EVALUATING THE SUPPLEMENTATION OF AZOMITE® PRODUCTS TO GROWTH PERFORMANCE, FEED UTILIZATION AND FILLET QUALITY IN STRIPED CATFISH (*PANGASIANODON HYPOPHTHALMUS*)

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I. INTRODUCTION

Tra catfish or striped catfish (*Pangasianodon hypophthalmus*) has been intensively cultured in Mekong Delta, Vietnam. The annual production obtained 1.35 million tons in 2018 (VASEP 2019). Feeds for the species are mainly from plant sources and inorganic minerals are supplemented to the feed in form of mineral and vitamin premix. That was done to supplement mineral deficiency due to reduced fishmeal in the diet.

AZOMITE is an inorganic mineral registered trademark for a complex silica (hydrated sodium calcium aluminosilicate, HSCAS); it contains over 70 minerals and trace rare elements. The inclusion of AZOMITE in aqua feed significantly to improve growth performances, feed utilization and disease resistance has been done in some fish species. In hybrid tilapia (*Oreochromis niloticus x Oreochromis aureus*), dietary supplementation of AZOMITE at 2.5 and 5 g kg−1improves the growth, pepsin activity, and nutrient digestibility (Liu et al., 2009). In grass carp (*Ctenopharyngodon idellus*) the AZOMITE supplemented at 2 g kg−1 improved the feed utilization efficiency, activity of intestinal digestive enzymes, and serum non-specific immune function (Liu et al., 2011). However, in channel catfish (*Ictalurus punctatus*) Aarattuthodiyil *et al.* (2019), showed that there was no significant difference in the growth performance of the fish that were fed AZOMITE (0.25% and 0.50%) supplemented diets compared with control animals (P>0.05). The mortality rate of channel catfish 28 d after the *E. ictaluri* challenge did not differ significantly between groups receiving different dietary treatments. However, the study in striped catfish (*Pangasianodon hypothalamus*) showed best growth performance and feed utilization without any significant increase in biochemical nutrients profile with 1.0% inclusion of AZOMITE in the diet (Batool *et al*., 2018).

The present study was therefore planned to test the impact of various levels of AZOMITE concentration on the growth performance, feed utilization and fish fillet quality at harvested size for frozen industry.

II. MATERIAL AND METHODS:

II.1. Experiment feed and feeding

Three iso-nitrogenous and iso-lipid diets, based on a commercial formulation having ingredients of fishmeal, soybean meal, cassava, rice bran, wheat grain, fish oil… were utilized to produce experimental diets.

The feed is produced in Godaco feed mill and extruded at 120-130°C to make a floating feed. Protein & fat content of the three diets to formulate of 28% and 5%, respectively. The control diet (A0 diet) is formulated not to supplement with AZOMITE. A15 and A30 diets were control diet A0 supplemented with 0.15% and 0.30% AZOMITE, respectively.

- A0: Control Diet
- A15: Control diet + 0.15% AZOMITE
- A30: Control diet + 0.30% AZOMITE

Table 1. The feed formulation for three experimental diets (%)

	AO	**A15**	**A30**
Dry rice bran	21.06	20.95	20.85
Polished rice bran	5.00	5.00	5.00
Fishmeal 60%	3.00	3.00	3.00
Soybean meal	47.74	47.85	47.96
Wheat grain	5.00	5.00	5.00
Soybean oil	0.71	0.75	0.80
Cassava	15.00	15.00	15.00
Dicalci-phosphate	1.68	1.68	1.69
DL Methionine	0.15	0.16	0.16
Choline Chloride	0.15	0.15	0.15
Premix catfish	0.50	0.50	0.50
AZOMITE		0.15	0.30

Feed were distributed twice a day and fed at satiation: one meal in the morning at 8.00 and one meal in the afternoon at 15.00. One hour after feeding unfed feed would be collected and dried to calculate daily consumed feed for each experimental unit. Feed intake was registered daily to compare the feeding intake of three diets at the end of the experiment.

II.2. Fish and facilities

Striped catfish (*Pangasianodon hypophthalmus)* fingerlings of initial body weight (19 g) were obtained from hatchery in Mekong delta. All the animals were acclimated in hapas and fed the control diet for at least two weeks before being assigned to the various treatments. Fish was cultured in hapa (2m x 1.5m x1.0m) that were immersed in an earthen 500 m2 pond. Fish was cultured in two stages: stage 1 (20-200g), stage 2 (200-500g)

- **Stage 1 (20 to 300 g)**

At the beginning of experiment, all fish in each hapa was weighed in batch to record the average initial weight. Fish was randomly distributed in 12 hapas with a stocking density of 80 fish per hapa (27 fish/m2). Therefore, each experimental diet was fed in four hapa (four replicates for each treatment). The first feeding stage was in 8 weeks then the fish would change to the Stage 2.

At the end of the first stage, fish in all hapa was weighed in batch and count the number to evaluate mean weight and survival rates. Ten fish per hapa were sampled to measure the

individual weight and total length in order to calculate the condition factor (CF), the abdominal fat and fish liver were also sampled to calculate the hepato-somatic index (HSI'index) and adipose-somatic index (ASI)

- **Stage 2 (200 to 500 g)**

The fish in each hapa continued to culture and the stocking density was reduced to 40 fish per hapa. The fish was cultured in 10 weeks to obtain the marketable size. Initial and final weight were weighed in batch in order to evaluate the growth gain and survival rates as well as feed conversion ratio (FCR) and feeding intake.

At the end of the feeding trial, 10 fish per hapa were sampled to measure the fillet ratio, CF, hepato-somatic index and adipose-somatic index. Other 10 fish were sampled to measure the thaw loss ratio and drip loss ratio. Other ten fish were also sampled and filleted to evaluate the water holding capacity when soaking in a sodium tripoly-phosphate.

During the feeding trial, water quality was monitored in order to evaluate water temperature, pH, dissolved oxygen and total ammonia. Water temperature and pH were daily monitored in the morning and in the afternoon. Dissolved oxygen and total ammonia were weekly checked.

II.3 Evaluate growth performances and feed utilization

In order to evaluate growth performances and feed utilization of fish fed three experimental diets in stage 1 & stage 2. Initial weigh and final weight of fish were measured by batch and fish was also counted in each hapa to calculate survival rate (SR), specific growth rate (SGR), daily weight gain (WG), feed conversion ratio (FCR) as follows

- Specific growth rates (SGR)

$$SGR = \frac{(LnW2 - LnW1)}{T2 - T1} X100 \quad \%/day^{-1}$$

- Daily weight gain (DWG) = (W2 – W1) /(T2-T1)

in which

- W2: Mean weight at the end of the experiment
- W1: Mean weight at the beginning of the experiment
- T2- T1: Duration of the experiment

- ***Condition factor (CF)*** is a parameter give information on the condition and growth patterns of the fish
- $CF = \frac{W}{L\text{^}3} x100$
  - W: Mean weight at the end of the experiment (g)
  - L: Total length of fish at the end of the experiment (cm)

- Feed conversion rate (FCR)

$$FCR = \sum F_{t1..2}/W2 - W1$$

in which

$\sum F_{t1..2}$ = the sum of feed given during the period from time 1 to time 2.

- ***Feeding intake (FI):*** Feed intake (FI) in each tank will be registered and the measure as follows

FI (g/fish/day) = $\sum F_{t1..2}$/*[(fish number)x culture time]*

Mortality in each tank will be recorded on a daily basis during the whole experimental period in order to calculate survival rate:

- ***Survival rate = N/N_0 x 100%***

Note: N_0 = number of fishes at the start of the study

N= number of fishes at the end of the study

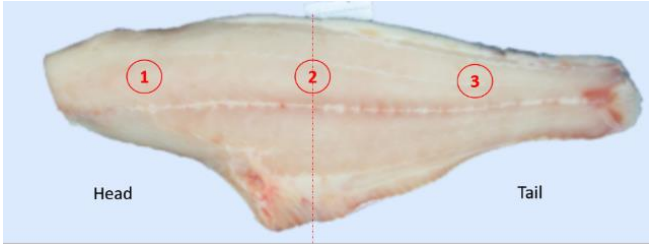
II.4. Evaluate fish fillet and fish fillet quality at harvest

At the end of the feeding trial, fish fillet quality was monitored by following parameters

- ***Fillet percentage (%):***
  - Fillet (%)= [weight of two fillet pieces (both sides of the fish)]/fish weight
- ***Adipose somatic index (ASI):*** *Measure the accumulated fat in abdominal of fish after the feeding trial*
  - ASI = (Abdominal fat/Total fish weight) x 100
- ***Hepato somatic index (HSI')***: *Measure the liver weight of fish at the end of the feeding trial*
  - HSI'(%) = (Liver weight/Total fish weight) x 100
- ***Drip loss:*** *Measure the weight lost by dehydration or due to physical damage of the fish muscle during chill for 72 hours at 4^oC*
  - ***Drip loss (%) =*** *[(Initial weight – Final weight $_{after\ chilling}$)/ Initial weight] x 100*
    - Initial wright: Weight of a fish fillet piece
    - Final weight: Weight of the fillet piece after chilling at 4oC for 72 hours
- ***Thaw loss***: *Measure the weight lost water lost during the freeze at -20C and store in 14 days*.
  - ***Thaw loss (%)=*** *[(Initial weight – Final weight $_{after\ freezing\ in\ 14\ day}$)/Initial weight] X 100*
    - Initial wright: Weight of a fish fillet piece
    - Final weight: the weight of the fillet piece after freezing at -20oC, stored in 14 days and then defrosting
- ***Water holding capacity*** (WH): *Measure the increased weight of fish fillet when soaking in a tripoly-phosphate solution*
  - ***WH (%):*** *[(Final weight $_{after\ soaking}$- Initial weight)/Initial weight] x 100*
    - Initial wright: Weight of a fish fillet piece
    - Final weight: the weight of the fillet piece after soaking in a tripoly-phosphate in 2 hours

- Fillet texture analysis: Texture profile of a fish fillet was evaluated by using a Zwick/Roell 1.0 texture analyzer (Zwick USA, 30,144 Kennesaw, GA, USA) with the use of a U15 mm spherical cylinder probe at three selected positions of the fillet (head, middle and tail as described in the picture 2). The strain was set at 50% of the fillet height at the measurement position and the movement speed of the probe was 30 mm/min. There are 3 parameters were used to evaluate the fillet structure

- Firmness/hardness (F1, maximum force of the first penetration), F2 (maximum force of the second penetration),
- Gumminess and cohesiveness were recorded.



Picture 1. Three positions of a fish fillet were tested its texture (1: head; 2: middle; 3: tail)

II.5. Statistical analysis

The final live weight, specific growth rate, live weight gain, feed conversion ratio, survival rates, ASI (%), fillet (%), drip loss (%), thaw loss (%) of fish fillet will be all subjected to one-way analysis of variance (ANOVA) to determine if significant differences occurred among the dietary treatments. The data are statistically analyzed Duncan's multiple range tests. Effects with a probability of $P < 0.05$ were considered significant. Statistical analyses were performed using SPSS for Windows (Standard Version 9.0 SPSS Inc.).

III. RESULT AND DISCUSSION

III.1. Water quality of culture system

Water in hapas were sampled and monitored during the first feeding and second feeding stage. Its values were presented in Table 2 and Table 3, respectively.

Table 2. Water quality of hapas during the first feeding stage (8 weeks)

	pH	Temperature (^oC)	Dissolved oxygen (DO: mg/l)	Ammonia (mg/l)
Mean -morning	6.85	29.46	3.04	0.00
Mean - afternoon	7.24	30.76	6.66	0.00
Max- morning	8.00	31.00	6.71	0.01
Max - afternoon	8.10	33.20	10.59	0.01
Min - morning	6.20	27.80	1.12	0.00
Min afternoon	6.50	28.20	4.23	0.00

In the first feeding stage, the water pH values were in the rage of 6.86-7.24 where the morning pH values were often lower than those in the afternoon. The maximal and minimal level of pH were 8.0 and 6.2. Such variation of pH is in the suitable range for normal life of *Pangasius* catfish. In the second feeding stage, the pH values varied in the same as those in the first feeding (Table 3)

Mean temperature of water in the first feeding (Table 2), were in the range of 29.46-30.76^{0}C. Maximal temperature in the morning and afternoon were 31.0-33.2^{0}C. Minimal temperature in the morning and afternoon were in 27.8-28.2^{0}C. In the second feeding trial, the minimal temperature was 25.7-27.9oC lower than those in the first feeding since the second feeding time were in September-October time. Pangasius catfish is a completely tropical fish; therefore, such temperature is suitable for a normal life.

Table 3. Water quality of fish pond during the second feeding stage (10 weeks)

	pH	Temperature (^{o}C)	Dissolved oxygen (DO: mg/l)	Ammonia (mg/l)
Mean -morning	6.90	28.87	2.00	0.01
Mean - afternoon	7.18	30.45	7.80	0.00
Max- morning	7.20	31.50	4.28	0.03
Max - afternoon	7.80	32.90	12.90	0.00
Min - morning	6.10	25.70	0.89	0.00
Min afternoon	6.90	27.90	2.67	0.00

Water dissolved oxygen (DO) in the first feeding, were in the range of 2.0-7.8 mg/l. The lowest DO were recorded in the morning of 0.89 mg/l (in second feeding time) and (1.12 mg/l in the first feeing time). Fish often cannot tolerate such low DO below 1 mg/l. However, striped catfish is an air breathing fish species. The fish can obtain oxygen in the air through its gas bladder. Therefore, the fish normally do a feeding and growth well.

Ammonia levels in water were quite low in the first and second feeding. The highest values were 0.01 mg/l and 0.03 mg/l in the first feeding and second feeding time. Such ammonia level is low and does not affect to growth and fish health.

III.2 Feed analysis

Three experimental diets were produced in Godaco feed mill following the feed formulation in the Table 1. The proximate analysis of three diets were presented in Table 4.

Table 4. Proximate analysis of nutrient of six experimental diets (% dry matter)

Nutrient composition	A0	A15	A30
Moisture	8.09	8.22	8.03
Ash	8.99	8.87	9.01
Protein	28.47	28.55	28.38
Hydrolyzed fat	6.50	5.78	6.32
Crude fiber	4.07	4.03	4.12
Starch	23.00	23.88	22.76
Calcium	0.99	0.88	0.85
Phosphorus	1.19	1.13	1.10

Experimental diets were designed to have 28% crude protein and 5% lipids. The analysis in Table 4 indicated all three diets having similar protein levels of 28.38-28.55% meanwhile the hydrolyzed fats in three diets were similar but higher than designed level (5.78-6.50%). Ash, fiber, starch, calcium and phosphorus of three diets were similar and in the range of designed levels.

III.3 Growth and feed utilization for the first feeding time

Three diets were fed to fish with four replicates in 8 weeks. Growth performances and feed utilization were presented in Table 5 and Table 6.

Table 5. Growth performances and survival of fish fed three experimental diets in the first feeding (8 weeks)

Treatment	W0 (g)	W56 (g)	DWG (g/fish/day)	SGR (%.day^{-1})	SR (%)
A0	19.43 ^{a} ± 1.11	160.73 ^{a} ± 13.43	2.52 ^{a} ± 0.24	3.77 ^{a} ± 0.18	97.50 ^{a} ± 1.02
A15	19.46 ^{a} ± 0.91	161.32 ^{a} ± 15.31	2.53 ^{a} ± 0.27	3.77 ^{a} ± 0.16	99.69 ^{ab} ± 0.62
A30	19.54 ^{a} ± 1.37	170.67 ^{a} ± 4.85	2.70 ^{a} ± 0.76	3.87 ^{a} ± 0.11	99.06 ^{b} ± 1.19
P values	***0.992***	***0.459***	***0.468***	***0.585***	***0.030***

W0 (Initial weight); W56 (weight after 8 week feeding); DWG (daily weight gain); SGR (Specific growth rate); SR (survival rate)

Mean ± SD 4 replicates)

Values in the same columns having the same superscript letter are not significantly different (P>0.05

At the beginning of the feeding trial, mean weight of three diet treatments were 19.43-19.54 g. They are not significantly different (P>0.05). After 8 week feeding, mean weights were 160.73-170.67 g. The growth rates in 8 weeks of the study were quite high (final weight was 7-8

folds of initial weight), similar to other studies. However, they were not significantly different among three treatments even there was a tendency of increased weight from diet A0 to A30 treatment. Daily Weight Gain (DWG) and Specific Growth Rate (SGR) of three treatments were not significantly different among treatments. It was observed an increased growth in fish fed 0.15% and 0.30%. AZOMITE supplemented diets did not significant improve growth from the control diet.

The survival rates of three treatments were quite high and significantly different among them ($P<0.05$). The A30 diet treatment gave the highest survival rates (99.06%) versus the lowest survival rates (97.50%). However, the 2% difference was a small value.

Table 6. Feed use efficiency and quality of fish fed three experimental diets in the first feeding (8 weeks)

Treatment	FI (g/fish/day)	FCR	CF (%)	HSI-index (%)	ASI index (%)
A0	2.92 [a] ± 0.20	1.17 [a] ± 0.04	1.51 [a] ± 0.02	2.38 [a] ± 0.15	2.50 [a] ± 0.28
A30	2.89 [a] ± 0.20	1.15 [a] ± 0.08	1.52 [a] ± 0.05	2.41 [a] ± 0.16	2.41 [a] ± 0.27
A30	3.07 [a] ± 0.07	1.14 [a] ± 0.04	1.52 [a] ± 0.03	2.50 [a] ± 0.21	2.40 [a] ± 0.07
P values	*0.328*	*0.763*	*0.909*	*0.609*	*0.776*

FI (Feeding intake); CF (Condition factor); HSI-index (Hepato-somatic index); ASI (adipose-somatic index); *Mean ± SD 4 replicates)*

Values in the same columns having the same superscript letter are not significantly different (P>0.05)

Feed utilization expressed in feeding intake (FI) and feed conversion ratio (FCR) that were presented in Table 6. FI and FCR were not significant different but there was a trend to have a reduced FCR from Diet A0 to Diet15 and Diet30.

Condition factor (FI), Adipose-somatic index (ASI) and Hepato-somatic index (HSI') of three diet treatments were not indifferent; however, there were a trend of increased CF and HSI' index meanwhile a reduced an adipose-somatic index (ASI).

It seems that supplementation of 0.15-0.30% AZOMITE in striped catfish of 20-200 g did not significantly improve growth performance and feed utilization versus the control diet; however, there was a trend to increase growth and reduce feed conversion ratio at diets supplemented with 0.30% AZOMITE.

III.4 Growth and feed utilization for the second feeding time

Fish in the first feeding stage continued to culture using the same feed (A0, A15, A30) but the stocking density was reduced to 40 fish per hapa. The fish was cultured in 10 weeks to evaluate fish growth, feed utilization and especially fish fillet quality at harvest.

Growth performances and feed utilization of fish fed three diets in the second feeding stage were presented in Table 7. Initial mean weight of three diet treatments was not significantly different and after 10-day feeding, the final mean weigh was significantly different: the highest weight at A30 diet (493.72 g) and lowest at A0 diet (434.56 g). Daily weight gain (DWG) has the same trend with final weight. However, the specific growth rate (SGR) was not significantly different among three diets but A0 diet had the lowest (1.37 %.day^{-1}) and A30 had the highest SGR (1.40%.day^{-1}).

Table 7. Growth performances and survival of fish fed three experimental diets in the second feeding (10 weeks)

Treatment	W56 (g)	W125 (g)	DWG (g/fish/day)	SGR (%.day^{-1})	SR (%)
A0	167.34 ^{a} ± 11.91	434.56 ^{a} ± 12.63	3.82 ^{a} ± 0.11	1.37 ^{a} ± 0.73	99.38 ^{a} ± 1.25
A15	177.46 ^{a} ± 12.07	470.75 ^{ab} ± 41.83	4.19 ^{ab} ± 0.57	1.39 ^{a} ± 0.14	99.38 ^{a} ± 1.25
A30	184.51 ^{a} ± 6.67	**493.72 ^{b} ± 38.91**	4.42 ^{b} ± 0.55	1.40 ^{a} ± 0.11	100.00 ^{a} ± 0.00
P values	0.122	0.094	0.233	0.895	0.662

W56 & W156: Mean weight at 56th and 126th day (after 10-week feeing); WG: (weight gain) SGR (specific growth rate); SR (survival rates)

Mean ± SD 4 replicates)

Values in the same columns having the same superscript letter are not significantly different (P>0.05)

Table 8. Feed use efficiency and quality of fish fed three experimental diets in the second feeding (10 weeks)

Treatment	FI (g/fish/day)	FCR	CF (%)	HSI-index (%)	ASI index (%)
A0	5.40 ^{a} ± 0.06	1.41 ^{a} ± 0.04	1.51 ^{a} ± 0.02	1.58 ^{a} ± 0.25	2.11 ^{a} ± 0.28
A15	5.67 ^{a} ± 0.57	1.35 ^{ab} ± 0.08	1.54 ^{a} ± 0.06	1.69 ^{a} ± 0.24	**1.58 ^{b} ± 0.18**
A30	5.72 ^{a} ± 0.69	**1.30 ^{b} ± 0.03**	1.57 ^{a} ± 0.08	1.67 ^{a} ± 0.31	**1.62 ^{b} ± 0.13**
P values	***0.665***	***0.071***	***0.348***	***0.847***	***0.010***

FI (Feeding intake); CF (Condition factor); HSI-index (Hepato-somatic index); ASI (adipose-somatic index)

Mean ± SD 4 replicates)

Feed utilization in the second feeding stage (150-500 g) expressed in Table 8 and had a tendency of increased feeding intake and A30 diet gave the lowest FCR (1.34) and significantly difference from the A0 diet (1.41). The CF and HSI-index were not significantly different but a tendency to increase from A0 to A30 diet. Meanwhile, there was a significant reduce of ASI index from A0 to A30 diet treatment.

In the second feeding stage, it was recognized a significant improve growth, reduce FCR and ASI index from A0 to A30 diet. It is noticed an improvement of growth ,feed utilization and reduced abdomen fat in fish fed diets containing 30 g/kg AZOMITE.

III.4. Fish fillet and the fillet structure

At the end of the second feeding, fish were sacrificed and filleted. The result was presented in Table 9

Table 9. Fish fillet quality of fish fed three experimental diets at harvest.

Treatment	Fillet percentage	Drip loss (%)	Thaw loss (%)	Water holding capacity (WH %)
A0	45.16 ^{a} ± 1.53	1.43 ^{a} ± 0.83	7.75 ^{a} ± 4.01	12.09 ^{a} ± 2.02
A15	46.93 ^{a} ± 1.13	1.23 ^{a} ± 0.52	7.27 ^{a} ± 2.16	16.54 ^{ab} ± 4.29
A30	47.42 ^{a} ± 1.70	1.07 ^{a} ± 0.36	5.36 ^{a} ± 1.02	**18.40 ^{b} ± 2.60**
P values	*0.130*	*0.705*	*0.448*	*0.049*

Mean ± SD 4 replicates)
Values in the same columns having the same superscript letter are not significantly different (P>0.05)

Fillet percentage (%) of three treatments were in the range of 45.15-47.42% not significantly different among treatments. **Therefore, AZOMITE supplementation in the diets does not improve fillet percentage at harvest; however, there was a tendency to have an increased fillet percentage from A0 to A30 diet treatment**

Water loss after chilling and freezing of fish fillet were presented Table 9 with drip loss (%) and thaw loss (%) parameters, respectively. Both drip loss and thaw loss were not significantly different among treatments but a tendency to reduce from A0 to A30 treatment for drip loss and thaw loss. **It seems that 0.30% AZOMITE supplementation has an effect to the reduce water loss during the frozen process through reduced drip loss and thaw of fish at harvest.**

Water holding capacity (WH%) in the study is defined as an increased water when soaking with sodium tri-polyphosphate. The WH (%) of three treatments were significantly

different where the A30 treatment had the highest WH (%) of 18.40% significantly different from the A0 treatment (12.095).

It is noted that AZOMITE supplementation in diets did not give significantly difference among treatment but there is a tendency to have increased fish fillet percentage, reduced drip loss and thaw loss in frozen process. It is also noticed a significantly increased the water holding capacity when soaking fillet in a sodium tri-polyphosphate, especially in 0.30% AZOMITE supplementation diet.

Fish fillet texture for three treatments with hardness, gumminess and cohesiveness that were sampled in three positions of a fillet at head, middle and tail. All measured values were presented in Table 10 & 11

Table 10. Fillet texture analysis of fillet of fish fed three experimental diets at harvest

	Hardness (N)			**Gumminess**		
	Head	Middle	Tail	Head	Middle	Tail
A0	11.98 [a] ± 1.35	10.94 [a] ± 1.23	9.43 [a] ± 0.81	3.12 [a] ± 0.55	2.93 [a] ± 0.53	2.80 [a] ± 0.35
A15	12.57 [a] ± 2.04	11.68 [a] ± 1.84	10.88 [a] ± 2.63	2.99 [a] ± 0.27	2.89 [a] ± 0.47	3.05 [a] ± 0.57
A30	12.08 [a] ± 1.16	11.71 [a] ± 1.50	10.32 [a] ± 0.78	2.79 [a] ± 0.26	2.90 [a] ± 0.24	2.65 [a] ± 0.30
P values	0.854	0.738	0.484	0.508	0.990	0.443

Mean ± SD 4 replicates)
Values in the same columns having the same superscript letter are not significantly different (P>0.05)

Table 11. The cohesiveness of fish fillet at harvest (N)

	Cohesiveness (N)		
	Head	Middle	Tail
A0	0.26 [a] ± 0.02	0.27 [a] ± 0.03	0.30 [a] ± 0.02
A15	0.24 [a] ± 0.02	0.25 [a] ± 0.02	0.28 [ab] ± 0.01
A30	0.23 [a] ± 0.01	0.25 [a] ± 0.02	**0.26 [b] ± 0.01**
P values	*0.122*	*0.498*	*0.021*

Mean ± SD 4 replicates)
Values in the same columns having the same superscript letter are not significantly different (P>0.05)

Generally, the hardness and gumminess of a fillet at head position was always higher than those at the tail position. That is due to the natural structure of fish fillet where the head position is always firm than the tail position of a fillet. The hardness and gumminess of fish fillet were not significantly different among treatments. Therefore, AZOMITE supplementation in diets did not have effect to the hardness and gumminess of fish fillet.

The cohesiveness of fish fillet was also a parameter related to muscle texture and expressed in Table 11. The cohesiveness of head and middle position of fillet were not significantly different among treatments but a significant difference was recorded at those of the tail position where the highest value at A0 (0.30) and lowest value at A30 (0.26) It seems the AZOMITE supplementation in diets has reduced the cohesiveness of a fish fillet.

In the study, the AZOMITE supplementation did not affect to the hardness, gumminess but reduce the cohesiveness of fish fillet. That needs more study to verify its effect to fish texture.

III. 5. General discussion.

In the study, AZOMITE supplementation did not significantly improve growth and feed utilization in the first feeding (20-200g). It has only a trend to ameliorate in striped catfish feed. However, in the second feeding 200-500g) the growth and feed utilization was significantly improved, especially the A30 treatment. That can be explained that the 8 week-first feeding was not long enough to develop its effectiveness which was clearly appeared in the second feeding. It seems AZOMITE supplementation in feed needs a longer time of 8-10 weeks to express its effect.

Dietary supplementation of AZOMITE in aquaculture improve growth and feed utilization in Tilapia (Liu *et al*. 2009), grass carp (Liu *et al*., 2011) and koi carp (Abdul Jaleel *et al*., 2008). The optimal inclusion rate for Tilapia and koi grass was 4 g/kg feed, equivalent to 0.40%. Meanwhile study in grass carp showed increased biomass by 16.65% (P=0.08) and decreased feed conversion rate (FCR) by 12.90% (P<0.05) by supplementation of 0.2% AZOMITE in diet (Liu *et al*., 2011). Therefore, the optimal 0.3% AZOMITE supplementation in the study for striped catfish was in the middle of inclusion rate of tilapia and grass carp.

However, a study in catfish (*Pangasius hypophthalmus*) in Pakistan, the same fish species of striped catfish (*Pangasianodon hypophthalmus*) since *Pangasius hypophthalmus* is an old name of *Pangasianodon hypophthalmus* (National Museum of National History: https://eol.org/pages/570181/names) showed best growth performance without any significant increase in biochemical nutrients profile with 1.0 % inclusion AZOMITE in diet (Batool *et al*., 2018). In his study, AZOMITE was added in the basal diet containing crude protein (CP 38.3%) with three graded levels 0% control, 0.5% T1 and 1.0% T2. After 90 days of study period, treatments with AZOMITE supplementation showed significantly higher growth than control group ($P \leq 0.05$). The feed conversion ratio (FCR) was found significantly ($P \leq 0.05$) better (1.9) in T2 than (2.4) control and (2.2) T1. However, his study has high FCR of 1.9-2.5 and low growth rates SGR of 1.1-1.2%.day^{-1} when compared to the present study of the first feeding that

had FCR of 1.1-1.2 and SGR of 3.9-4.0 %day^{-1}. Anyway the difference in culture facilities can explain difference in growth rate and feed utilization.

Also in channel catfish the diet containing 0.25% or 0.5% AZOMITE did not have significantly different with control diet in terms of growth performances and feed utilization (Aarattuthodiyil *et al*., 2019). In the channel catfish study, the feeding trial was in only 9 weeks that can be too short to express any significant difference among treatments like the result in striped catfish in which the first feeding lasted in 8 weeks. **It seems that catfish needs longer time in feeding so as to express its effect in growth and feed utilization**.

In the study, the fish fillet percentage has a tendency to increase in AZOMITE supplemented diets but not significantly different. The water holding capacity (WH%) of 0.30% AZOMITE supplemented diet was significant difference with the control and it has increased 50% the WH% from the control diet. During frozen storage, the properties of proteins forming the structure of fish meat, such as muscle cell membranes, are greatly affected, resulting in alterations in the water holding capacity and texture (Shenouda 1980). **It is noticed that AZOMITE supplementation in diets has an effect to properties of fish proteins of fillet resulting in increased water holding capacity in fish fillet that needs more study to clarify its activities.**

IV. CONCLUSION

The AZOMITE supplementation of 0.15%-0.30% in striped catfish feed seems not improve growth and feed utilization in 8 week feeding; however, continued feeding in 10 weeks it shows 0.3% AZOMITE diet significantly improved growth and feed utilization. That helps increased 13% growth performances and reduced 7.8% FCR when compared to the control diet.

Moreover, 0.30% AZOMITE diet has reduced the abdomen fat and increased the water holding capacity of fish fillet after feeding in 18 weeks to obtain the marketable size at harvest.

V. REFERRENCE

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APPARENDIX

Picture 1. Fish at harvest

Picture 2. Filletage of fish

Picture 3. A Zwick/Roell 1.0 texture analyzer connected to a computer

Picture 4. Measuring the hardness of a fish fillet of striped catfish (middle position)