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Effect of Aqua -Mos on growth performance and survivability of climbing perch (*Anabas testudineus*) during larval rearing

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Abstract
In the present study, the experiment was conducted for a rearing period of 90 days, the experimental animals were fed with three different treatments incorporated with Aqua-Mos at a level of T_1 (0.5%), T_2 (1.0%) and T_3 (1.5%) and T_0 (Control). In a treatment T_2 (1%) inclusion of Aqua-Mos to the basal diet showed better result in terms of increment in growth, percentage of maximum specific growth rate and better survivability. The food conversion efficiency, body weight gain, and survival of fry of *Anabas testudineus* was significantly improved by supplementing diets with 1.0% inclusion of Aqua-Mos in the basal diet as compared to that of 0.5% and 1.5%. Adding 1.0% of Aqua-Mos to the feed significantly improved immune capacity of the species under study as indicated by the growth rate of the fish as well as survival percentages. The treatment (T_2) contains a crude protein percentage of 37.60 ± 0.32% where as the treatments like T_1 and T_3 contains a higher crude protein percentage of 43.75 ± 0.60 and 40.68 ± 0.22 respectively. However, the mean weight gain at the end of experimental period was found to be maximum in the treatment (T_2) fed with 1% incorporation of Aqua-Mos in the basal diet. It was recorded that a mean weight gain of 7.80 ± 0.18g with a maximum specific growth rate of percentage of 3.00 ± 0.24. In the present study, Adding 1.0% (T_2) of Aqua-Mos to the feed significantly improved survival percentages *i.e* 100% survivability followed by 1.5% (T_2) with 90% survivability.

Keywords: Aqua-Mos, growth, survival, food conversion efficiency, *Anabas testudineus*

Introduction
Nowadays, with the recent advances in aquaculture globally, crucial need to be improved and focus more on the important avenue for production of aquatic organisms of nutritional, therapeutic, ornamental and industrial value. Besides, feed plays an important operational input which shares more than 50 to 70% of the recurring expenditure. For instance, one of the major constraints in fish production is the water quality deterioration due to the feeding of poor quality feeds; non-availability of good quality raw materials and unscientific on-farm feed management practices emphasizes reorientation of recent focus to develop sustained technological packages for feed and feed management in aquaculture.

Anabas testudineus (Bloch, 1792) commonly called 'climbing perch', is a live fish of tropical freshwaters of Asia and far East, inhabiting in brackish waters, but mainly inhabits small densely grown streams, rice fields and muddy pools of freshwater origin. The fish contains high quantities of physiologically available iron and copper which are essential for haemoglobin synthesis along with the easily digestible fat and essential amino acids like arginine, histidine, tyrosine, tryptophan etc [11] [15]. However, due to a declined or reduced in abundance in the wild, the species is presently categorized as Vulnerable (Vn) as per International Union of Conservation of Nature and Natural Resources (IUCN). Although culture, breeding and larval rearing technology of the major carps has been developed in India, other species having commercial importance have been neglected. The culture of climbing perch *A. testudineus* is gaining importance nowadays because of high market demand as well as a greater consumer preference and also considered as one of the potential and candidate species for aquaculture in the swampy and derelict water bodies for revitalization of the fishery. But the main problem in proliferation of this climbing perch culture in India is due to unavailability of quality seed for stocking purpose in the cultivable water bodies. Aqua-Mos, a mannan oligosaccharide sugar purified from the cell wall of the yeast *Saccharomyces cerevisiae* was known to promote health and production performance by improving the structure and function of the intestine. It also increased the immune capacity of the animal and

prevents colonization of several pathogens in the intestinal tract by improving production performance without the use of antibiotics [25]. Thus, Aqua-MOS rich in nucleotides, the building blocks of nucleic acids have high protein content and a rich source of amino acids, Vitamin-B and inositol. Further, the present investigation was carried out to know the significant effect of Aqua-Mos on growth and survivability of the seeds during larval rearing of air- breathing fish *A. testudineus***.**

2. Materials and methods

2.1 Probiotics

The probiotics like Aqua-MOS rich in nucleotides, the building blocks of nucleic acids has high protein content and a rich source of amino acids, Vitamin-B and inositol were used during formulation of food are procured from M/s Alltech Biotechnology Pvt. Ltd, Bangalore for the experimental purpose during the present investigation. The additive was included in the basal diet at levels of 0.5, 1.0 and 1.5% in test diets T_1, T_2, and T_3. A diet without Aqua-MOS served as control (T_0).

2.2 Test animal

The present investigation was carried out in glass aquaria of 40-liter capacity in the wet lab of the college of Fisheries, Rangeilunda. All the treatments were conducted in triplicates with a control to avoid experimental error. Each tank is stocked with 20 numbers of 15 days old fry for the experimental purpose with more or less similar body weight and length. The experiment was conducted for a period of 90 days to assess different growth parameters.

2.3 Experimental diets

The standard fishmeal based pelleted feed [35] was used for Aqua-MOS incorporation. The locally available different feed ingredients like fish meal, soyabean meal, rice bran, corn flour, vegetable oil, vitamin and mineral premix were purchased and pelleted feeds were formulated after following the standard procedures for formulation of feed, maintaining 35% protein level in the basal diet.

2.4 Feed Ingredients

2.4.1 Fish meal

The fish meal was prepared in the laboratory. Silver bellies were collected from the local market, cleaned properly and dried at 80^0C for 3 hrs. After it is dried properly, the dried fishes were pulverized in a pulveriser to get fishmeal. The fishmeal prepared contains a crude protein of 40%, fat 2% and ash 18% on dry weight basis.

2.4.2 Soya bean meal

Whole soyabean seeds were procured from the local market and was sun dried properly. Subsequently upon thorough drying the soyabean seeds were grinded and pulverized to get a powdered consistency. The soyabean meal on dry weight basis found to contain 45% crude protein, 0.9% crude fat and 0.6% ash.

2.4.3 Rice bran

Rice bran was procured from the local market and sun dried properly to reduce the moisture content. The dried and pulverized rice bran contains 12% crude protein, 11% crude fat and 10.2% ash.

2.4.4 Corn flour

Corn flour was procured from the market and added as one of the component of different feed ingredients, which serves as binder as well as provides stability to the diets**.**

2.4.5 Fat source

Commercially available vegetable oil was used during the formulation of feed, which was procured from the market.

2.4.6 Vitamin and mineral premix

The vitamin and mineral premix manufactured by M/s Sarabhai chemicals used for the preparation of the experimental diets at the recommended dosages. The quantity of different vitamins and minerals required in gram per kg diet were, Vitamin-A, 40,000 IU; Vitamin D 8000IU ; Vitamin B_2 0.016 ; Vitamin E 6.0 units ; Vitamin K 0.008, Calcium pantothenate 0.02 ; Nicotinamide 0.08 ; Vitamin B_{12} 0.048 ; Choline chloride 1.2 ; Calcium 6.0; Manganese 0.22 ; Iodine 0.008 ; Iron 0.06 ; Zinc 0.12 ; Copper 0.016; Cobalt 0.004.

2.5 Preparation of the experimental diet

All the different ingredients as mentioned above were locally procured and dried properly before preparation of the experimental diet to ensure reduction in moisture to prevent formation of crumbles. The dried ingredients were weighed individually and mixed well using pulveriser. The quantity of individual ingredients required to formulate a kg of diet was worked out using Pearson's square method to balance protein and energy levels. Thus, a basal diet with 35% protein was formulated taking in to consideration of two protein sources used like fishmeal and soya bean meal. All the weighed ingredients were mixed thoroughly in a pulveriser and oil was added to the dry ingredients along with the incorporation of growth promoters or probiotics except vitamins and mineral premixes. The dough thus prepared and sterilized and allowed it to cool in a room temperature. After proper cooling, required quantity of weighed vitamin and mineral premix was added, mixed properly and further palletized by using a hand feed pelletizer to form experimental feed pellets. The pellets thus formed were oven dried at 100 ^{0}C. Further, the dried pellets were powdered to approximate sizes before feeding to the experimental animals.

2.7 Water

Luke warm water was added to different feed ingredients at a rate of 30% of the total quantity in order to get a thick consistency for preparation of thick dough for utilization during the process of sterilization and pelletization.

2.8 Water exchange

Daily 30% of the total volume of water from each glass aquaria was exchanged to remove the accumulated faecal matter from the experimental containers with replenishment of filtered aged, well aerated water. The process was continued till the termination of the experiment spreading over to a total of 90 days.

2.9 Feeding schedule

The test animals in each treatment tank were fed with the formulated feed specially developed for this set of investigation at 50% of their body weight in two instalments, once during morning hours and at evening hours. The feed quantity was readjusted based on average bodyweight gain recorded at fortnightly intervals.

2.10 Aeration
Continuous uninterrupted aeration facilities were provided to each experimental container throughout the period of investigation for maintenance of good water quality parameters.

2.11 Water quality parameters
Important water quality parameters like pH, temperature, dissolved oxygen, free carbon dioxide, and alkalinity was measured from each of the experimental containers at fortnightly intervals by following the standard procedures (APHA, 1985) [2].

2.12 Proximate composition
The proximate composition of six experimental diets and one control were analysed following the procedures recommended by AOAC (1975) [1] which are as follows:

2.12.1 Moisture
Moisture was determined by oven drying at 85 ^{0}C for constant weight.

$$\text{Moisture \%} = \frac{\text{Initial wieght of sample} - \text{Final weight of sample}}{\text{Intial weight of sample}} \times 100$$

2.12.2 Crude Protein
Crude protein was determined indirectly from the analysis of total nitrogen (crude protein = N x 6.25) by the Micro-kjeldhal method.

Calculation of crude protein:

$$\text{Nitrogen content of sample (\%)} = \frac{\text{ml. of acid (v)} \times \text{Normality of standard acid (N)}}{\text{Weight of sample}} \times 0.014 \times 100$$

Crude protein (%) = Nitrogen content x 6.25.

2.12.3 Crude fat
Crude fat was determined by extraction with Petroleum ether for 6 hrs in Soxhlet apparatus.

$$\text{Crude fat (\%)} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

2.12.4 Ash
Ash was determined from weighed samples in a porcelain crucible placed in a muffle furnace at 600 ^{0}C for 6 hrs.

$$\text{Ash (\%)} = \frac{\text{Weight of initial sample}}{\text{Weight of dried sample}} \times 100$$

2.12.5 Growth studies
The growth rates in term of percentage weight gain, daily weight gain (gm), percentage specific growth rate, food conversion ratio (FCR), and protein efficiency ratio were calculated by following the standard procedures which are as follows:

$$\text{Percentage weight gain} = \frac{\text{Final weight of fish} - \text{Initial weight of fish}}{\text{Initial weight of fish}} \times 100$$

$$\text{Daily weight gain (g)} = \frac{\text{Final weight of fish} - \text{Initial weight of fish}}{\text{Total no. of experimental days}}$$

$$\text{Percentage of specific growth rate} = \frac{(\log_e \text{Final body weight} - \log_e \text{Initial body weight})}{\text{Total no. of experimental days}} \times 100$$

$$\text{Food conversion ratio} = \frac{\text{Total dry food intake(g)}}{\text{Total live weight gain(g)}}$$

$$\text{Protein efficiency ratio} = \frac{\text{Total weight gain (g)}}{\text{Total protein intake (g)}}$$

2.13 Statistical analysis
The data gathered during the process of present investigation were subjected to statistical analysis like analysis of variance (ANOVA) followed by Duncan's multiple range test [31] to find out the significant differences between the feeds as well as between the species to arrive at a conclusion with respect to efficacy of the feed.

3. Results
The present investigation was carried out to study the impact of Aqua-Mos, a mannan oligosaccharide on growth and survival of *A. testudineus* larval rearing under laboratory conditions.

3.1 Water quality parameters
During the experimental period, the average temperature varied between 27.0 ^{0}C to 31.0 ^{0}C. The average pH values in all the treatments were 7.80, which were slightly above the neutral pH. The dissolved oxygen content of the experimental units varied between 6.50 to 8.50 mg/l all throughout the experimental period. The total alkalinity of the water in the experimental containers ranged between 120 mg $CaCo_3$/l and 130 mg $CaCo_3$ /l throughout the period of investigation. The data gathered for the physico-chemical parameters during the experimental period indicates that, they are at the desired level without much variation (Table. 1).

3.2 Proximate composition of experimental diets
Aqua-Mos was incorporated at three different levels viz., 0.5%, 1.0%, and 1.5% to the basal feed in order to formulate the experimental diet for the present set of experiment. The percentages of different sources of ingredients, percentage incorporation of Aqua-Mos, and proximate composition of the formulated feed under different treatments are depicted in

(Table. 2). From the table, it is evident that, in the experimental diet under the treatment (T_1, T_2, & T_3) had an average crude protein percentage of 43.7 ±0.60; 37.69±0.32; and 40.68±0.22 respectively. The moisture percentage showed a similar trend with slight variations. The average moisture percentage varied from 8.63±0.12 to a highest of 9.83±0.14. The proximate composition of different experimental diets under treatments reveals that, the fat percentage varied with slight variation ranging from 3.50±0.04 minimum to a maximum of 4.00±0.08.

3.3 Effect of Aqua-Mos on growth of experimental animals

The mannan oligosaccharide, Aqua-Mos was incorporated to the experimental diet at 0.5%, 1.0%, and 1.5% level. The test animals were fed at a level of 5% of their body weight under each treatment for 90 days. The following growth parameters Viz., average net weight gain (g), increment in length (cm), average daily weight gain (g), specific growth rate (%), food conversion efficiency (%), protein efficiency ratio, percentage weight gain (%) and overall survival (%) were recorded individually for the treatment as well as for the species under study.

The average initial weight of fry of *A. testudineus* under control was recorded to be 0.53±0.057g. The control fishes were fed with the basal diet with an average crude protein content of 36.20% without supplementation of Aqua-Mos. The growth parameter in terms of increment in weight was recorded at fortnight interval (Table. 3). The study reveals that, there is an increment in weight of experimental animal under control. The average weight increased from 0.53±0.057 to 0.72±0.11g within 30 days; 0.72±0.11g to 1.23±0.15g within 60 days and 1.23±0.15 to 2.61±0.33g within 90 days. Along with the increment weight, a simultaneous increment in length from 1.20±0.02 to 4.80±0.36 cm was recorded for the control group of fishes. In addition to control, fishes fed with different levels of Aqua-Mos in the basal feed exhibited a different trend in their growth in terms of increment in weight as well as length.

Under the treatment (T_1) incorporated with Aqua-Mos at 0.5% level to the basal diet exhibited the following growth pattern in terms of increment in weight (Table. 4). The average initial weight of experimental animal was recorded to be 0.50±0.10g, which registered an increasing trend with respect to experimental period. Average initial weight of 1.86±0.11g increased to an extent of 088±0.11g; 1.80±0.27g and 3.29±0.47 after a lapse of 30 days, 60 days and 90 days respectively (Fig. 1). The size in terms of increment in length was increased initially from 1.20±0.02 cm to 5.40±0.35 cm within the total experimental period of 90 days.

The data gathered for the treatment (T_2) incorporated with Aqua-Mos at 1.0% level to the basal diet experienced all together a different trend in comparison to treatments (T_1) and (T_3). The average crude protein percentage of the treatment (T_2) was estimated to be 37.60±0.32. Consequent upon the feeding of this experimental diet to the fry of *A. testudineus* reveals that, at the time of termination of the experiment after 90 days, the experimental animals had gained an average weight of 8.36±0.45g from an average initial weight of 0.56±0.57g (Fig. 2). The increment in growth was much rapid between 60 to 90 days. There was also a simultaneous increase in length of the experimental animal from an initial length of 1.20±0.02 cm to 9.90±0.48 cm within a time gap of 90 days.

The average crude protein percentage of the diet estimated to be 40.68±0.22 under the treatment (T_3). There was a slow increment in gain in weight by the test animals under the treatment (T_3) in comparison to the increment in growth in other two treatments (Table. 3). The average initial weight of the experimental animal at the time of initiation of the investigation was worked out to be 0.60±0.17g which has increased to 1.22±0.37, 3.39±0.39 and 6.72±0.11g after a gap of 30 days, 60 days and 90 days respectively. Along with the slow increment in growth there was also a corresponding slow increment in length. The average initial length at the time of initiation of the experiment was calculated to be 1.20±0.02 cm, which was subsequently increased to 7.30±0.67 cm with in an experimental period of 90 days.

The food consumption, weight gain, specific growth rate, protein efficiency ratio are presented in (Table. 2). Experimental animals fed with the diet under treatment (T_2) showed the highest weight gain followed by the treatment (T_3), while there was no significant difference ($P > 0.05$) between the treatment (T_1) and (T_3) in terms of weight gain, specific growth rate and food conversion ratio. There was a significant difference ($P<0.05$) among the control and treatment groups when comparing the overall results in terms of food consumption, weight gain, specific growth rate, food conversion ratio and protein efficiency ratio. Meanwhile, the experimental animals which were fed with treatment diet (T_2) showed 100% survival, whereas, T3 achieved 90% survival during larval rearing showed in (Fig. 3).

Table 1: Average value of physico-chemical parameters of water during larval rearing of *A. testudineus*

Water Parameter	Larval rearing
Temperature	28.5-31.0 ^{0}C
pH	7.80
Dissolved oxygen (ppm)	8.50
Hardness (ppm)	130.0
Carbon dioxide (ppm)	Nil
Free Ammonia (ppm)	0.1
Hydrogen sulphide (ppm)	Nil
Nitrite (ppm)	0.02

Table 2: Percentage incorporation of different ingredient and proximate composition of experimental diets fortified with Aqua-Mos

Treatments / Source of Ingredients (%)	Diets			
	T_0	T_1	T_2	T_3
1. Fish meal	38.75	38.75	38.75	38.75
2. Soybean mal	38.75	38.75	38.75	38.75
3. Rice bran	13.40	13.40	13.40	13.40
4. Corn-flour	04.00	04.00	04.00	04.00
5.Vegetable Oil	04.00	04.00	04.00	04.00
6. Vitamin-mineral Premix	02.00	02.00	02.00	02.00
7. Aqua-Mos	0	0.50	01.00	01.50
Proximate Composition (%)				
1. Moisture	9.85 (0.18)	9.15 (0.16)	9.63 (0.12)	9.83 (0.14)
2. Crude Protein	36.20 (0.28)	43.75 (0.60)	37.60 (0.32)	40.68 (0.22)
3.Crude fat	3.80 (0.06)	4.00 (0.08)	3.50 (0.04)	3.50 (0.04)
4. Total ash	21.60 (0.60)	15.83 (0.68)	15.78 (0.46)	12.34 (0.32)

Figures in parentheses indicate standard deviation.

Table 3: Growth performance of *A. testudineus* advanced fry fed with Aqua–Mos.

Duration / Treatment	Replications	Initial weight (g)	Average Weight ± S. D.	Weight gained After 30 Days (g)	Average Weight gain ± S. D.	Weight gained After 60 Days (g)	Average Weight gain ± S. D.	Weight gained After 90 Days (g)	Average Weight gain ± S. D.	Average Daily weight gain (g) ± S. D.
Control	R_1	0.50	0.53 ± 0.057	0.80	0.72 ± 0.11	1.10	1.23 ± 0.15	2.38	2.61 ± 0.33	0.023 ± 0.005
	R_2	0.60		0.60		1.20		2.46		
	R_3	0.50		0.78		1.40		3.00		
T_1 Basal feed + 0.5% Aqua-Mos	R_1	0.40	0.50 ± 0.10	0.90	0.88 ± 0.11	1.70	1.80 ± 0.27	3.48	3.29 ± 0.47	0.031 ± 0.008
	R_2	0.60		0.76		1.60		2.75		
	R_3	0.50		0.98		2.12		3.64		
T_2 Basal feed + 1.0% Aqua-Mos	R_1	0.50	0.56 ± 0.057	2.20	2.10 ± 0.24	5.86	5.49 ± 0.60	8.40	8.36 ± 0.45	0.086 ± 0.015
	R_2	0.60		1.82		4.80		8.80		
	R_3	0.60		2.28		5.82		7.90		
T_3 Basal feed + 1.5% Aqua-Mos	R_1	0.50	0.60 ± 0.17	1.20	1.22 ± 0.37	2.94	3.39 ± 0.39	6.80	6.72 ± 0.11	0.068 ± 0.0025
	R_2	0.50		0.86		3.60		6.60		
	R_3	0.80		1.60		3.65		6.78		

± indicates standard deviation

Table 4: Growth parameters of *A. testudineus* fry fed on Aqua-Mos

Parameters / Treatments	Diets			
	T_0 Control	T_1 Basal Feed + 0.5% Aqua-Mos	T_2 Basal Feed + 1.0% Aqua-Mos	T_3 Basal Feed + 1.5% Aqua-Mos
1. Average Initial weight (g)	0.53 (0.09)	0.50 (0.09)	0.56 (0.11)	0.60 (0.17)
2. Average Final Weight (g)	2.61 (0.11)	3.29 (0.18)	8.36 (0.24)	6.72 (0.69)
3. Average Net Weight gain (g)	2.08 (0.10)	2.79 (0.16)	7.80 (0.18)	6.12 (0.42)
4. Average Initial length (cm)	1.20 (0.02)	1.20 (0.02)	1.20 (0.02)	1.20 (0.02)
5.Average final length (cm)	4.80 (0.36)	5.40 (0.35)	9.90 (0.48)	7.30 (0.67)
6. Increment in length (cm)	3.60 (0.18)	4.20 (0.20)	8.70 (0.26)	6.10 (0.32)
7. Daily weight gain (g)	0.023 (0.005)	0.031 (0.008)	0.086 (0.015)	0.068 (0.002)
8. Specific growth rate (%)	1.17 (0.60)	2.09 (0.45)	3.00 (0.24)	2.68 (0.32)
9. Food conversion efficiency (%)	1.80 (0.10)	1.71 (0.18)	1.27 (0.02)	1.56 (0.26)
10. Protein efficiency ratio	1.65 (0.012)	1.43 (0.018)	1.25 (0.024)	1.39 (0.038)
11. Percentage weight gain (%)	3.92 (0.22)	5.58 (0.46)	13.90 (0.14)	10.20 (0.26)
12. Overall Survival (%)	70	70	100	90

Figures in parentheses indicate standard deviation.

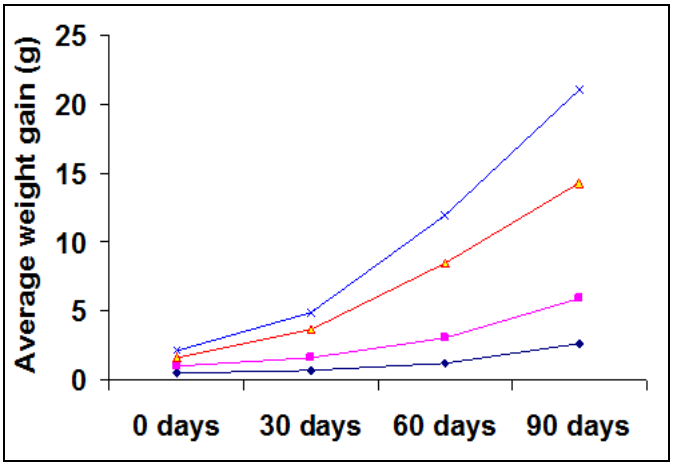

Fig 1: Average weight gained (g) attended by *A. testudineus* seed fed on Aqua-Mos under different treatment

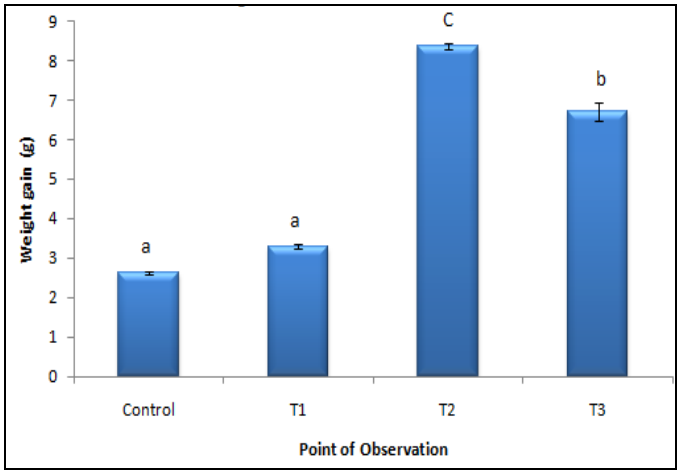

Fig 2: Final weight gained (g) attended by *A. testudineus* seed fed on Aqua-Mos under different treatment

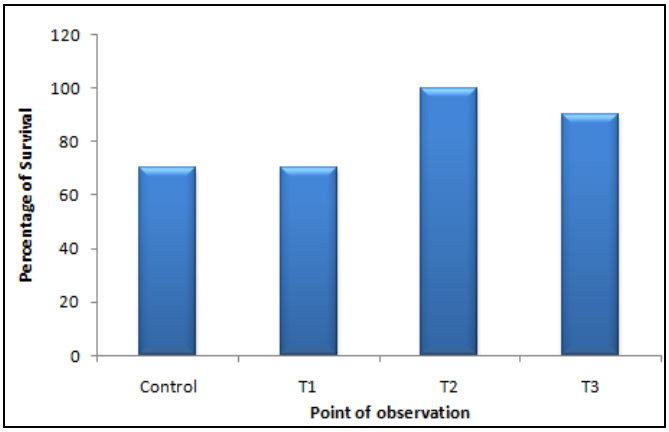

Fig 3: Survival percentage of A. testudineus seed fed on Aqua-Mos under different treatment

4. Discussion

Bacteria and yeast function against harmful microbes and contribute to the sustenance of intestinal microflora. These beneficial microbes are called Probiotics. Probiotics are live microbial feed supplements, which beneficially affect the host animal by improving its internal microbial balance [8]. Roberfroid (2000) [24] introduced the concept of Probiotics in the sense a non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and or the activity of one or a limited number of bacteria in the colon would improve host's health. Use of Probiotics is gaining acceptance in aquaculture, with many commercial preparations. These are known to suppress the proliferation of disease causing bacteria.

A Prebiotic has been defined as a non-digestible carbohydrate that beneficially affects the host animal by selectively stimulating the growth and activity of one or a limited number of bacteria in the colon. The use of prebiotics can be synergistic with many other feed additives including antibiotics, mannan oligosaccharides, direct microbial, and acidifiers. The structure of prebiotic sugars prevents digestive enzymes in stomach and small intestine from breaking them down. This enables commensal organisms in the large intestine to directly utilize prebiotic sugars. Prebiotics can be especially beneficial in conjunction with mannan oligosaccharides. Mannan oligosaccharides have been shown to act as pathogen binders to remove pathogen out of the gastrointestinal tract where as prebiotic may promote growth of beneficial bacteria in the colon.

Supplementation of yeast derived mannans in the form of Bio-Mos has been reported to improve the composition of the intestinal micro flora in chickens [32]. Zhou and Li (2004) [36] investigated the effects of dietary Bio-Mos in aquaculture and reported an increase in performance of fish. Zhou *et al.* (2004) [36] based on FCR and weight gain responses of *Cyprinus carpio* concluded that the optimum dietary Bio-Mos greatly improves survival. Fischer *et al.* (2001) [7] opines that, mannan based products if added at a level of 2-4g/kg of diet improves immune capacity, enhanced body weight, survival rate along with improved food conversion ratio. In order to maximize performance, the diet must supply essential nutrients in the right forms and concentration, as well as pro-nutrients to maximize fish health and performance. Optimal nutrition can help fish to overcome health challenges. Supplementation of trout and carp diets with 2g Bio-Mos per kg of diet improved food conversion ratio reared fish. Hanley *et al.* (1995) [10] and Peter (2003) [21] obtained a food conversion ratio which has 27% lower than the control with red tilapia when fed with 6g of Aqua-Mos which had a positive effect on growth rate, weight gain and total biomass production with high rate of survival. The study conducted by Peng *et al.* (2004) [20] on Grobiotic concludes that, the feed supplement used can serve as functional feedstuffs in the diets of hybrid striped bass by enhancing growth performance and immunological responses. The beneficial influence of Grobiotic on growth was possibly due to alterations of the intestinal micro flora by mannan oligofructose, lactose or other carbohydrates from the dietary ingredients.

The present investigation was carried out to determine the influence of Aqua-Mos on growth and survival of fry of *A. testudineus*. The mean weight gain at the end of experimental period was found to be maximum in the treatment (T_2) fed with 1% incorporation of Aqua-Mos in the basal diet. It recorded a mean weight gain of 7.80 ± 0.18g with a maximum specific growth rate of percentage of 3.00 ± 0.24.

The probiotics used as growth promoters in *A. testudineus* in the present investigation showed a significant increase in growth rate of the juveniles when compared with the control. The analysis of variance also reveals a significant difference between the treatments with respect to the growth of the experimental animals.

Gatesoupe (1991) [9], Noh *et al.* (1994) [19], Queiroz and Boyd (1998) [22] also opined that, the probiotic incorporated feed had a definite role in enhancing the growth of channel catfish, turbot and carp larvae. The present study also confirmed the findings of Hanley *et al.* (1995) [10], Rengipat *et al.* (1998) [23], Fischer *et al.* (2001) [7] and Peng *et al.* (2004) [20].

The protein requirements of cultivable carps viz., *Cyprinus carpio*, spawn and fry were 38% and 45% respectively (Singh, 1991) [30]. Sen *et al.* (1978) [27] obtained maximum growth of common carp spawn, fry and fingerlings with the diets containing 45% protein and 26% carbohydrate with in a temperature of 24-32 ^{0}C. Lochmann and Phillips (1994) [16] observed the best weight gain and feed efficiency when gold fishes were fed diets containing 28.9% protein with in a temperature range of 25 ± 2 ^{0}C for 6 to 8 weeks. Bardach *et al.* (1972) [3]; Sehgal and Thomas (1987) [26] opines that, diets containing protein from more than one sources performed better than diets containing protein from a single source.

In the present investigation, the experimental animals fed with 1% inclusion of Aqua-Mos to the basal diet gave the better result in terms of increment in growth, percentage of maximum specific growth rate and better survivability. The treatment (T_2) contains a crude protein percentage of 37.60 ± 0.32% where as the treatments like T_1, and T_3 contains a higher crude protein percentage of 43.75 ± 0.60 and 40.68 ± 0.22 respectively. From the result it is evident that 38% protein is sufficient for fry of *A. testudineus* with in a water temperature range of 28-30 ^{0}C which coincides with the earlier findings of Sen *et al.* (1978) [7], Singh (1991) [30] and Lochmann and Phillip (1994) [16].

The effects of protein content vary with species. Steffens (1981) [32] found that food conversion ratio and protein efficiency ratio decreased with increase in protein content. A distinct decreasing trend for FCR and PER were observed with increasing in protein level to a limit where maximum growth was observed there after it increased with further increase in the dietary protein level in the present investigation which indicates better food conversion efficiency.

A positive correlation between specific growth rate and dietary protein requirements has been observed by Tacon and Cowey (1985) [34]. The growth rate correlated to the daily protein consumption, irrespective of the dietary lipid content in red tilapia De silva *et al.* (1991) [5] and Chinook salmon (Silver *et al.* 1991) [29]. In the present study the specific growth rate was better with the diet enriched with Aqua-Mos at a level of 1% in comparison to control and other treatments even though there were no significant differences observed among them. Specific growth rate is a reliable index of growth in the evaluation of diets. Specific growth rate showed an increasing trend with the increase in dietary Aqua-Mos.

From the present investigation, the food conversion efficiency, body weight gain, and survival of fry of *A. testudineus* was significantly improved and achieved the highest survival rate *i.e* 100% survivability by supplementing diets with 1.0% inclusion of Aqua-Mos in the basal diet. Adding 1.0% of Aqua-Mos to the feed significantly improved immune capacity of the species under study as indicated by the growth rate of the fish as well as survival percentages. Aqua-Mos supplementation improved the performances of fry of *A. testudineus* with increased immune system as well as different body growth parameters like percentage of specific growth rate, percentage of food conversion efficiency and protein efficiency ratio,

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6. References

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