the body weight and subsequently adjusted based on daily intake. Round-the-clock aeration was provided to all the containers from a compressed air pump, and manual water exchange was carried out daily. Water quality parameters were checked every week using the methods as described by APHA [25].

The feed was made of fish meal, soybean meal, corn meal, rice bran, wheat flour, fish and corn oils, vitamins and minerals, CMC, phytase, and Cr_2O_3, where fish meal functioned as a source of animal protein, soybean meal as a source of plant-based protein, corn meal, rice bran, and wheat flour as sources of carbohydrate, fish oil and corn oil as sources of fat, vitamin mix and mineral mix as sources of vitamins and minerals, CMC as a binder, phytase to unbind phytic acid; and Cr_2O_3 as much as 0.5 % [1]. Proximate analysis was conducted to determine the nutrient content of feed and feed composition used in this study [26]. Phytase used was purchased commercially with the brand name Natuphos 5000G, produced by PT. BASF Indonesia. One unit of phytase activity (*Phytase Unit*) was defined as the amount of enzyme that releases 1 micro molecule of non organic per minute from 0.0051 mol/l of phytic acid at pH 5.5 and 37 ^{o}C [24].

The procedure to prepare feed was started with dissolving an appropriate dose of phytase into warm water (45° C) and then mixing with soybean meal evenly. The mixture was stored in the air-sealed container for 24 h [27]. According to National Research Council (NRC) [1], feed is made by mixing the least amount of the ingredients first and gradually adding and mixing other ingredients with larger amounts except fat sources that are added after all the ingredients have been mixed. The mixture was then formed into granules with diameter of 1-2 mm. Then, the feed was dried in the oven at 40 °C. The composition and results of proximate analysis of the feed can be seen in table 1.

Table 1. Composition and proximate analysis in the artificial feed.

Ingredients	Composition			
	A	B	C	D
Phyetase enzyme	0	0.5	1	1.5
Fish meal	26	26	26	26
Soybean meal	24	24	24	24
Corn meal	16.5	16.5	16.5	16.5
Rice bran	14	14	14	14
Wheat flour	12.0	11.5	11.0	10.5
Fish oil	1.00	1.00	1.00	1.00
Corn fish	1.00	1.00	1.00	1.00
Vit Min Mix	3.00	3.00	3.00	3.00
Cr_2O_3	0.5	0.5	0.5	0.5
CMC	2.00	2.00	2.00	2.00
Total (g)	100	100	100	100
Proximate analysis results				
Protein (%)*	30.18	30.17	30.14	30.16
Fat(%) *	7.39	7.38	7.34	7.37
Extracted materials without nitrogen (%)*	42.52	42.49	42.48	42.41
Energy (kkal)	271.79	271.62	271.13	271.29
Ratio E/P	9.01	9.00	8.98	9.00

Notes:
a. The values were calculated based Digestible Energy for 1 g protein equals 3.5 kcal, 1 g fat equals 8.1 kcal, and 1 g carbohydrate equals 2.5 kcal [19].
b. According to Bulbul *et al*. [20], the optimal E/P ratio for growth ranges from 8 kcal/g to 12kcal/g.
*Animal Nutrient Laboratory, Faculty of Husbandry and Agriculture, Diponegoro University (2017)

Data collected were ADC_P and ADC_F according to Fenucci [30], EFU, RGR, PER, FCR according to Tacon [31], and SR according to National Research Council [1]. The chromic oxide level in feeds and feces were analyzed using a modified colorimetric method Tacon [31] using a spectrophotometer (at 540 nm) (Shimadzu UV-2102 PC, UV-visible Scanning Spectrophotometer) after perchloric acid oxidation and formation of a colored complex with diphenylcarbazide (DPC). Samples were analyzed to determine concentration of phosphor (P) by flame atomic absorption spectrophotometer Shimadzu

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AA6800 (Shimadzu, Japan). Variables of water quality that were tested were pH, DO, temperature, and Ammoniac (HANNA: HI. 8633). Aerator to recirculate the water was placed in every container.

$$ADC_P : 100\% \left\{ \frac{Cr_2O_3 \text{ in the feed}}{\% \; Cr_2O_3 \text{ in the feces}} \times \frac{\% \text{ protein in the feces}}{\% \text{ protein in the feed}} \right\} \quad (1)$$

$$ADC_F : 100\% \left\{ \frac{Cr_2O_3 \text{ in the feed}}{\% \; Cr_2O_3 \text{ in the feces}} \times \frac{\% \text{ phosphor in the feces}}{\% \text{ phosphor in the feed}} \right\} \quad (2)$$

$$EFU : \frac{\text{Final weight} - \text{Initial weight}}{\text{The amount of feed consumed}} \times 100\% \quad (3)$$

$$RGR : \frac{\text{Final weight} - \text{Initial weight}}{\text{Initial weight} \times \text{Time experiment}} \times 100\% \quad (4)$$

$$PER : \frac{\text{Final weight} - \text{Initial weight}}{\text{The amount of feed consumed} \times \text{Protein content of feed}} \times 100\% \quad (5)$$

$$FCR : \frac{\text{The amount of feed consumed}}{(\text{Final weight} + \text{Total weight fish death}) - \text{Initial weight})} \times 100\ \% \quad (6)$$

$$SR : \frac{(\text{Final count})}{\text{Initial count}} \times 100\%$$

Analysis of variance (ANOVA) was used to analyze the data. Before analysis, the data were first tested for normality, additivity, and homogeneity. The tests was to make sure that the data were normal, homogenous, and had additive property. If the analysis of variance was significant ($p<0.05$) or highly significant ($p<0.01$), Duncan test was conducted to find out the differences among the treatments, while water quality data were descriptively analyzed. To determine optimal dose of phytase, polynomial orthogonal test was conducted using SAS9 and Maple12 [23].

3. Results and Discussion

The results of study on common carp (*C. carpio*) for ADC_P, ADC_F, EFU, RGR, PER, FCR, and SR are shown in table 2.

Table 2. The values of ADC_P, ADC_F, EFU, RGR, PER, FCR, and SR common carp.

Treatment	Data						
	ADC_P (%)	ADC_F (%)	EFU (%)	RGR (%/hari)	PER	FCR	SR (%)
A	63.68±0.07^c	54.65±0.06^c	50.15±0.81^c	2.17 ±0.06^c	1.68±0.03^c	1.70±0.07^c	89.00±4.00^a
B	78.91±0.07^b	74.41±0.06^b	57.23±3.46^b	2.63.±0.26^b	1.98±0.12^b	1.48±0.04^b	87.78±6.11^a
C	85.13±0.07^a	81.23±0.06^a	67.34±2.09^a	3.16 ±0.23^a	2.18±0.07^a	1.39±0.03^a	89.00±4.00^a
D	77.52±0.07^b	73.52±0.06^b	54.23±4.15^b	2.43 ±0.25^b	1.78±0.14^b	1.59±0.12^b	90.37±2.31^a

Note: The Values with the same superscripts in the column show that there was no difference

The addition of phytase significantly ($P<0.01$) affected protein and phosphor digestibility of common carp (*Cyprinus carpio*). Table 2 shows that addition of phytase at 500-1000 U kg^{-1} feed could increase the digestibility of protein and phosphor. Similar finding was also reported by Storebakken *et al*. [33] where addition of enzyme in the feed increased digestibility and retention of protein. Rachmawati and Samidjan [22] also suggested that the raw protein and total protein digestibility depended on the ability of the fish to absorb the nutrients. The increased feed digestibility was followed by the increase of PER (2.18) and EFU (67.34 %); therefore, it positively affected the RGR (3.16 %/day). Debnath *et al*. [13] also found that Atlantic salmon increased its protein digestibility and retention when phytase was added to its feed; meanwhile, without addition of phytase, it resulted in low digestibility and retention of protein. Hunter [34] found that the addition of enzyme increased protein digestibility from 84.5 % to 87.7 %. Similar results were found in the species of carp [35], rainbow trout [36, 37], and *Labeo rohita* [18]. Other researchers have observed that addition of phytase in feed made of plant ingredients increased protein digestibility due to the breakdown of phytin-protein complex [14, 22, 24]. According to Husain *et al*. [8], also reported that phytase can unbind anti-nutrient in feed, such as phytic acid, non-starch polysaccharide, and trypsin inhibitor, and it also improved nutrient digestibility. The equation resulted from orthogonal test was a cubical equation as $Y = -0.0000000006x^3 - 0.0000008x^2 + 0.0363x + 63.683$, $R^2 = 0.99$ figure 1). The optimum dose of the phytase in feed was 1040 U kg^{-1} feed, with the maximum value of ADC_P 86.03 %.

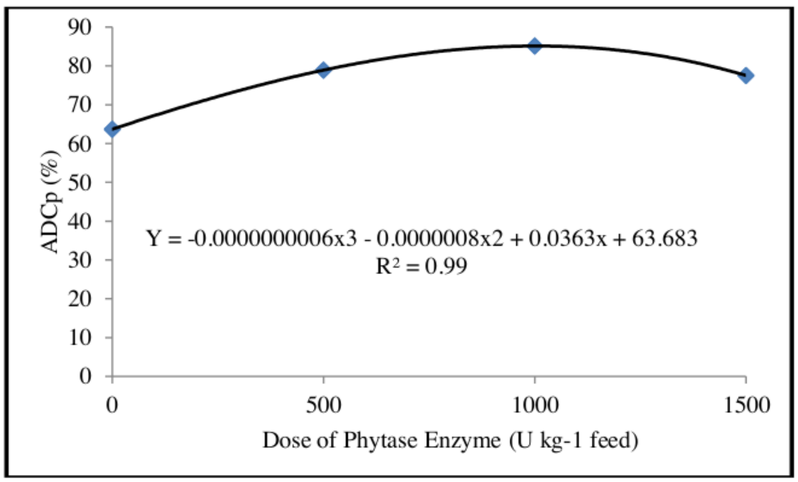

Figure 1. ADC_P polynomial orthogonal (%) of common carp (*C. carpio*).

Digestibility of phosphor is one of the most sensitive criteria for assessing the influence of phytase on phosphor utilization in fish [38]. In the present study, digestibility of phosphor was increased with phytase supplementation, confirming the established properties of phytate with respect to nutrient availabilities in feed. phosphor digestibility increased from 54.65 to 81.23%, but the relationship was not linear. The equation resulted from orthogonal test was a cubical equation as $Y = -0.0000000002x^3 - 0.000002x^2 + 0.0514x + 54.653$, $R^2 = 1$ (figure 2). The optimum dose of phytase in the feed was 1100 U kg^{-1} feed, with the maximum value of ADC_F 84.24 %.

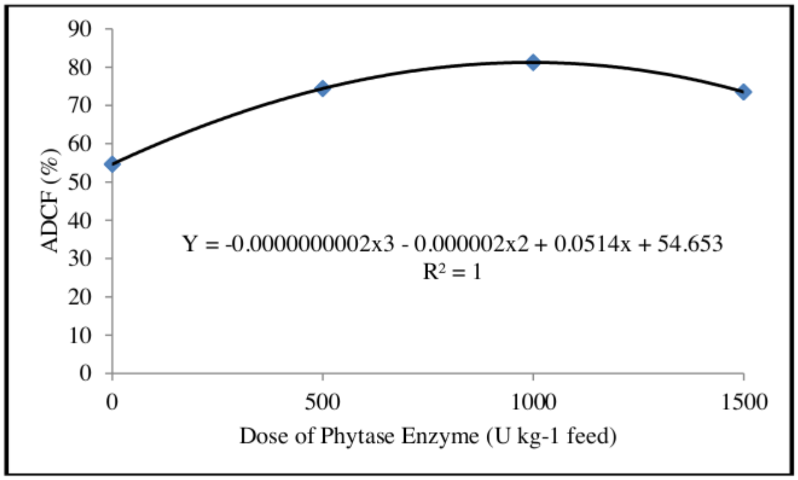

Figure 2. ADC_F Polynomial Orthogonal (%) of Common carp (*C. carpio*)

The highest efficiency of feed utilization was in treatment C with (1000 U kg^{-1} feed phytase) with 67.34 %, while the lowest was treatment A (0 mg kg^{-1} feed phytase) with 50.15 %. treatment C (1000 U kg^{-1} feed) had the highest growth as it was expected, due to the suitable dose of phytase to effectively hydrolyze phytic acid in soybean meal. In turn, it could help the fish to digest nutrient and mineral very well. The same results were also reported by several author [14, 20, 21, 22]. The high efficiency of feed utilization shows that the fish can efficiently absorb protein to support their growth instead of using it for metabolism, osmoregulation, and reproduction. growth happens when there is an excess energy from activities for survival, such as breathing, swimming, metabolism, and maintenance. low efficiency of feed utilization indicated that the fish need more feed to grow. Density and protein content in the feed also influences feed utilization efficiency [39]. Addition of phytase can break down complex compound, therefore they were able to be absorbed by the digestion system and distributed to the whole body optimally, as suggested by Bulbul *et al*. [20] who stated that addition of phytase in soybean meal could increase feed utilization efficiency better than that of fish meal.

The lowest efficiency of feed utilization was in treatment A (0 U kg^{-1} feed phytase), since the fish were not able to absorb the nutrient efficiently due to the existence of phytic acid. Low efficiency of feed utilization also indicated the decrease of feed quality, as suggested by Qinghui dan Xiaojun [40] who mentioned that the absence of phytase in the digestion system of fish caused the nutrient in the soybean meal difficult to be absorbed, thus the nutrients would be excreted with feces. The equation resulted from orthogonal test was a cubical equation as $Y = -0.000000004x^3 + 0.000006x^2 - 0.0064x + 50.51$, $R^2 = 0.88$ (figure 3). The optimum dose of phytase in the feed was 943 U kg^{-1} feed with the maximum value of EFU at 63.93%.

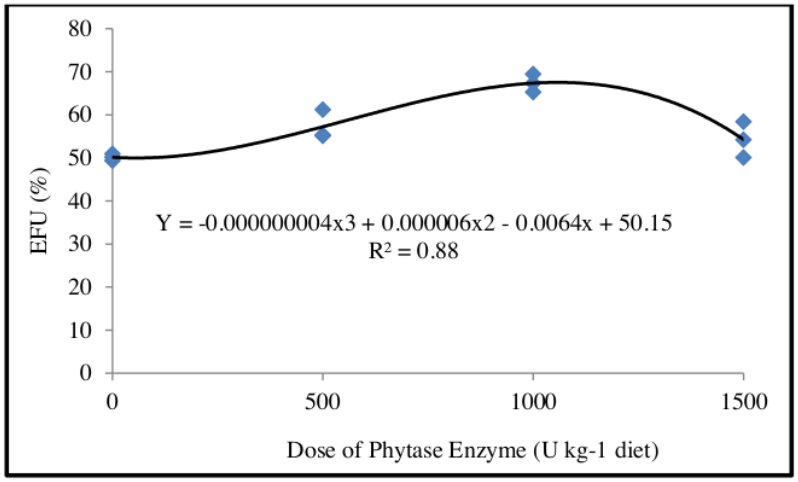

Figure 3. EFU polynomial orthogonal (%) of common carp (*C. carpio*).

The Analysis of Variance showed that different doses of phytase in the artificial feed had significant effects (P<0,01) on RGR of common carp (*C. carpio*). growth rate is related to addition of body weight from utilization of protein in the feed. protein could be hardly absorbed due to the existence of phytic acid that hinders the availability of minerals and suppresses growth of the cultivant. phytase is able to hydrolyze protein bound by phytic acid into amino acids that are readily digested by the fish. The more protein digested, the higher the energy the fish get to grow [41, 42]. palatability is also increased with addition of phytase since it breaks down phytate-protein and phytate-minerals bounds, thus It can increase the fish growth . This phenomenon was proven by Rachmawati and Istiyanto [22] in their study that showed phytase broke down phytic acid into inositol and phosphate acid. Inositol is a compound that is needed to support normal growth and maintain reproduction. Baruah *et al.* [24] and Fox *et al.* [27] also reported that there was an increase in the growth, raw protein coefficiency, sulfur, total phosphor, and phytate-phosphor of rainbow trout, after they were fed with plant-based feed supplemented with phytase.

A significant increase in growth was concurrent with increase in phytase concentration to a level of 1000 U kg^{-1} feed, after which it decreased. it indicated that concentration of 1000 U kg^{-1} feed was effective in enhancing the bioavailability of nutrients for common carp (*C. carpio*). The positive effect of phytase on growth performance of the fingerlings in the present study was consistent with the results obtained by various authors [12, 13, 20, 24, 35, 37, 43, 44].

The highest growth was obtained treatment C (1000 U kg^{-1} feed) with 3.16 %/day, and the lowest growth was treatment A (0 U kg^{-1} feed) with 2.18 %/day. treatment C had the highest growth as expected due to suitable dose of phytase; therefore it could effectively hydrolyze phytic acid. In turn, it could make the fish to digest nutrient and minerals very well. This results was also supported by Nwanna *et al*. [45], in their study that showed addition of phytase could release phosphor and minerals from phytic acid, so the fish could absorb the nutrient effectively. Moreover, Carter and Sajjadi [6] also proved that addition of phytase could increase digestibility of phosphor and reduce the effect of anti-nutrient compounds. treatment A (0 U kg^{-1} feed) had the lowest RGR. It was suggested that phytic acid in the feed was still intact and it caused the fish not to be able to digest nutrients and minerals. similar results were also obtained in a study on carp [47], African catfish [48], striped bass [49], rainbow trout [35], and Atlantic salmon [38], Korean Sebastes schlegeli [44], *Penaeus monodon* [22], and *Channos channos* [14]. The equation resulted from the orthogonal test was cubical equation as $Y = -0.0000000002x^3 +$

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$0.0000003x^2 - 0.000007x + 2.17$, $R^2 = 0.81$ (figure 4). The optimum dose of phytase in the feed was 988 U/kg feed, with the maximum value of RGR 3.10 %/day.

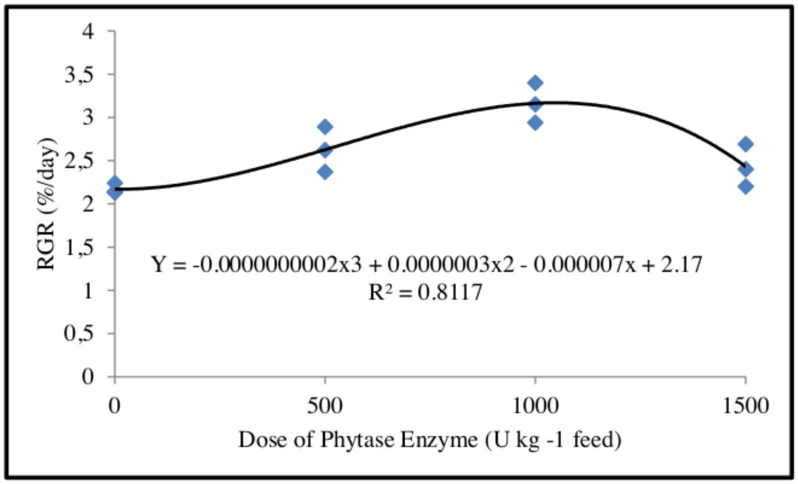

Figure 4. RGR polynomial orthogonal (%/day) of common carp (*C. carpio*).

The results of variance analysis showed that addition of phytase significantly (P<0,01) influenced PER of common carp (C. *carpio*). The highest protein conversion was showed by treatment C (1000 U phytase kg^{-1}feed). It was suggested that the protein broke down into amino acids, so the fish could easily digest it. In turn, it increased protein efficiency ratio, as reported by Rachmawati and Istiyanto [22]. Moreover, Danwitz *et al*. [21] found addition of phytase in feed increased nutrient digestibility, feed utilization, and growth of turbot fish. He also suggested that the enzyme addition could increase protein utilization. These findings were also supported by Trichet *et al*. [50], who reported that addition of phytase could hydrolyze phytic acid, so the fish could easily digest raw protein.

The lowest protein efficiency ratio was 1.68 in treatment A (0 U phytase $k^{-1}g$ feed) . It was expected that phytic acid in the feed had not been broken down yet into amino acids. This finding was supported by Gatlin *et al*. [10] who found phytic acid could create complex compound by capturing calcium, magnesium, cuprum, zinc, carbohydrate, and protein. The equation resulted from orthogonal test was cubical equation as $Y = - 0.00000000007x^3 + 0.00000009x^2 + 0.0003x + 1.68$, $R^2 = 0.85$ (figure 5). The optimum dose of phytase in feed was 1000 U kg^{-1} feed with the maximum value of PER 2.18.

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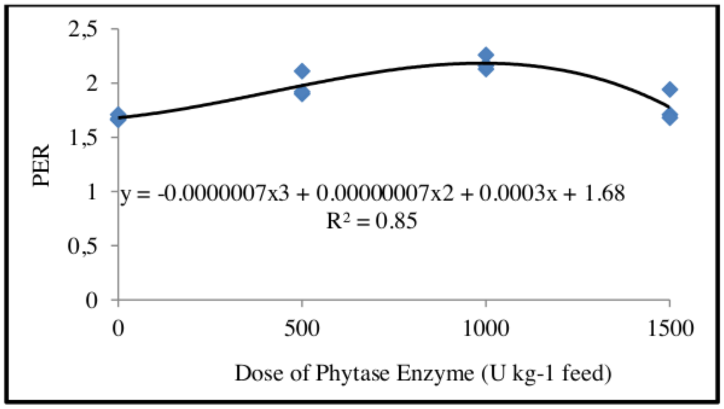

Figure 5. PER polynomial orthogonal of common carp (*C. carpio*).

The enzyme addition can increase palatability and FCR since phytase breaks down the bound between phytic acid and protein and minerals [51]. The results indicated that treatment C (1000 U phytase kg^{-1} feed) had the lowest FCR, i.e. 1.39. It was suggested that the dose had suitable amount of phytase, so it resulted in the lowest FCR. Feed conversion is highly related to the efficiency of feed utilization. optimum feed utilization would generate abundant energy. Energy was produced from the breakdown of protein into amino acids. Due to the availability of simple compounds so the fish were able to digest nutrients very well [39]. Feed conversion was an indicator of feed utilization efficiency. The lower the feed conversion, the more efficient the use of feed by the fish.

high growth and feed efficiency make feed conversion low. treatment C (1000 U phytase kg^{-1} feed) increased growth and feed efficiency; therefore, they made feed conversion low. These findings were supported by Storebakken *et al*. [33], who suggested that Atlantic salmon fed with protein made of soybean meal with addition of phytase resulted in better feed conversion. Moreover, Hassan *et al*. [51], also reported that addition of phytase in the feed increased the palatability and feed conversion because it could break down the bound between phytic acid and protein and minerals. According to Debnath *et al*. [13], also suggested that addition of phytase in feed can generate feed conversion better in catfish (*Pangasius pangasius*). The equation resulted from orthogonal test was cubical equation as $Y = -0.00000000002x^3 - 0.000000006x^2 - 0.0005x + 1.7033$, $R^2 = 0.80$ (figure 6). The optimum dose of the phytase in the feed was 1000 U kg^{-1} feed with the maximum value of FCR 1.39.

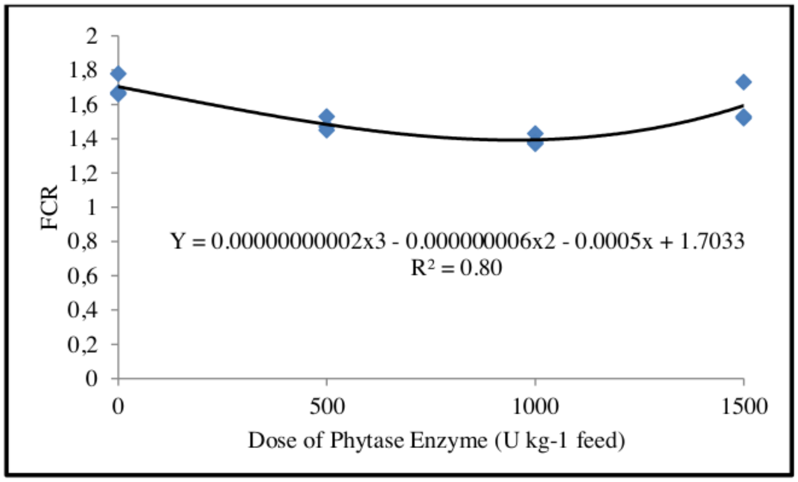

Figure 6. FCR polynomial orthogonal of common carp (*C. carpio*)

The results of variance analysis showed that addition of phytase in feed insignificantly (P>0.05) affected SR of common carp (*C. carpio*). According to Yakuputiyage [52], feed is not a factor that influences survival rate, because survival rate is affected by the initial treatment of the fish and quality of the cultivation media. The same results were also reported by Rachmawati *et al.* [14], Rachmawati and Istiyanto [22], Viela *et al.* [35], Sajjadi and Carter 38], Yoo *et al.* [44], Schaefer *et al.* [47], Weerd *et al.* [48], Papatryphon *et al.* [49], who reported that survival rate was affected by fish gender, heredity, age, reproduction, disease resistance, and external factors such as water quality, density, amount, and composition of amino acids in the feed [53]. quality of Water during the research was on viable condition for common carp (*C. carpio*). Measurements of water parameter during cultivation of common carp (*C. carpio*) are shown in table 3.

Table 3. Parameters of water quality for common carp (*C. carpio*) cultivation.

Treatment	Water Quality			
	Temperature (⁰C)	pH	DO (mg/l)	NH_3 (%)
A	26 – 33	7.50 – 7.85	3.30 – 3.55	0.0072 – 0.0074
B	26 – 33	7.50 – 7.82	3.24 – 3.48	0.0072 – 0.0074
C	26 – 33	7.50 – 7.81	3.28 – 3.58	0.0072 – 0.0074
D	26 – 33	7.50 – 7.81	3.32 – 3.53	0.0072 – 0.0074
Feasibility	14-38*	6.50 – 8.5*	>2*	<0.1*

Note : * [54]

4. Conclusion

Addition of phytase in feed significantly increased digestibility of feed, efficiency of feed utilization, and relative growth rate of common carp (*Cyprinus carpio*). The optimal doses of phytase based on ACD_p, ACD_f, EFU,RGR,PRR and FCR in common carp (*C. carpio*) were 1040, 1100, 943, 988, 1000 and 1000 U kg^{-1} feed respectively.

5. References

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Acknowledgments
Appreciation are expressed to those who helped this study, especially for the Head of the Hatchery Center and Freshwater Aquaculture, Muntilan, Central Java, Indonesia who has provided its laboratory to do the study

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