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Zootechnical Performance and Body Composition of *Clarias gariepinus* (Burchell, 1822) Fingerlings Fed Local Feeds Enriched with Azomite

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Key words
Fingerlings, *Clarias gariepinus*, Azomite, Local feed, Zootechnical performance, Natural mineral

ABSTRACT

The study was conducted to assess the impact of azomite, a natural mineral derived from volcanic ash, on the zootechnical performance of *Clarias gariepinus* fingerlings fed with formulated diets based on local by-products. The study lasted 28 days. A total of four diets (T_0, 0%; T_1, 1%; T_2, 2%; T_3, 3% azomite) were tested on fingerlings of 1.06± 0.01 g mean initial weight distributed in tanks of 1 m^3 each. The rationing rate was 12%. Zootechnical performance varied significantly between treatments ($P < 0.05$). Specific growth rate varied from 4.21 ± 0.25%/day to 5.73 ± 0.23%/day, and survival rate from 85.33 ± 2.31% to 89.33 ± 9.24%. T2 diets (2% azomite) produced the best growth and feed efficiencies. We can therefore conclude that the best rate of azomite supplementation for good zootechnical performance of *C. gariepinus* fingerlings is 2%.

INTRODUCTION

The aquaculture sector has been booming worldwide since the 2000s. In 2018, aquaculture production accounted for 46.0% compared with 25.7% in 2000 (FAO, 2020). This situation is clearly justified by the growing demand for aquaculture products. Average apparent per capita consumption rose from 18.4 kg in 2015 to 20.5 kg in 2018 (FAO, 2020). Fish is a low-cost source of protein and lipids, of good nutritional quality and accessible to all Africans (Kaushik, 2001; Fermon *et al*., 2010). The major problems undermining the development of aquaculture in Benin include the quality of the feed produced and the lack of species diversification. Most of the feed used in fish farming comes from the Netherlands, Brazil, Israel, Egypt, Ghana and Nigeria (Rurangwa *et al*., 2014). Feed is the biggest expense in aquaculture, accounting for 50-70% of production costs (Rana *et al*., 2009). It therefore deserves special attention and in-depth work to reduce fish production costs and thus increase fish farmers revenues.

Considered a natural mineral product from Utah (USA), azomite is very useful, and widely used in Asia. It is a certified organic trace element booster that has been used as a supplement in livestock and aquatic animal feeds worldwide for over a decade. It has also been used in poultry, shrimp and tilapia feeds as a trace element blend for several years and claims to improve feed quality, increase weight gain, feed conversion and palatability (Ahamed *et al*., 2020). An azomite-supplemented diet has been reported to improve growth, intestinal digestive enzyme activity, nutrient digestibility and non-specific serum immune function in tilapia (*Oreochromis niloticus* x *O. aureus*)

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(Liu *et al*., 2009), grass carp (*Ctenopharyngodon idellus*) (Liu *et al*., 2011), koi carp (*Cyprinus carpio*) (Jaleel *et al*., 2015). It is necessary to incorporate trace elements into fish diets, as they are involved in the biochemical processes required for normal fish growth and development (Hooge, 2008). Given the importance of including azomite in experimental and commercial animal and poultry diets and its effects on growth and survivability, the present study was initiated to test the effect of azomite-enriched feeds on the zootechnical performances and carcass composition of *Clarias gariepinus* fingerlings.

MATERIALS AND METHODS

Experimental set-up

This study was carried out at the research station of the Laboratoire d'Hydrobiologie et de Recherche sur les Zones Humides (LHyReZH) of the University of Abomey-Calavi (UAC). Twelve circular concrete basins, each with a capacity of 500 L, were used to conduct the study. Each basin was filled with 300 L of water at a flow rate of 3 L min^{-1}. The water in the basins was changed twice a day: in the morning before the first feeding, and in the evening before the last feeding. Half of each basin was covered with a screen to prevent direct sunlight penetration.

A total of 375 *C. gariepinus* fingerlings with an average initial weight of 1.06 ± 0.2 g were used in the experiment. The stocking density was 30 fingerlings per tank. Feeding frequency was three times a day (08AM, 12AM and 5PM). The duration of the study was 28 days.

Four experimental diets (Table I) formulated with local ingredients using the feed calculator application were used in the experiment. Of these experimental diets, three (T_1, T_2 and T_3) contained azomite at various rates of incorporation. The fourth is the control diet (T0 without azomite). All diets are isoproteic, isolipid and isoenergetic. Each diet was tested in triplicate. The rationing rate was 10% of biomass per tank.

During the manufacturing process of the tested diets, the raw ingredients are finely ground, weighed and blended until a homogeneous whole is obtained. Then, purified amino acids (DL-methionine), azomite, vitamins and minerals and palm oil were added. Water was then added to obtain a malleable paste. The resulting mixture was passed through the 1 mm mesh of a food mill. The resulting spaghetti was cold dryed in a dehydrator at 32°C for 36 h and then broken down by hand into small granules. The resulting granules were stored in small containers kept at a cool temperature (4°C) until distribution. The feed was distributed manually every three (03) h from 8:00 am to 5:00 pm.

Control fishing was carried out every 7 days from 7 am to 9 am. At each control fishing, the fingerlings were counted and the biomass per pound was assessed in order to adjust the feed ration.

For water quality monitoring, physico-chemical parameters such as temperature, dissolved oxygen, TDS, electrical conductivity and pH were measured using a portable multimeter (Calypso ORCHIDIS SN-ODEOA 2138) every morning before the first feeding.

Table I. Diets tested during experimentation.

Ingredients	T_0	T_1 (1%)	T_2 (2%)	T_3 (3%)
Mineral vitamin premix[a]	0.25	0.25	0.25	0.25
Maize meal	16.5	15.5	14.5	13.5
Palm oil	3.73	3.73	3.73	3.73
Wheat bran	5	5	5	5
Blood meal	2	2	2	2
Fish meal [a]	22.5	22.5	22.5	22.5
Soybean meal	30	30	30	30
Soya meal	20	20	20	20
DL-methionin[e]a	0.02	0.02	0.02	0.02
Azomite [b]	0	1	2	3
Proximate compsition	100	100	100	100
Crude protein (%)	39	39	39	39
Crude lipid (%)	10.24	10.24	10.24	10.24
Energy (KJ/g) [c]	17.5	17.5	17.5	17.5
Protein/ Energy [c]	2.23	2.23	2.23	2.23

[a] Drugstore , premix (vitamin-mineral) contains (‰): Vitamin A 4 000 000 U.I; Vitamin D 800 000 U.I; Vitamin E 40 000U.I; Vitamin K_3 1600 mg; Vitamin B_1 4 000 mg Vitamin B_2 3 000 mg; Vitamin B_6 3 800 mg; Vitamin B_{12} 3 mg; Vitamin C 60 000 mg; Biotin 100 mg; Inositol 10 000 mg Pantothenic acid 8 000 mg; Nicotinic acid 18 000 mg; Folic acid 800 mg; Cholin chloride 120 000 mg; Colbat carbonate 150 mg; Ferrous sulphate 8 000 mg; Potassium iodide 400 mg; Manganese oxide 6 000 mg; Cuivre 800 mg; Sodium selenite 40 mcg; Lysine 10 000 mg ; Methionin 10 000 mg ; Zinc sulphate 8 000 mg;. [b] Mineral Products, Inc. hereby certifies that this analysis is a typical analysis of AZOMITE® Country of Origin: United States [c]Calculated from nutrient content of experimental diets : 23.01 Kj/g protein; 38.07 Kj/g lipid and 17.15 Kj/g carbohydrates

Biochemical analysis

Biochemical analyses (proteins, lipids, ash and dry matter) were carried out in triplicate using AOAC (1999) standard methods. These analyses were carried out on ingredients, feed and experimental fry. For crude protein, the Kjeldahl method (%N x 6.25) was used. Lipids were determined by the Soxhlet hot method, using a mixture of chloroform and methanol (2 :1 v/v) for lipid extraction (Folch *et al*., 1957). Dry matter is determined by measuring weight loss after drying for 24 h in an oven at 105 °C, and ash by incinerating samples in an oven at 550°C for 16 h. The gross energy of the experimental regimes was calculated according to Azaza *et al*. (2006). All analyses were carried out at the Laboratoire de Biochimie et de Biologie Moléculaire of the Faculté des Sciences et Techniques (Université d'Abomey-Calavi).

Zootechnical parameters and feed utilization

Growth, survival and feed utilization performances were calculated. These were specific growth rate (SGR), average daily weight (ADW), survival rate (SR), protein efficiency ratio (PER) and feed efficiency (FE). These parameters were assessed using the following formula:

SGR (% / d) = [(ln FBW - ln IBW) / Experimentation duration] x 1001

ADW (g/d)=(FBW - IBW) / Experimentation duration

SR(%)= (Final number of fish/Initial number of fish) x 100.

FE = (FBW - IBW)/ Qa

PER = Wet body mass gain/ Protein intake

Where IBW and FBW are initial body weight and final body weight, respectively and Qa= Quantity of feed consumed.

Statistical analysis

Experimental data were subjected to ANOVA1 analysis after verification of normality and data homogeneity using Statviews software (version 5.01). Fisher's LSD (Least-Significant-Difference) test was used to perform a paired comparison of means. The significance level considered was 5%.

RESULTS

Physico-chemical parameters of water

Table II shows the average values of the physico-chemical parameters of the water according to the treatments during the trial. These results show that the experimental feed had no significant effect on the physico-chemical quality of the water in which *C. gariepinus* fingerlings were reared (p>0.05).

Zootechnical parameters and experimental feed utilization

Data on growth, survival and feed utilization are presented in Table III. Treatments T_0, T_1 and T_3 had the lowest average final weights (p>0.05). The highest specific growth rates were obtained in fry fed the T2 diet (p<0.05). Survival rates ranged from 85.33 ± 0.98 (T_1) to 89.33 ± 1.21 (T_2). The best survival rates were obtained with treatments T_2 and T_3 (p<0.05).

Feed utilization parameters evaluated in this trial varied significantly between treatments (p<0.05). The best feed efficiency (FE) was obtained with treatment T2 (Fig. 1).

Table II. Variation in physico-chemical parameters as a function of treatments.

Parameters	Temperature (°C)	DO (mg/l)	pH	TDS (ppt)	Conductivity (ms)
T_0	29.26 ± 0.48a	7.46 ± 0.04a	6.87± 0.12a	0.19 ± 0.05a	0.39±0.07a
T_1	29.27 ± 0.55a	7.47 ± 0.59a	6.86 ± 0.22a	0.18 ± 0.08a	0.37±0.05a
T_2	29.25 ± 0.47a	7.46 ± 0.92a	6.88 ± 0.18a	0.19 ± 0.04a	0.39±0.09a
T_3	29.26 ± 0.53a	7.46 ± 0.50a	6.85 ± 0.15a	0.19 ± 0.06a	0.38±0.07a

Mean values on the same line, followed by the same exponents, were not significantly different (P > 0.05).

Table III. Variation in zootechnical parameters of *C. gariepinus* fingerlings according to treatments.

Parameters	T_0	T_1	T_2	T_3
IBW (g)	1.05±0.02a	1.06±0.01a	1.06±0.03a	1.07±0.01a
FBW (g)	3.41±0.30b	3.46±0.11b	5.27±0.13a	3.53±0.10b
ADG(g/d)	0.08±0.01b	0.09±0.00b	0.15±0.01a	0.09±0.00b
SGR (%/d)	4.21±0.25b	4.22±0.16b	5.73±0.23a	4.26±0.13b
PER (%)	0.01±0.00b	0.01±0.00b	0.02±0.01a	0.02±0.01a
SR (%)	86.67±0.28b	85.33±0.98b	89.33±1.21a	88.00±0.98a

IBW, initial body weight; FBW, final body weight; ADG, average daily weight; SGR, specific growth rate; PER, protein efficiency ratio; SR, survival rate.
Mean values on the same line followed by different exponents are significantly different (P < 0.05).

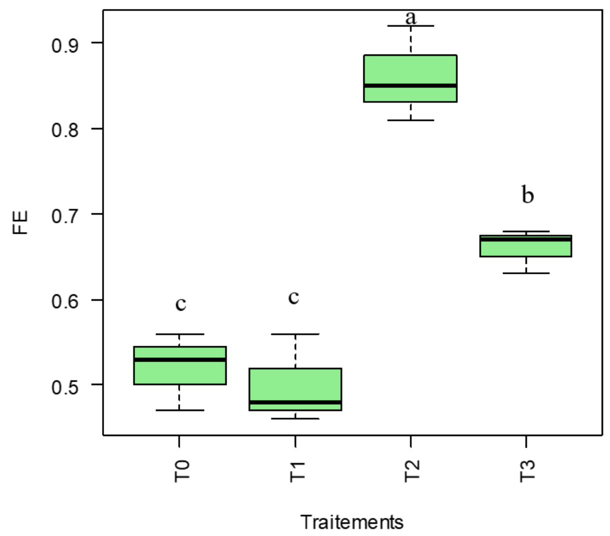

Fig. 1. Evolution of feeding efficiency (FE) in *C. gariepinus* fingerlings as a function of treatments.

Bromatological composition of fish carcasses

Table IV shows that the bromatological composition of fish carcasses varied according to treatment. The ash, protein, lipid and dry matter contents of the carcasses of the final samples were higher than those of the initial fish. The experimental feeds had a significant effect on the protein content of the carcasses of *C. gariepinus* fingerlings reared in this study (p <0.05).

Table IV. Bromatological composition of fish carcasses according to treatments.

Parameters (%)	Initial	T_0	T_1	T_2	T_3
Ash	3.36± 0.11	3.67± 0.11^a	3.72± 0.10^a	3.80± 0.16^a	3.87± 0.16^a
Protein	12.32± 0.61	14.21± 0.44^a	15.12± 1.12^a	16.52± 0.13^a	16.55± 0.33^a
Lipid	3.28± 0.09	4.93± 0.32^a	5.35± 0.23^a	5.89± 0.35^a	5.99± 0.65^a
Dry matter	44.24± 1.01	47.92± 1.21^a	48.61± 1.02^a	49.61± 1.02^a	49.32± 0.53^a

Mean values on the same line followed by different exponents are significantly different (P < 0.05).
See Table I for details of T_0-T_3.

DISCUSSION

Physical and chemical parameters of the water

The physico-chemical parameter values recorded showed that the experimental regimes did not have a significant impact on water quality during this experiment. Similar observations were made by Kpogue *et al.* (2024) who also used black soldier fly larvae meal *H. illucens* for the pre-growth of *Oreochromis niloticus*. Physico-chemical parameters in general were found to be within an acceptable range for the growth of *C. gariepinus* fingerlings. In addition, water temperatures have varied from 29.25 to 29.27°C. This range of variation is well in line with the temperatures required by the species for its rapid growth. As for pH, fluctuation is almost non-existent and is very closed to neutral which is ideal for the development of *C. gariepinus* individuals.

These values are in line with the species requirements (Kanangiré, 2001; Amoussou and Toguyeni, 2016; Cherif and Guechache, 2018).

Zootechnical parameters and experimental feed utilization

The importance of trace elements as essential ingredients in diets, albeit in small quantities, is evident in aquaculture. Indeed, the use of azomite and other trace elements in feeds for aquaculture species significantly enhances growth performance, immunity and digestive functions in several species (Mustafa *et al*., 2016; Zhang *et al*., 2023). Liu *et al*. (2009) and Liu *et al*. (2011) had similar results in tilapia (*Oreochromis niloticus* × *O. aureus*), carp (*Ctenopharyngodon idella*) and shrimp (*Macrobrachium rosenbergii*). Our results also showed an improvement in growth when 2% azomite was incorporated into feed for *Clarias gariepinus* fingerlings. The increase in growth is related to the increase in feed intake and apparent protein utilization showing a similar change with final weight and percentage weight gain and their relationships with azomite levels. Batool *et al.* (2018) noted a significant increase in growth performance and feed utilization in *P. hypophthalmus* fingerlings when adding 0.5% and 1.00% azomite compared with the control diet. Also, Azam *et al*. (2016) reported that the addition of 0.75% azomite to the diet of *Oreochromis niloticus* significantly increased growth and feed efficiency. The results of Aijun *et al.* (2009) showed that the addition of 2.5 $g.kg^{-1}$ azomite to the diet improved the growth and nutrient digestibility of tilapia (*Oreochromis niloticus* and *O. aureus*). Batool *et al*. (2018) showed that incorporating 1% azomite into diets for *Pangasius hypophthalmus* fingerlings improved their zootechnical performance. Man-zi *et al*. (2011) showed that incorporating 2% azomite into feed increased growth and feed efficiency in *Ctenopharyngodon idellus* fingerlings. The best zootechnical and sanitary performances were observed in *Micropterus salmoides* fingerlings when feed contained 4 g/kg citric acid + 1.5 g/kg azomite (Zhang *et al*., 2023).

Survival rates observed during this study ranged from 85.33 to 89.33%, with the highest observed in fingerlings from treatment T2. These results are similar to those recorded by d'Almeida *et al.* (2020) who worked on the effects of garlic (*Allium sativum*) on attractiveness and weight growth in *C. gariepinus* reared in soilless tanks. These authors found survival rates ranging from 96.66 to 100%. According to Mustafa *et al*. (2016), the use of azomite at optimal levels in fish diets increases their resistance to disease and stress. It then increases their survival rate (Shah *et al*., 2015). The better survival rates obtained with *C. gariepinus* fingerlings fed diets containing 2% and 3% azomite confirm this assertion.

Bromatological composition of fish carcasses

The bromatological composition of the carcasses of *C. gariepinus* fingerlings fed our experimental diets showed that the use of azomite did not adversely affect their nutritional quality. The best protein accretions were obtained with treatments T2 and T3. Zhang *et al.* (2023) also showed that incorporation of azomite at optimal levels in the diet of *Micropterus salmoides* fingerlings resulted in an increase in carcass protein. This undoubtedly reflects improved protein assimilation in these fish.

CONCLUSION

The use of azomite in the diet of *C. gariepinus* fingerlings positively influences growth, survival and feed utilization performance. The best results were obtained with feed containing 2% Azomite. This rate can therefore be recommended to fish farmers as a feed supplement to improve the zootechnical performance of *C. gariepinus* fingerlings.

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Generative AI and AI-assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Ahamed, H.A., Mohamed, J.M., Arunachalam, K.D., Raiyaan, G.I.D., Musthafa, M.S., Begum, S.S., Doan, H.V., 2020. Effects of Azomite enriched diet on gonadal steroid hormone levels and milt quality indices in *Oreochromis mossambicus*. *Aquacult. Rep.*, **17**: 100341. https://doi.org/10.1016/j.aqrep.2020.100341

Aijun, L., Xiangjun, L., Xiaoqin, L., Liping, W., Yunxian, L. and Ruijun, Z., 2009. Effects of Azomite on growth. intestinal structure and non-specific immunity of tilapia (*Oreochromis niloticus* x *Oreochromis aureus*). *Chinese J. Anim. Nutr.*, **21**: 1006-1011.

Amoussou, T.O. and Toguyeni, A., 2016. Caractéristiques biologiques et zootechniques des tilapias africaicains *Oreochromis niloticus* et *Sarotherodon melanotheron*. *Int. J. Biol. Chem. Sci.,* **10**: 1869-1887. https://doi.org/10.4314/ijbcs.v10i4.35

AOAC, 1999. *Official Methods of Analysis (16th ed., 5th rev.)*. Association of Official Analytical Chemists, Washington, D.C., USA.

Azam, A.R., Khan, N. and Iqbal, K.J., 2016. Impact of azomite supplemented diets on the growth. Body composition and endogenous enzymes in genetically male tilapia. *Pakistan J. Zool*., **48**: 1205-1208.

Azaza, M.S., Dhraïef, M.N. and Kraïem, M.M., 2006. Effects of feeding level on growth performance, feed conversion ratio, and body composition of juvenile Nile tilapia (*Oreochromis niloticus* L.) reared in a recirculating system. *Aquacult. Res*., **37**: 1226–1234.

Batool, S.S., Khan, N., Atique, U., Azmat, H., Iqbal, K.J., Mughal, D.H., Ahmad, M.S., Batool, S., Munawar, S., Dogar, S., Nawaz, M. and Amjad, S., 2018. Impact of azomite supplemented diets on the growth and body composition of catfish (*Pangasius hypophthalmus*). *Pakistan J. Zool*., **13**(**Suppl.**): 8-12.

Cherif, M.T.L. and Guechache, S., 2018. *Contribution à l'étude de la croissance de Tilapia du Nil.* Oreochromis niloticus *dans un milieu aquatique artificiel dans la région de M'cif (M'sila).* Université Mohamed Boudiaf M'sila. Mémoire de Master. Faculté des Sciences. Département Des Sciences Agronomiques. 47p.

d'Almeida, A.F.M., Kpogue Gangbazo, D.N.S., Aboh, B.A., Ogbon, M. and Mensah, G.A., 2020. Effet de l'Ail (*Allium sativum*) sur l'attractivité de l'aliment et la croissance pondérale chez *Clarias gariepinus* (Burchell, 1822). *Bull. Recherche Agron. Bénin (BRAB)*, **30**: 32-43.

FAO, 2020. *The state of world fisheries and aquaculture 2020*. Sustainability in action. Rome. Italy: Food and Agriculture Organization of the United Nations. pp. 206.

Fermon, Y., Clements, J., Pouomogne, V., Brummett, R., 2010. Aquaculture à petite échelle pour les moyens d'existence ruraux: Lignes directrices pour les agents de vulgarisation. FAO, Rome.

Folch, J., Lees, M. and Sloane-Stanley, G.H., 1957. A simple method for the isolation and purification of total lipides from animal tissues. *J. biol. Chem*., **226** : 497–509. https://doi.org/10.1016/S0021-9258(18)64849-5

Hooge, D., 2008. Natural minerals can benefit broiler diets. *Feedstuffs*, **80**: 24-26.

Jaleel, M.A., Musthafa, M.S., Ali, A.J., Muhammad, M.J., Kumar, M.S.A., Natarajan, G. and Thiagarajan, V., 2015. Studies on the growth performance and immune response of koi carp fingerlings (*Cyprinus carpio* koi) fed with azomite supplemented diet. *J. Biol. Nat*., **4**: 160-169.

Kanangiré, C.K., 2001. *Effet de l'alimentation des poissons avec* Azolla *sur la production d'un écosystème agro-piscicole en zone marécageuse au Rwanda*. Thèse de Doctorat. Université Notre Dame de la paix. Namur. Belgique, pp. 222.

Kaushik, S.J., 2001. Alimentation humaine. Ressource et avenir de l'aquaculture. In: *Aquaculture et environnement.* INRA Edition. 26: 20-25.

Kpogue-Gangbazo, D.N.S., Tossavi, N.D., Atchamou, J.B.O., Decko, Z.P.E., Djissou, A.S.M., Danhossou, G. and Imorou Toko, I., 2024. The use of black soldier fly larvae meal *H. illucens* for the pre-growth of *Oreochromis niloticus* (Linnaeus, 1758) fingerlings reared in floating cages in Benin. *J. Aquacult. Livest. Prod.,* SRC/JALP-24-158.

Liu, A.J., Leng, X.J., Li, X.Q., Wang, L.P., Luo, Y.X. and Zhu, R.J., 2009. Effects of Azomite on growth. intestinal structure and non-specific immunity of tilapia (*Oreochromis niloticus* × *O. aureus*). *Chinese J. Anim. Nutr*., **21**: 1006-1011.

Liu, M.Z., Leng, X.J., Li, X.Q., Chang, X. and Chen, D.R., 2011. Effects of Azomite on growth performance. intestinal digestive enzyme activities and serum nonspecific immune of grass carp (*Ctenopharyngodon idellus*). *J. Zhejiang Univ. (Agric. Life Sci.)*, **37**: 312-318.

Man-Zi, L., Xiang-Jun, L., Xiao-Qin, L., Chang-Wu, X. and Dao-Ren, C., 2011. Effects of AZOMITE on growth performance. intestinal Aquaculture Nutrition digestive enzyme activities and serum nonspecific immune of grass carp (*Ctenopharyngodon idella*). *J. Zhejiang Univ. Life Sci*., **37**: 312–318.

Mustafa, M.S., Ali, A.R.J., Mohamed, M.J., Ali, A.R.H., Mohamed, J.M., Jaleel, M.M.A., Kumar, M.S.A., RaniK, U., Vasanth, K., Arockiaraj, J., Preetham, E., Balasundaram, C. and Harikrishnan, R., 2016. Protective efficacy of AZOMITE enriched diet in *Oreochromis mossambicus* against *Aeromonas hydrophila*. *Aquaculture*, **451**: 310-315. https://doi.org/10.1016/j.aquaculture.2015.09.006

Rana, K.J., Siriwardena, S. and Hassan, M.R., 2009. Impacts of rising feed ingredients prices on aqua feeds and aquaculture production. *FAO Fish. Aquacult. Techn. Pap.,* N°541. Rome. 63 p.

Rurangwa, E., van den Berg, J., Laleye, P.A., van Duijn, A.P. and Rothuis, A., 2014. *Mission exploratoire Pêche*. Pisciculture et Aquaculture au Bénin Un quick scan du secteur pour des possibilités d'interventions. *IMARES report C072/14 LEI report.* 14-049

Shah, S.Z.H., Afzal, M., Khan, S.Y., Hussain, S.M. and Habib, R.Z., 2015. Prospects of using citric acid as fish feed supplement. *Int. J. Agric. Biol.,* **17**: 1-8.

Zhang, Y., Huang, H., Chang, W.T.H., Li, X. and Leng, X., 2023. The combined supplementation of AZOMITE and citric acid promoted the growth. Intestinal health. Antioxidant. and Resistance against *Aeromonas hydrophila* for Largemouth Bass. *Micropterus salmoides*. *Aquacult. Nutr.,* **5022456**: 12. https://doi.org/10.1155/2023/5022456