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Effect of Supplementation Yeast Fermented *Acacia mangium* Leaf in Diets on Growth Performance, Carcass Quality, and Haematology of Climbing Perch (*Anabas testudineus*)

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Abstract: A total of 360 juvenile *Anabas testudineus* of mean weight (2.88 ± 0.02 g/fish) were randomly distributed in triplicate of 20 fish per tank. *Acacia mangium* leave meal (AM) and yeast-fermented *Acacia mangium* leave meal (FAM) were used at 0, 2.5, 2.5, 5, 7.5, and 10 % supplemental in the experimental diets. They were fed for 12 weeks to *A. testudineus* fingerling stocked in 18 plastic tanks (200 liters) set up to recirculation system. Results indicated that the final body weight, weight gain, FCR, SGR, and PER were the best in treatment 4 (FAM 5.0%), significantly different ($P < 0.05$) from other FAM and AM treatments. There was no significant difference ($P > 0.05$) in HSI, FR, VSI, L*, a*, and b* across the test diets. The hematological indices' result showed no significant difference($P > 0.05$) in hematocrit and red blood cells among the experimental groups. However, the thrombocyte and lymphocyte were significantly different ($P < 0.05$) in experimental diets FAM 5.0% and FAM 7.5% compared to AM 2.5%, FAM 2.5%, and FAM 10%. The study showed that the inclusion of yeast-fermented *Acacia mangium* leave meal (FAM) at 5% had the best-enhanced growth performance and feed utilization without any adverse effect on the fish carcass quality and hematological indices.

Keywords: Yeast fermented; *Acacia mangium*; Growth performance; *Anabas testudineus*

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1. Introduction

The culture of climbing perch (*Anabas testudineus*) has long been implemented in Chumphon, Thailand. This fish has become the most popular cultural species in this region, with high economic value and demand. The climbing perch is commercially important and its value in Thailand was USD 19.13 million in 2010 [1]. This is due to its reasonable growth rate and resistance to pathogens, a favorite for consumption in Thailand. Besides that, scientists have focused their research on genetics development and the use of immunostimulants to improve growth performance and enhance fish disease resistance [2]. Using an immunostimulant could also potentially promote fish

growth [3]. Moreover, Immunostimulant does not leave any residue in fish bodies and the environment and is not harmful to human health. Baker's yeast (*Saccharomyces cerevisiae*) is a natural product from the baker's yeast industry that contains various immunostimulating compounds such as β-glucan, nucleic acid, mannan oligosaccharides, and chitin [4]. Fermentation of baker's yeast cells in *Acacia mangium* leaves meal and supplement the combination in diets has been proven to enhance fish growth and immunity [5].

Acacia mangium is a fast-growing species that can maintain active growth during the dry season and is used for reforestation in tropical regions [4]. It is the most common tree in many areas in southeast Asia and other tropical countries. Despite the documented low intake and degradability of *Acacia mangium*, there is an interest in finding the optimal way to feed this foliage[6]. The crude protein content in acacia foliage is relatively high, from 162 g to 170 g CP/kg dry matter [7]. The *Acacia mangium* leaves meal (AM) so obtained contained, on a dry weight basis, 15.97% crude protein, 2.25 % lipid, 4.04% ash, and 25% crude fiber [8]. Supplemented with 10% *Acacia mangium* leaves meal mixed with 10% coconut meal was found to have a suitable level to fulfill the growth performance of Nile tilapia(*Oreochromis nilitcus*) [9]. The nutrient digestibility of *Acacia mangium* leave is also low but was improved by fermentation with Baker's yeast (*Saccharomyces cerevisiae*) [10]. The use of brewer's yeast has positively affected several fish species' performance and welfare. The inclusion of 30–50% brewers yeast in the diet improved the feed efficiency of European seabass [11]

The objectives of this study were to examine the effect of supplementation of yeast-fermented *Acacia mangium* leaves meal on growth performance, carcass quality, and hematology of climbing perch (*Anabas testudineus*).

2. Materials and Methods

2.1 Sample preparation

The Baker's yeast (*Saccharomyces cerevisiae*) was purchased from a store at Pathiu market in Chumphon, Thailand. Mature *Acacia mangium* (AM) leaves were collected from the Inland Aquaculture field, King Mongkut's Institute of Technology Ladkrabang, Prince of Chumphon Campus (KMITL PCC), Chumphon, Thailand and dried in a hot air oven in 60 °C for 36 hours, and ground into powder using an electric blender. After passing through a 550 mm mesh sieve, the AM was fermented with *S. cerevisiae* yeast.

2.2 Solid state fermentation of Acacia mangium leave using S. cerevisiae

Eighty grams of *Acacia mangium* leaves were weighed into a 250 ml conical flask. The powdered leaves were mixed with liquid basal medium containing distilled water, 0.8 g of urea, 24 g of molasses, 16 g of tapioca starch, 0.56 g of $MgSO_4.2H_2O$ and 1.04 g KH_2PO_4 to obtain a final moisture content of 60%. The mixture was sterilized at 121 °C for 15 minutes and then cooled to room temperature (27 ± 2 °C). Four grams (6.77×10^6 CFU/g) of fermented yeast powder was added to the sterilized *Acacia mangium* leaves in the 250 ml conical flasks, mixed gently, loosely covered with aluminum foil, and incubated at 27 °C for 5 days with intermittent manual shaking. During incubation, samples were collected at 24 h for yeast cell count, spread on metallic trays, and oven-dried at 600 °C for 5 h, cooled to 27 ± 2 °C, milled, and packaged in air-tight containers [11].

2.3 Diet formulation and preparation

The formulations of the experimental diets for the supplementation of yeast-fermented *Acacia mangium* leaves meal (FAM) study are shown in Table 1. The fermented *Acacia mangium* leaves meal (FAM) was serially included at the rates of 2.5, 5, 7.5, and 10%, whereas unfermented *Acacia mangium* leaves meal (AM) was included at 2.5%. The control diet had no added AM or FAM. All diets were formulated to be isonitrogenous (40% crude protein) and isoenergetic (4,500 kcal/kg diet) [12]. The experimental diets were prepared following the procedure described by Nalinanon et al. [13]. The FAM was randomized for initial yeast cell count before supplementing to the experimental diets.

Table 1. The formulations and composition of the experimental diets are shown in Table 1.

Ingredient (%) As-fed basis	Treatments					
	Control 0%	**AM 2.5%**	**FAM 2.5%**	**FAM 5%**	**FAM 7.5%**	**FAM 10%**
Corn starch	2	1.5	1.5	1.5	1.5	1.5
Brocken rice	12.6	11.3	11.3	10.0	9.8	9.6
Rice bran	15.4	15.2	15.1	14.2	12.0	9.8
Fish meal (60% CP)	40.0	40.0	40.0	40.0	40.0	40.0
Soybean meal (45% CP)	27.0	26.5	26.6	26.3	26.2	26.1
AM	0	2.5	0	0	0	0
FAM	0	0	2.5	5.0	7.5	10.0
DCP (P17)	0.5	0.5	0.5	0.5	0.5	0.5
Premix[1]	1.0	1.0	1.0	1.0	1.0	1.0
Binder	1.0	1.0	1.0	1.0	1.0	1.0
Palm oil	0.5	0.5	0.5	0.5	0.5	0.5
Total (g)	100	100	100	100	100	100
Nutrient analysis [10]						
Moisture (%)	8.92	9.03	9.12	9.05	8.98	9.00
Crude protein (%)	40.02	40.03	40.02	40.04	40.01	40.05
Gross energy (Kcal/Kg)	4442.80	4466.69	4460.10	4473.34	4475.62	4477.89
Crude fat (%)	12.51	12.40	12.43	12.10	12.16	12.31
Fiber (%)	15.06	15.34	15.08	15.13	15.32	15.41
Ash (%)	11.81	12.02	12.51	12.60	12.83	12.86
NFE[2] (%)	11.68	11.18	10.84	11.08	10.70	10.37

[1] Vitamin-mineral premix provides per kg of diet: vitamin A 15,000 IU; vitamin D3 3,000 IU; vitamin E 25 IU; vitamin K30.5 g; vitamin B1 2.5 mg; vitamin B2 7 mg; vitamin B6 4.5 mg; vitamin B12 0.025 mg; pantothenic acid 35 mg; nicotinic acid 35 mg; choline chloride 0.25 g; biotin 0.025 mg; Cu 1.6 mg; folic acid 0.5 mg; Mn0.06 g; Se 0.15 mg; Fe 0.08 g; I 0.4 mg and Zn 0.045 g.
[2] NFE = Nitrogen-free extract = 100 - (moisture + protein + lipid + fiber + ash)
[2] NFE = Nitrogen-free extract = 100 - (moisture + protein + lipid + fiber + ash)

2.4 Experimental procedure

Juvenile climbing perch (*Anabas testudineus*) was provided by The Chumphon Aquaculture Genetics Research and Development Center. Before the study, The fish were maintained in an indoor oxygenated (1,000 L) tank in the Inland Aquaculture Laboratory, King Mongkut's Institute of Technology Ladkrabang, Prince of Chumphon Campus (KMITL PCC), Chumphon, Thailand. A domesticated strain of climbing perch was used in this study. The experimental fish were fed a control diet (40% crude protein and 4,500 kcal/kg gross energy) during the 2-week acclimatization period before starting the experiment. At the start of the investigation, 20 juvenile climbing perch (mean weight 2.88 ± 0.02 g) were reared in recirculation aquaculture tanks (RAT) for the experiment. The RAT was integrated into a single system of 15 (200-L) rearing tanks. Each rearing tank supplied 8 L/min of treated water, constant temperature (28 °C) with an aqua heater, and constant DO (6.0 mg/L). The six dietary treatments of AM and FAM in the experiment were fed to randomly assigned triplicate groups of fish and to apparent satiation twice a day. Fish were batch-weighed by tank once every two weeks and the daily ration was adjusted accordingly for 12 weeks.

2.5 Sample collection chemical analysis and color determination

At the start of the experiment, 60 fish were sacrificed, weighed, and measured in length. At the end of the feeding trial, 15 fish per treatment (5 fish per replicate) were randomly chosen, starved for 24 h, weighed, measured length, killed, and dissected. Liver, gut, and flesh were weighed to determine Hepatosomatic (HSI) and Viscerosomatic (VSI) indexes and Flesh ratio (FR) as described in Tawakalitu et al. [14]. Analysis of crude protein, crude fat, fiber, ash, moisture, NFE, and GE contents of the test diets followed the methods of Association of Official Analytical Chemists (AOAC) [15]. The fish fillets were analyzed for color by Konica Minolta CR-400 Chroma Meter. The samples were put into the glass dish, and

the measuring head of the meter was carefully placed in three different locations on the fillet. Means and standard deviations were determined from triplicate measurements.

2.6 Haematology studies

At the end of the trial, three fish per replication (n=9/treatment) were randomly captured, and blood samples were collected using a 2 ml syringe from the caudal vein to evaluate hematology studies. Before the blood samplings, fish were starved for 24 h. Hematocrit values were determined using microhematocrit heparinized capillary tubes. Red and white blood cells were counted in a Neubauer hemocytometer[16]. To estimate the differential leucocyte count, blood smears were prepared, air-dried, fixed in methanol, and stained using Giemsa (Merck, Germany) [17]. Leucocytes in blood smears were categorized into thrombocytes, eosinophils, basophils, neutrophils, lymphocytes, and monocytes.

2.7 Calculations and statistical analysis

Growth, survival rate, feed utilization, and some physical qualities were calculated using the following equations[13].

(1) WG = Wf – Wi; where WG is the weight gain, Wi and Wf is the initial and final mean body weights.

(2) FCR = [sum of dried diet consumed /weight gain]; FCR is the feed conversion ratio.

(3) SGR = [100 × [(ln(FW) – ln(IW)] /day]; where SGR is the specific growth rate measured in percent per day and IW is the initial weight, and FW is the final weight both measured in grams.

(4) PER = wet weight gain (g)/total protein intake (g); where PER is the protein efficiency ratio

(5) SR = [100 × (remaining number of fish)/ (initial number of fish)], where SR is the survival rate measured in percent.

(6) HSI = [100 × liver weight / total body weight]; where HSI is the hepato-somatic index measured in percent.

(7) FR = [100 × flesh weight / total body weight]; where FR is the flesh ratio measured in percent.

(8) VSI = [100 × visceral mass weight / total body weight]; where VSI is the visceral-somatic index measured in percent.

All data were calculated as mean ± SD and subjected to one-way variance analysis. Duncan's new multiple-range test was used to test for significant differences at the ($P < 0.05$) level.

3. Results and Discussion

3.1 Results

The growth performance of *A. testudineus* juveniles over the period is presented in Table 2. The final body weight was significantly higher ($P < 0.01$) in FAM 5.0% and control, respectively, compared with other treatments. In the present study, dietary supplementation of yeast (*S. cerevisiae*) fermented *Acacia mangium* leaves meal at 5.0% level significantly enhanced the growth (weight gain and SGR), PER, and reducing trend of FCR in climbing perch. However, the final body weight of the group AM 2.5% (7.78 ± 0.17 g), FAM 7.5% (7.68 ± 0.20 g), and FAM 10% (7.50 ± 0.21g) were not differenced significantly ($P > 0.05$) between the group. Feed conversion ratio (FCR), specific growth rate (SGR), and protein efficiency ratio (PER) showed a highly significant difference ($P < 0.01$) among the treatment. A better FCR, 1.52 ± 0.16, was observed in FAM 5.0%, which was significantly lower from AM 2.5% (1.83 ± 0.09), FAM 7.5% (1.88 ± 0.10) and FAM 10% (1.97 ± 0.12). Similarly, significantly higher PER, 2.57 ± 0.15, was registered in FAM 5.0% compared to 1.89 ± 0.10, 2.18 ± 0.09, 1.87 ± 0.10, and 1.84 ± 0.08 in AM 2.5%, FAM 2.5%, FAM 7.5% and FAM 10% respectively. However, no significant difference in final body weight, weight gain, FCR, SGR, and PER was observed between FAM 5.0% and control.

Table 2. Growth performance of *Anabas testudineus* juveniles fed with yeast-fermented *Acacia mangium* leaves meal (FAM) supplemented diets

Growth parameters	Control	AM 2.5%	FAM 2.5%	FAM 5.0%	FAM 7.5%	FAM 10%	Level of significance
Initial wt. (g)	2.86 ± 0.04	2.88 ± 0.02	2.90 ± 0.01	2.88 ± 0.02	2.87 ± 0.02	2.87 ± 0.03	NS
Final wt. (g)	8.77 ± 0.18^{a}	7.78 ± 0.17^{c}	8.47 ± 0.14^{b}	8.78 ± 0.23^{a}	7.68 ± 0.20^{c}	7.50 ± 0.21^{cd}	**
Weight gain (%)	206.64 ± 5.36^{a}	170.14 ± 5.06^{c}	192.07 ± 5.12^{b}	204.86 ± 5.24^{a}	167.60 ± 5.03^{c}	161.32 ± 5.04^{cd}	**
FCR	1.58 ± 0.13^{a}	1.83 ± 0.09^{b}	1.56 ± 0.11^{a}	1.52 ± 0.16^{a}	1.88 ± 0.10^{b}	1.97 ± 0.12^{b}	*
SGR	2.56 ± 0.07^{a}	1.96 ± 0.05^{c}	2.20 ± 0.04^{b}	2.54 ± 0.04^{a}	1.98 ± 0.05^{c}	1.91 ± 0.06^{c}	**
PER	2.58 ± 0.11^{a}	1.89 ± 0.10^{c}	2.18 ± 0.09^{b}	2.57 ± 0.15^{a}	1.87 ± 0.10^{c}	1.84 ± 0.08^{c}	*
SR (%)	100 ± 0.00	98.33 ± 2.89	100 ± 0.00	100 ± 0.00	100 ± 0.00	100 ± 0.00	NS

The means with no superscript letter in common per factor indicate significant difference; Values are presented as mean ± SD; If the effect were significant, ANOVA was followed by the Duncan test. *P < 0.05; **P < 0.01; NS, not significant.

Table 3. Water quality parameters in the experimental tanks during the study period (mean ± SD)

Parameters	Control	AM 2.5%	FAM 2.5%	FAM 5.0%	FAM 7.5%	FAM 10%	Level of significance
Temperature (°C)	26.85 ± 0.42	26.83 ± 0.46	26.72 ± 0.43	26.90 ± 0.48	26.76 ± 0.39	26.78 ± 0.45	NS
pH	7.10 ± 0.16	7.13 ± 0.11	7.13 ± 0.12	7.11 ± 0.13	7.12 ± 0.18	7.11 ± 0.15	NS
Alkalinity (mg/l $CaCO_3$)	85.32 ± 1.83	86.10 ± 2.01	85.26 ± 1.76	86.11 ± 1.95	85.42 ± 2.08	85.58 ± 2.02	NS
Total hardness (mg/l)	55.52 ± 1.52	54.34 ± 2.11	55.12 ± 1.83	55.20 ± 1.24	55.39 ± 1.46	54.42 ± 2.01	NS
Total ammonia-N (mg/l)	0.25 ± 0.02	0.25 ± 0.02	0.25 ± 0.01	0.25 ± 0.01	0.25 ± 0.02	0.25 ± 0.01	NS
Nitrite-N (mg/l)	0.08 ± 0.01	0.08 ± 0.01	0.08 ± 0.01	0.08 ± 0.01	0.08 ± 0.01	0.08 ± 0.01	NS
Nitrate-N (mg/l)	0.21 ± 0.01	0.20 ± 0.01	0.20 ± 0.01	0.21 ± 0.01	0.21 ± 0.01	0.20 ± 0.01	NS
Dissolved oxygen (ppm)	5.69 ± 0.18	5.67 ± 0.12	5.65 ± 0.11	5.60 ± 0.15	5.59 ± 0.14	5.66 ± 0.10	NS

The means with no superscript letter in common per factor indicate a significant difference; If the effect were significant, ANOVA was followed by the Duncan test; NS was not significant.

The water quality parameters during the study period are presented in Table 3. No significant difference ($P > 0.05$) among the treatments was observed in water quality parameters during the experimental period.

The proximate composition (%) of FAM and experimental diets are presented in Tables 4 and 5. The dried FAM contained 14.47 ± 0.1% crude protein, 2.55 ± 0.18% crude lipid, and 49.67 ± 0.23% nitrogen-free extract (NFE). The mean ash content and organic matter were 5.97 ± 0.02% and 94.03 ± 0.78% of dried FAM, respectively. Experimental diets did not significantly differ ($P > 0.05$) in crude protein, lipid, ash, and crude fiber. However, the nitrogen-free extract (NFE) content was significantly higher ($P < 0.01$) in experimental diets FAM 7.5% and FAM 10% compared to control, AM 2.5%, FAM 2.5%, and FAM 5.0%. The crude protein and gross energy content ranged from 39.78 ± 0.16 to 40.02 ± 0.08% and 4,490.10 ± 2.64 to 4,497.89 ± 3.06 Kcal/Kg in the experimental diets.

Table 4. Proximate composition of yeast-fermented *Acacia mangium* leaves meal (FAM) and *Acacia mangium* leaves meal (AM) (mean ± SD)

Nutrients	FAM (%)	AM (%)
Organic matter[1]	94.03 ± 0.78	95.96 ± 0.83
Moisture	6.71 ± 0.01	8.56 ± 0.02
Crude protein	14.47 ± 0.1	15.97 ± 0.08
Crude lipid (EE)	2.55 ± 0.18	2.25 ± 0.21
Ash	5.97 ± 0.02	4.04 ± 0.01
Crude fiber	20.63 ± 0.52	25.00 ± 0.62
Total NFE[2]	49.67 ± 0.23	44.18 ± 0.26
Gross energy (Kcal/Kg)[3]	4,720.64 ± 2.85	4,963.14 ± 3.15

[1] Organic matter = 100-Ash; [2] NFE = 100 – (CP + EE + CF + ash + moisture) [3] Gross energy (GE) = (CP x 5.56) + (EE x 9.44) + (CF x 4.1) + NFE x 4.1) Kcal/Kg.

The carcass quality and fillet color parameters are presented in Table 6. No significant difference ($P > 0.05$) among the treatments was observed in carcass quality and fillet color at the end of the experiment. But also, The hepato-somatic index and flesh ratio ranged from 1.94 ± 0.06 to 2.05 ± 0.05% and 48.82 ± 2.98 to 50.04 ± 1.91% in the experimental diets. There was no difference in chromatic component a* (ranging from 7.11 ± 0.49 to 7.76 ± 0.54) and b* (ranging from -0.78 ± 0.11 to -0.62 ± 0.21) between fish fillets among the treatments

Table 7 shows the hematological indices of *Anabas testudineus* juveniles at the end of the trial. White blood cells were significantly higher in FAM-fed groups than in control and AM 2.5% diet-fed groups ($P < 0.01$). There was no significant difference in hematocrit and red blood cells among the experimental groups ($P > 0.05$). However, the thrombocyte and lymphocyte significantly differed ($P < 0.05$) in experimental diets FAM 5.0% and FAM 7.5% compared to AM 2.5%, FAM 2.5%, and FAM 10%. No significant difference ($P > 0.05$) among the treatments was observed in eosinophil, basophil, and monocyte at the end of the trial.

Table 5. Proximate composition (%) of experimental diets supplemented with graded levels of yeast-fermented *Acacia mangium* leaves meal (FAM) and *Acacia mangium* leaves meal (Am) (mean ± SD)

Nutrients	Control	AM 2.5%	FAM 2.5%	FAM 5.0%	FAM 7.5%	FAM 10%	Level of significance
Organic matter[1]	94.28 ± 0.73	94.43 ± 0.68	94.63 ± 0.70	94.74 ± 0.62	95.24 ± 0.34	95.51 ± 0.21	NS
Moisture	10.03 ± 0.10	10.12 ± 0.06	10.32 ± 0.21	9.96 ± 0.24	10.08 ± 0.11	10.15 ± 0.05	NS
Crude protein	39.89 ± 0.18	39.92 ± 0.12	39.78 ± 0.16	39.96 ± 0.20	40.02 ± 0.08	39.86 ± 0.13	NS
Crude lipid (EE)	11.34 ± 0.28	11.42 ± 0.16	11.32 ± 0.12	11.50 ± 0.21	11.56 ± 0.22	11.70 ± 0.10	NS
Ash	5.72 ± 0.41	5.57 ± 0.42	5.37 ± 0.60	5.26 ± 0.25	4.76 ± 0.67	4.49 ± 0.70	NS
Crude fiber	12.12 ± 0.35	12.08 ± 0.48	12.34 ± 0.26	12.67 ± 0.08	12.52 ± 0.11	12.78 ± 0.03	NS
NFE[2]	20.90 ± 0.05[b]	20.89 ± 0.02[b]	20.87 ± 0.04[b]	20.65 ± 0.13[b]	21.06 ± 0.02[a]	21.02 ± 0.01[a]	**
Gross energy[3]	4,492.80 ± 3.18	4,496.69 ± 3.10	4,490.10 ± 2.64	4,493.34 ± 2.88	4,495.62 ± 3.04	4,497.89 ± 3.06	NS

[1]Organic matter = 100-Ash; [2]NFE = 100 – (CP + EE + CF + ash + moisture); [3]Gross energy (GE) = (CP x 5.56) + (EE x 9.44) + (CF x 4.1) + NFE x 4.1) Kcal/Kg; The means with no superscript letter in common per factor indicate significant difference; Value is presented as mean ± SD; If the effect were significant, ANOVA was followed by Duncan test. *P < 0.05; **P < 0.01; NS, not significant.

Table 6. Carcass quality and fillet color (L*, a*, b*) of *Anabas testudineus* fed with yeast-fermented *Acacia mangium* leaves meal (FAM) supplemented diets (mean ± sd)

Parameters	Control	AM 2.5%	FAM 2.5%	FAM 5.0%	FAM 7.5%	FAM 10%	Level of significance
[1]HSI (%)	2.04 ± 0.07	2.00 ± 0.06	2.05 ± 0.05	2.01 ± 0.02	1.94 ± 0.06	1.97 ± 0.05	NS
[2]FR (%)	49.60 ± 2.81	49.02 ± 2.90	49.66 ± 2.06	50.04 ± 1.91	49.63 ± 2.54	48.82 ± 2.98	NS
[3]VSI (%)	24.13 ± 3.14	24.90 ± 3.02	26.65 ± 3.51	22.32 ± 3.97	21.76 ± 4.08	24.17 ± 3.21	NS
L* (lightness)	41.40 ± 1.97	40.14 ± 1.42	41.18 ± 1.47	39.55 ± 1.99	40.64 ± 1.82	41.24 ± 1.84	NS
a*	7.32 ± 0.57	7.76 ± 0.54	7.24 ± 0.52	7.11 ± 0.49	7.70 ± 0.46	7.67 ± 0.50	NS
b*	-0.62 ± 0.21	-0.77 ± 0.16	-0.74 ± 0.27	-0.66 ± 0.18	-0.68 ± 0.20	-0.78 ± 0.11	NS

[1] HSI = [100 × liver weight / total body weight]; where HSI is the hepato-somatic index measured in percent; [2]FR = [100 × flesh weight / total body weight]; where FR is the flesh ratio measured in percent; [3]VSI = [100 × visceral mass weight / total body weight]; where VSI is the viscero-somatic index measured in percent.

Table 7. The blood parameters of *Anabas testudineus* fed with yeast-fermented *Acacia mangium* leaves meal (FAM) supplemented diets

Parameters	Control	AM 2.5%	FAM 2.5%	FAM 5.0%	FAM 7.5%	FAM 10%	Level of significance
Hematocrit (%)	38.67 ± 3.06	40.00 ± 7.21	35.84 ± 1.58	35.84 ± 5.86	37.22 ± 5.00	36.30 ± 1.53	NS
Red blood cell (1×10^6cell/mm^3)	4.07 ± 0.56	4.35 ± 0.74	4.14 ± 0.85	4.30 ± 0.92	4.24 ± 0.79	4.44 ± 0.87	NS
White blood cell (1×10^4cell/mm^3)	6.10 ± 0.38^{d}	5.73 ± 0.21^{d}	8.08 ± 0.35^{c}	8.38 ± 0.23^{bc}	8.83 ± 0.49^{b}	10.49 ± 0.55^{a}	**
Thrombocyte (%)	44.33 ± 9.29^{ab}	54.00 ± 10.15^{a}	52.00 ± 1.00^{a}	39.00 ± 4.00^{b}	38.33 ± 2.08^{b}	54.67 ± 7.37^{a}	*
Eosinophil (%)	3.00 ± 1.73	2.67 ± 1.53	6.00 ± 4.00	2.00 ± 1.00	6.67 ± 4.16	6.67 ± 4.16	NS
Basophil (%)	0.00 ± 0.00	0.33 ± 0.58	1.00 ± 1.00	0.33±0.58	1.00 ± 1.00	1.00 ± 1.00	NS
Neutrophil (%)	0.33 ± 0.58^{b}	2.00 ± 0.00^{a}	1.33 ± 0.58^{ab}	1.67±1.15^{a}	2.33 ± 0.58^{a}	1.67 ± 0.58^{a}	*
Lymphocyte (%)	48.00 ± 9.64^{a}	34.00 ± 8.72^{b}	31.67 ± 4.73^{b}	52.33±5.03^{a}	45.67 ± 5.51^{a}	29.67 ± 0.58^{b}	*
Monocyte (%)	4.33 ± 1.53	7.00 ± 6.00	8.00 ± 6.08	4.67±0.58	6.00 ± 1.73	6.33 ± 5.03	NS

The means with no superscript letter in common per factor indicate significant difference; values are presented as mean ± SD; If the effect were significant, ANOVA was followed by the Duncan test. *P < 0.05; **P < 0.01; NS, not significant.

3.2. Discussion

The present study illustrates the role of FAM as a dietary supplement on growth performance, carcass quality, and hematology of climbing perch (*Anabas testudineus*). Including baker's yeast (*Saccharomyces cerevisiae*) as a dietary ingredient in the fish diet improved the growth performance of African Catfish [18]. In the present study, dietary supplementation of yeast (*S.cerevisiae*) fermented *Acacia mangium* leaves meal at 5.0% level significantly decreased the trend of crude fiber in diets and enhanced the growth (weight gain and SGR), PER, and reduced the FCR in climbing perch. These results agree with Israeli carp [19] and Nile tilapia [20]. Similar results were obtained when *S.cerevisiae* was added to the fish diet of hybrid striped bass [21]. The improved fish growth and feed utilization may be due to enhanced nutrient digestibility. In this regard, [18] found that adding yeast improves diet and protein digestibility, which may explain the better growth and feed efficiency recorded with yeast supplements. As inasmuch, dried yeast is a source of nucleic acids and non-starch polysaccharides, including β-1,3 glucan. In avian species, β-glucans may affect the absorption of nutrients, possibly by increasing gut viscosity, while the high concentration of nucleic acids may affect nutrient metabolism in monogastric animals. [22] On the other hand, [23] reported a linear decrease in growth performance and efficiency in nutrient utilization when juvenile tilapia were fed above 15% yeast. HSI (Hepato-Somatic Index), FR (Flesh Ratio), VSI (Viscero-Somatic Index), and fillet color (L*, a*, b*) of the fish were not significantly affected by the supplementation of yeast-fermented *Acacia mangium* leaves meal in the diet ($P > 0.05$). This study reveals that FAM does not influence the color attributes of climbing perch fillet, wherewith, As fish is not capable of synthesizing carotenoids de novo, there is a need to incorporate carotenoids in the diet of cultured species. According to Bustari et al. [24], the carcass quality of fish at the end of their experiment showed that edible flesh, dress-out percentage, carcass waste, fillet color, and sensory quality of the fish slightly fluctuated among all the experimental diets without significant differences. These results followed the same trend as those obtained by Olvera-Novoa, et al. [25]. A linear increase trend in white blood cells when climbing perch were fed FAM component diets significant difference ($P < 0.01$) with control and *Acacia mangium* leaves meal AM 2.5% diet. The highest value of white blood cells was observed in diet 6 (FAM 10%), while a high level of thrombocyte, eosinophil, and basophil was observed in diet 6 (FAM 10%). Several workers [26-28] reported that *S. cerevisiae* improved the efficacy of the immune system, improved intestinal lumen health, and increased digestion and absorption of nutrients, which resulted in better performance.

4. Conclusions

The present study indicates that yeast (*S.cerevisiae*) fermented *Acacia mangium* leaves meal at 5.0% (FAM 5.0%) in diet positively enhanced growth performance and feed utilization of Climbing perch (*Anabas testudineus*) without any adverse effect on the fish health and carcass quality.

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