International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 7.328
Peer Reviewed Bi-Monthly
Vol.4 No.19 May-June 2023

Agaricus bisporous: A formulated Aqua feed for Aquatic Organisms

Shaikh Nusrat Jahan[1], Tasmi Nasim Ansari[2]
[1]DRT's A.E. Kalsekar Degree College, Mumbra. Department of Zoology
[2]G.M. Momin Women's Degree College, Bhiwandi. Department of Zoology
***Corresponding Author*- Shaikh Nusrat Jahan**

Abstract:

Worldwide aquaculture making (including aquatic plants) stands at 150.2 million tonnes, with the first sale value predictable at USD 253.5 billion. The total production included 80.0 million tonnes of food fish and 30.1 million tonnes of aquatic plants. Currently aquaculture contributes to 46.8 percent of total global fish production. Dietary fibres and high fibre-containing foods have been a huge magnetism among researchers and nutraceutical industries due to their health-promoting benefits. This increase in growth of aquaculture has been primarily attributed to development in good quality feeds. Any good quality feed is prepared from proper and essential feed flavours. Presently research and developments in functional feed additives are showing promising yields to aqua farmers. Functional feed additives not only improve the growth performance of the fishes but also improve the health performance of the fishes. These functional feed additives are derived from different sources. These are organic and eco-friendly to fishes and environment. These functional feed additives include prebiotics, probiotics, seaweeds, mushrooms, microalgae, enzymes, organic acids, mycotoxin binders, photogenic. Nowadays, mushrooms and their by-products have been used to brace various food products as well as for use in animal feed owing to their bioactive, therapeutic and nutritional value. Hence, this review intends to highlight the current knowledge on edible mushrooms and their waste for food and feed enrichment and nutritional purposes, along with their role in human and animal diet.

Key Words: Aquaculture, Feed Additives, Dietary-Fibres And Edible Mushrooms.

Introduction:

Mushrooms are one of the most important food items since the ancient times because of their nutritional values and therapeutic properties. It was believed in ancient China that the mushroom establishes human body and health, it preserves the youth for as long as possible (Safwat and Al Kholi, 2006). In 2019, United States in world population prospects states that the growth of the human population leading into the middle of the 21st century poses significant challenges to the supply of high-quality, nutrient-rich food. Whereas FAO in 2018, reported that the farming of aquatic species (i.e. aquaculture) will make available a progressively noteworthy constituent of the worldwide animal-derived protein financial plan. Statistically, aquaculture has been the fastest budding nutrition production sector by annual growth rate over the last three decades, with annualized growth rates recorded of 10% in the 1990s and 5.8% annually between 2000 and 2016.

The global production of cultivated mushrooms was 495.127 metric tons in 1961. From 1961 to 2016, mushroom production increased to 10.378.163 metric tons (FAO, 2016). Although the percent of total global production of *Agaricus sp.* has decreased, it still retains the highest overall world production. Today China is leading in global mushroom production. China produces approximately 73% of world mushroom production in 2014. The second highest mushroom producing country is Italy, followed by USA (FAO, 2016). In recent years, interest in mushrooms has become increasingly apparent in all over the world due to their nutritional properties. High contents in proteins and polysaccharides associated with low content of fat, which profile is characterized by a higher concentration of mono and polyunsaturated fatty acids. A saturated fatty acid, is also being an interesting source of phenolic compounds as well as of some micro and macronutrients (Rodrigues et al., 2015). The nutritional attributes of edible mushrooms and the health benefiting effects of the bioactive compounds they contain, makes mushroom a healthy food (Pereira et al., 2012). Many researchers from different regions of the world confirmed the medicinal importance and nutritional quality of *A. bisporus*. In this review study, we have summarized the recent findings regarding many aspects of the nutritional importance of *Agaricus bisporus*.

Nutritional Properties Of *Agaricus bisporous*:

Protein and Amino acid content:

Mushrooms are considered as a good source of protein. A nutritional composition data of mushrooms published by different authors working with even the same species are variable. The protein content of *A. bisporus* presented by Sadiq et al. (2008) with 11.01 %, by Muszynska et al., (2011) with 25%, by Mohiuddin et al. (2015) with 17.7%–24.7% and by Ahlavat et al. (2016) with 29.14% in different growing substrates. Kakon et al. (2012) reported that mushroom proteins contain all nine essential amino acids required by humans, enabling their use as a substitute for a meat diet. The amino acids like alanine, aspartic acid, glutamic acid, arginine, leucine, lysine, phenylalanine, serine, proline, tyrosine and threonine found highest amount in *A. bisporus* (Muszyńska et al., 2013). Phromkunthong et al., (2014) mentions that mushroom by product is one of the alternative sources for replacement of fishmeal protein in fish with the advisable effect on growth performance compared to fishmeal protein. Mukhopdhay and Guha, (2015) reported that mushrooms are well acknowledged for their quality protein such as glutathione, single cell protein and rich quantity of essential amino acids and are used as dietary supplement feed. They did all-inclusive examination of the nutritional quality of edible mushroom Pleurotussajor-caju grown in deproteinized whey medium.

Carbohydrate and Fiber:

In Mushroom carbohydrates are not a major source. Digestible carbohydrates include mannitol and glucose, usually present in very small amounts (less than 1% DW) and glycogen (5–10% DW) while nondigestible carbohydrates include oligosaccharides such as trehalose and nonstarch polysaccharides (NSPs) such as chitin, ß-glucans and mannans, which are the major portion of mushroom carbohydrates (Cheung., 2010). Dietary fiber includes components of fungal cell walls such as chitin (Maftoun et al., 2015), hemi-celluloses, mannans and beta glucans play a key role in some healthy properties of mushrooms (Cheung, 2009). Nitschiske et al. (2011) determined that chitin content of *A. bisporus* was 9.60 g/100 g DM. Cherno et al. (2013) reported that *A. bisporus* contains 2 times more chitin than *P. ostreatus*. Chou et al., (2013) mention that stalk cut off is 25 to 33% of total production and studied the applications of polysaccharides from various mushroom wastes as prebiotics in different systems.

Anticancer Properties:

Agaricusbisporus contains different bioactive compounds that have been shown to exhibit immunomodulating and anticancer properties. The Canadian Cancer Society recommends consumption of *A. bisporus* mushroom because of its effectiveness against human diseases. Zhang et al. (2014) reported that brown *A. bisporus* polysaccharide possessed strong immunostimulatory and antitumor bioactivity in vivo and in vitro.Zhang et al., (2007) reviewed antitumor polysaccharides from mushroom: a review on their isolation, process, structural characteristics and anti-tumor activity. He mentions mushrooms have a low glycemic record and high mannitol, a high amount of potassium (K) and phosphorus (P) which is an imperative ortho-molecule. Various biologically active metabolites including glycoproteins, hydrolytic and oxidative compounds, phenolic and lipids were exerted immune modulation, enhancing nonspecific defense and increase disease resistance in aquaculture animals.

Chen et al. (2006) reported that the major active compounds in A. bisporus are unsaturated fatty acids such as linoleic acid, linolenic acid, and CLA which have been shown to inhibit aromatase activity. Roupas et al. (2012) also reported that an inhibition of aromatase activity and subsequent reduction of estrogen using extracts of mushroom that provide a physiologically suitable mechanism for influents on estrogen receptor positive tumors.

Digestive Enzyme Properties:

Santos et al., (2013) studied the complexity of digestive functions could be observed for animals maintained under different rearing conditions. Some of the studied enzymes showed potential adaptations of their activities and/or expression that may allow the experimental fish to achieve a more efficient nutrient utilization. This fact could be observed for both experimental culture systems. Thus, comparing the zoo-technical and enzymatic parameters, there are evidences that tilapia (*O. niloticus*) under present experimental conditions could adapt to culture systems under practical standards. Ahmed et al., (2020) finding revealed that analysis of digestive enzymes such as, protease and amylase in freshwater fishes. These categories of study deliver more understandings than monitoring of biochemical changes in gill and other organs. The researchers determined enzyme activities from the digestive tract using SDS-PAGE provide first-hand information on the impact of fenvalerate. Zhang et al., (2017) studied effect of replacing fish meal with fermented mushroom bran hydrolysate on the growth, digestive enzyme activity, and antioxidant capacity of Allogynogenetic Crucian Carp (*Carassius auratus gibelio*).

Growth Performance Properties:

Xu et al., (2015) showed and prepared the functional and high protein feeds from mushroom bran by the stepwise fermentation. Kesan et al., in (2015) studied the effect of mushroom supplementation as a prebiotic compound in super worm-based diet on growth performance of red tilapia fingerlings and reported the improvement of growth performance and survival with 10% prebiotic supplemented diet may result in 26 promising productivities in various aquaculture enterprises leading to a beneficial return of investment. Growth performance obtained by diet treatment was the best and feeding with this dietary treatment with supplementation of prebiotic compound makes fish culture worthy because it comes with a combination of medication treatment in the diet against infections. The use of natural immune-stimulants such as mushroom in fish culture for prevention of fish diseases showed a promising new development and could solve the problem of massive use of antibiotics. The results obtained in the present study indicated a distinct improvement of growth with the addition of prebiotic. Fernandes et al., (2016) studied the dietary protein requirement for zebrafish juvenile growth should be set at 37.6% for maximum weight gain and 44.8% for maximum protein retention.

Ye et al., (2016) observations show that complete or partial compensatory growth (CG) can be induced in Nile tilapia fed diets with different protein and lipid levels under a restricted feeding regime. This response is due to hyperphagia and an increased feed efficiency. All diets under a controlled feeding regime produced growth analogous to feeding a diet at low protein and lipid levels under a usual feeding regime. This effect was more distinct with diets at the blend of high protein and lipid levels. From a perspective of employment cost, despite the growth rate of fish subjected to the intermittent feeding regime being slightly lower than fish subjected to the normal feeding regime, this intermittent feeding regime is still economically helpful to labor and a decrease of labor costs, with the feeding time reduced from 44 days to 33 days, a decrease of 11 days. Manee et al., (2017) recently studied and reported the effects of different mushroom by product types and levels on growth performance and survival rate in dietary of Nile tilapia. Muin, et al., (2015) studied and established the effect of partial and complete replacement of fishmeal with mushroom stalk meal and soy bean on growing performance of Nile tilapia, *Oreochromis niloticus* fingerlings.

Stevens et al., (2018) strongly suggested that the constant growth and strengthening of the aquaculture industry therefore delivers an opportunity to improve the processing capacity of aquaculture to intercept additional byproducts and upsurge the quantity used for fish meal. This would also result in additional benefits including growing perceived environmental sustainability of the industry, on condition that economic and social benefits through the valorization of waste products and generating downstream processing jobs, which will eventually contribute to the long-lasting sustainability of, fed aquaculture.

Immunity Boosting Properties:

Dawood et al., (2020) showed when Nile tilapia fed white button mushroom showed activated immune mechanisms, which led to their development of resistances against heat stress. This study confirmed the protective role of using white button mushroom for fish reared under heat stress by a significant alleviation of hematological, biochemical, and immune variables. Additionally, a significant decrease of hepatic HSP70 in heat-stressed tilapia given white button mushroom was observed, indicating that dietary white button mushrooms partly alleviated the stress response of fish resulting from heat stress. Based on the polynomial regression analysis, the supplementation of white button mushrooms at 2.15 to 2.75% of feed has the potential to increase the growth, health, and immunity of Nile tilapia. Zou et al., (2016) reported that dietary administration of white bottom mushroom powder (WBMP) in carp diet stimulates mucosal immune response as well as cytokines gene expression. Besides, addition of WBMP in carp diet elevated serum nonspecific immune parameters. These outcomes suggest administration of 1 or 2% WBMP as an effective immunostimulants for initial stage of carp culture. This preliminary study encourages evaluation of this mushroom species on other commercially significant 30 cultured species. Carneiro et al., (2019) reported that levels of 40 and 50 g/kg of Chlorella sp. meal (CM) replacing FM for 60 days encouraged greater growth, number of eggs and survival of zebrafish spawn. In addition, 50 g/kg of Chlorella sp. meal (CM) decreases total cholesterol level, which may suggest the use of Chlorella to advance these fish health. Since feed feeding of zebrafish is very low, the higher levels of Chlorella sp. meal (CM) inclusion (40 and 50 g/kg) in this study are financially justified. Chlorella sp. meal (CM) bids prodigious potential for inclusion in practical diets for zebrafish juveniles and this preliminary study delivers support for future research to classify the bioactive compounds present in Chlorella sp. and their effects on other species used in aquaculture.

Wu et al., (2019) established the oral administration of chitosan diets enhanced the growth performance, body composition and immunity status of tilapias. However, high dose of chitosan (N 6g kg−1) decreased growth performance. Therefore, 6 g kg−1 was optimal for the growth of tilapias. The outcomes specified that chitosan 29 may be used as a diet supplement to improve the growth, body composition and immunity of tilapias.

AN OVERVIEW OF *Agaricus bisporous* USED AS FEEDS FOR DIFFERENT AQUATIC ORGANISMS:

Alam et al., (1996) studied and showed growth response of indigenous and exotic carp species to different protein sources in pelleted feeds where he asserted that fish meal is considered as the major protein source and the best ingredient for fish feed because of the compatible with the protein requirement. El-Sayed, (1998) reported the total replacement of fishmeal with animal protein sources in Nile tilapia *Oreochromis niloticus* (L.), feeds and again (El-Sayed, 1999) reported that alternative dietary protein sources could be used for farmed tilapia; *Oreochromis spp*. Mattila et al., (2001) reported the contents of vitamins, mineral elements, and some phenolic compounds in cultivated mushrooms. Unwanted mushroom, stalk of mushroom, comprises of a rich source of protein, polysaccharide and antioxidant following in application either replacement fish meal protein. He studied mushroom by-products (Pleurotussajor-caju (Fr.) Singers) for fishmeal in red tilapia (*Oreochromis niloticus* x *O. mossambicus*) with practical diet experiment. Song et al, (2014) studied the effects of fishmeal replacement with soy protein hydrolysates on growth performance, blood biochemistry, gastrointestinal digestion and muscle composition of juvenile starry flounder (*Platichthysstellatus*). Where they reported the replacement of dietary fishmeal with soy protein hydrolysates (SPH) within a range of 15%–70% was shown to elevate the T-AOC of the juvenile starry flounder.

Kwak et al., (2008) studied the broiler litter supplementation increases storage and feed nutritional value of 25 sawdust based spent mushroom substrate. Nasiri et al., (2013) did the comparative study on the main chemical composition of button mushrooms (*Agaricus bisporus*) cap and stipe. Yang et al, (2011) studied the Effect of replacing fish meal with soybean meal on growth, feed utilization and nitrogen and phosphorus excretion on rainbow trout (*Oncorhynchus mykiss*). Deborah et al., (2011) premeditated that substituting fish meal with earthworm and mushroom meals in practical diets of *Labeorohita* and *Hemigrammus caudovittatus* fingerlings and asserted that mushroom meal is more appropriate and adequate ingredient in the fish feed than fishmeal for the improved and healthier growth of fingerlings of *Labeo rohita* and *Hemigrammus caudovittatus.*

The researchers propose that the probable protein requirement should be taken into account to formulate a more suitable, cost-effective, and less pollutant diet for this species. Guerrera et al., (2015) found out results obtained in zebra fish species could be further integrated with those reported 27 from other fish and used for digestive physiology comparative studies, common to allvertebrates. Omsaki et al., (2016) worked on feed efficiency where economic values were consequential for breeding objective traits for Nile tilapia farmed in earthen ponds where oxygen is a limiting factor for production. The assortment on feed efficiency is a crucial factor to financial profitability of Nile tilapia breeding programs. The findings are not unique to Nile tilapia or pond systems but can be extended to any fish production system. The key is to categorize which limiting factors are acting on the production system and to embrace thesein a bio-economic model to measure the consequences of selection on growth.

Other General Properties Of *Agaricus bisporous:*

Ahmed et al., (2017) studied the influence of raw polysaccharide extract from mushroom stalk waste on growth and pH perturbation induced-stress in Nile tilapia, *Oreochromis niloticus*. It was reported that its polysaccharide extract increased in specific growth rate, weight gain, and hepatosomatic index (HSI) in Nile tilapia Zhang et al (2017) prepared fermented mushroom bran hydrolysate (FMBH) by enzymatic hydrolysis after the solid fermentation of mushroom bran (MB) inoculated with *Ganodermalucidum* and *Saccharomyces cerevisiae*. In conclusion, they presented the study mainly demonstrates the significant role of FMBH peptides for the nutrition of allogynogenetic crucian carp. When 64%-80% of the dietary fish meal was replaced with FMBH, the weight gain ratio, protein efficiency ratio, digestive enzyme activity, and antioxidant capacity of the fish were shown to significantly improve. The study promotes the application value of mushroom bran in aquaculture feeds. Van Doan et al., (2019) reported mushrooms, seaweed, and their derivatives as functional feed additives for aquaculture and reported mushroom-derived polysaccharides also contain antitumor, antimicrobial, antioxidant, antiviral, and immunomodulatory properties thus, the usage of mushrooms in aquaculture is on the rise due to their properties and awareness among farmers. Eswari et al., (2019) 28 studied the phytochemical characterization of the mushroom *Agaricus bisporus* and valuation of its nutritious ability in the place of fishmeal for survival and growth of the freshwater prawn *Macrobrachium rosenbergii* post-larvae. The authors reported that isonitric diets were prepared by replacement of the fishmeal (25%, 50%, 75% and 100%) with *A. bisporus* powder were fed. Diet prepared without replacement of fishmeal was served as control. These diets were fed to *M. rosenbergii* for 90 days, The significant positive changes were demonstrated when 75% replaced diet was fed and showed elevations in survival and growth rate, muscle total protein, amino acid, carbohydrate, lipid and ash contents, profiles of proteins, amino acids and fatty acids and activities of protease, amylase and lipase Thus, they recommended that up to 75% of fishmeal can be replaced with *A. bisporus* for sustainable maintenance of *M. rosenbergii* seeds in the nursery which will serve better nutrition and employment opportunity. Hedge, et al., (2016) studied growth and behavior of larval zebrafish, *Danio rerio* fed a processed formulated diet, live food, or the amalgamation and their outcomes specify that live diets may enhance and optimize growth of larval zebrafish during the first 14 days. Wafer et al., (2016) studied effects of environment supplementation on fertility and fecundity of zebra fish. Their findings supported the hypothesis that zebra fish in a breeding tank with plastic plant enrichment will show better fertility and fecundity than those in a barren tank.

Conclusion:

From the above-mentioned account, it shows that work supported out on the use of *Agaricus bisporus* as a nutritional and formulated feed on various animal models needs a thorough investigation with a better conclusive understanding. *A bisporus* may provide significant support against malnutrition due to high nutritional values especially in developing and undeveloped countries. In the last decades, edible mushroom has been used as a source of treatment or health food supplements increasingly. The goal of this literature review is to illustrate that research work sustained out on the use of *Agaricus bisporus* enriched diet as a formulated feed on several animal models needs a systematic exploration and study with an enhanced irrefutable thoughtful understanding. The formulated diet consisting of mushroom *Agaricus bisporus* has influence on the growth and development of the different organisms. The improvement of growth indices and survival with 100% *Agaricus bisporus* enriched diet might result in promising efficiency in various aquaculture initiatives leading to a valuable return of investment in aquaculture venture.

References:

1. Alam MS, Teshima S, Ishikawa M, Koshio S (2002) Arginine requirement of juvenile Japanese flounder Paralichthysolivaceus . Estimated by growth and biochemical parameters. Aquacult 205: 127-140.
2. Ahlavat, O.P., Manikandan, K. & Singh, M. (2016). Proximate composition of different mushroom varieties and effect of UV light exposure on vitamin D content in Agaricusbisporus and Volvariellavolvacea. Mushroom Research, 25(1), 1-8.
3. Ahmed H.M., Noura M. Darwish, Young Ock Kim, P. Viayaraghavan, Jun-Tack Kwon, Sae Won Na, Jae Chul Lee, Hak-Jae Kim., 2020, Fenvalerate induced toxicity in Zebra fish, Danio rerio and analysis of biochemical changes and insights of digestive enzymes as important markers in risk assessment, Journal of King Saud University - Science, 32(2);1569-1580.
4. Ahmed M, N. Abdullah, A.S. Shuib, S. Abdul Razak., 2017, Influence of raw polysaccharide extract from mushroom stalk waste on growth and pH perturbation induced-stress in Nile tilapia, Oreochromis niloticus, Aquaculture 468, Part 1 (60-70).8888882226677675.
5. Carneiro W.F., T.F.D. Castro, T.M. Orlando, et al., 2019, Replacing fish meal by Chlorella sp. meal: Effects on zebrafish growth, reproductive performance, biochemical parameters and digestive enzymes, aquaculture, https://doi.org/10.1016/j.aquaculture.2020.735612
6. Chen, S., Oh, S-R., Phung, S., Hur, G., Ye, J.J., Kwok, S.L., Shrode, G.E., Belury, M., Adams, L.S. & Williams, D. (2006). Anti-aromatase activity of phytochemicals in white button mushrooms (Agaricusbisporus). Journal of Cancer Research and Clinical Oncology, 66, 12026– 12034.
7. Cherno, N., Osalina, S. & Nikitina, A. (2013). Chemical composition of Agaricusbisporus and Pleurotusostreatus fruiting bodies and their morphological parts. Food and Environment safety, 7(4), 291-299.
8. Cheung, P.C.K. (2009). Mushrooms as functional foods (ed P. C. K. Cheung), John Wiley & Sons, Inc., Hoboken, NJ, USA.
9. Cheung PCK. 2010. The nutritional and health benefits of mushrooms. British Nutrition Foundation Nutrition Bulletin, 35, 292– 299.
10. Chou, W.T., Sheih, I.C., Fang, T.J., 2013, The applications of polysaccharides from various mushroom wastes as prebiotics in different systems. Journal of Food Science 78: 1750– 3841.
11. Dawood, N. M. Eweedah, M.E. El-Sharawy, S.S. Awad, H.Van Doan, B. A.Paray., 2020, Dietary white button mushroom improved the growth, immunity, antioxidative status and resistance against heat stress in Nile tilapia (Oreochromisniloticus),Aquaculture,523,735229,https://doi.org/10.1016.
12. Deborah Paripuranam T, Divya VV, Ulaganathan P, Balamurugan V. Umamaheswari S, et al., 2011, Replacing fish meal with earthworm and mushroom meals in Practical diets of practical diets of labeorohita and hemigrammusCaudovittatus fingerlings. Indian J Anim Res 45: 115-119.

13. El-Sayed, A. F. M., 1998, Total replacement of fishmeal with animal protein sources in Nile tilapia Oreochromis niloticus (L.), feeds. Aquaculture Research 29: 275-280.
14. El-Sayed, A. F. M., 1999, Alternative dietary protein sources for farmed tilapia, Oreochromis spp. Aquaculture 179(1-4): 149-168.
15. Eswari S, SaravanaBhavan P, Kalpana R, Dharani C, Manjula T, Sarumathi K and Rajkumar G., 2019, Phytochemical characterization of the mushroom Agaricusbisporus 212 and assessment of its nutritional ability in the place of fishmeal for survival and growth of the freshwater prawn Macrobrachiumrosenbergii post-larvae, Department of Zoology, Bharathiar University, Coimbatore-641046, India.
16. FAO (Food and Agriculture Organization), 2016, The State of World Fisheries and Aquaculture. Food and Agriculture Organization of the United Nations, Rome.
17. FAO (Food and Agriculture Organization), 2018, The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals. Rome. Licence: CC BY1NC-SA 3.0 IGO
18. FAO (Food and Agriculture Organization). 2018, The State of World Fisheries and Aquaculture 2018— Meeting the Sustainable Development Goals (FAO).
19. Fernandes H, Peres H, Carvalho A.P., 2016, Dietary protein requirement during juvenile growth of Zebrafish (Danio rerio). Zebrafish. 13(6):548-555. Doi: 10.1089/zeb.2016.1303
20. Guerrera MC, De Pasquale F, Muglia U, Caruso G. Digestive enzymatic activity during ontogenetic development in zebrafish (Danio rerio). J Exp Zool B Mol Dev Evol. 2015 Dec;324(8):699-706. doi: 10.1002/jez.b.22658. Epub 2015 Oct 18. PMID: 26477613.
21. Hedge, J., D. Korest, D. Hunter, and S. Padilla., 2018, Growth and Behavior of Larval Zebrafish Danio rerio Fed a Processed Diet, Live Food, or The Combination. Aquaculture 2016, Las Vegas, NV, February 22 – 26.
22. Kakon, A.J., Choudhury, B.K. & Saha, S. (2012). Mushroom is an ideal food supplement. Journal of Dhaka National Medical College and Hospital, 18(1), 58-62.
23. Kesan, S.,Cendawan, Prebiotik, Bahan, Berasaskan, Makanan,Roti, Ulat, Pertumbuhan, Kadar,Tilapia, Ikan,Rahman, Abd,Din, Jabir, A. Razak, Shaharudin and S.Vikineswary., 2015, Effect of Mushroom Supplementation as a Prebiotic Compound in Super Worm Based Diet on Growth Performance of Red Tilapia Fingerlings. Sains Malaysiana 41(10): 1197–1203
24. Kwak, W.S., Jung, S.H., and Kim, Y.I., 2008, Broiler litter supplementation improves storage and feed nutritional value of sawdust based spent mushroom substrate. Bioresource Technology, 99(8):2947-2955. http://dx.doi.org/ 10.1016/j.biortech. 2007.06.021
25. Kpundeh M.D., Qiang J., He J, Yang H, Xu P., 2015, Effects of dietary protein levels on growth performance and haemato-immunological parameters of juvenile genetically improved farmed tilapia (GIFT), Oreochromis niloticus. Aquaculture International. 23(5):1189-1201
26. Maftoun, P., Helmi, J., Mohammad, S., Roslinda, M., Nor Zalina, O. (2015). The edible mushroom Pleurotus spp.: I. Biodiversity and nutritional values. International Journal of Biotechnology for Wellness Industries, 4(2), 67-83.
27. Mohiuddin, K.M., Alam, M., Arefin, T., Ahmed, I. (2015). Assessment of nutritional composition and heavy metal content in some edible mushroom varieties collected from different areas of Bangladesh. Asian Journal of Medical and Biological Research, 1(3), 495-501.
28. Mukhopadhyay, R. and Guha, A. K., 2015, A comprehensive analysis of the nutritional quality of edible mushroom Pleurotussajor-caju grown in deproteinized whey medium. LWT-Food Science and Technology 61: 339-345.
29. Muszyńska, B., Sułkowska-Ziaja, K., Ekiert, H. (2011). Indole compounds in fruiting bodies of some edible Basidiomycota species. Food Chemistry, 125, 1306–1308.

30. Muszyńska, B., Sułkowska-Ziaja, K. &Wójcik, A. (2013). Levels of physiologically active indole derivatives in the fruiting bodies of some edible mushrooms (Basidiomycota) before and after thermal processing. Mycoscience, 54, 321–326
31. ManeeSrichanun, ThammanoonNganwisuthiphan, SuneeWanlem and TanawatRakkamon, 2017, Effects of Different Mushroom By-Product Types and Levels on Growth Performance and Survival Rate in Dietary of Nile Tilapia (Oreochromis niloticus); international Journal of Agricultural Technology,13(7.1):1093-1101 Available online http://www.ijat-aatsea.com ISSN 1686-9141.
32. Muin, H., Taufek, N. M., Abiodum, R. A., Yusof, H. M. and Razak, S. A., 2015, Effect of partial and complete replacement of fishmeal with mushroom stalk meal and soy bean 236 on growth performance of nile tilapia, Orechromisniloticus fingerlings. SainsMalaysiana 44(4): 511- 516.
33. Mattila P, Konko K, Eurola M, Pihlava JM, Astola J, et al., 2001, Contents of vitamins, mineral elements, and somephenolic compounds in cultivated mushrooms. J Agricul Food Chemist 49: 2343-2348.
34. Nitschke, J. Altenbach, H.J., Malolepszy, T. &Mölleken, H. (2011). A new method for the quantification of chitin and chitosan in edible mushrooms. Carbohydrate Research, 346, 1307–1310.
35. Nasiri F, Ghiassi T.B., Bassiri A.R., Hoseini S.E., Aminafshar M., 2013, Comparative study on the main chemical composition of button mushroom's (Agaricusbisporus) cap and stipe. J Food BiosciTechnol; 3:41-8.
36. Omasaki S K. Janssen, M. Besson, H. Komen., 2017, Economic values of growth rate, feed intake, feed conversion ratio, mortality and uniformity for Nile tilapia. doi: 10.1016/j.aquaculture,04:.013
37. Pereira, E., Barros, L., Martins, A., Ferreira, I.C.F.R. (2012). Towards chemical and nutritional inventory of Portuguese wild edible mushrooms in different habitats. Food Chemistry, 130(2), 394– 403.
38. Phromkunthong, W., Yokrat, S., Intasorn, S., Rattanakal, Y. and Nuntapong, N., 2014, Replacement of Grey Oyster Mushroom by-products (Pleurotussajor-caju (Fr.) Singers) for Fish Meal in Red Tilapia (Oreochromis niloticus x O. mossambicus) Practical Diet. Prawarun Agricultural Journal 11: 25-38
39. Rodrigues, D., Freitas, A.C., Pereira, L., Rocha-Santos, T.A.P., Vasconcelos, M.R., Rodriguez-Alcala, L.M., Gomes, A.M.P. & Duarte, A.C. (2015). Chemical composition of red, brown and green macroalgae from Buarcos bay in Central West Coast of Portugal. Food Chemistry, 183, 197– 207.
40. Roupas, P., Keogh, J., Noakes, M., Margetts, C. & Taylor, P. 2012. The role of edible mushrooms in health: Evaluation of the evidence. Journal of Functional Foods, 4, 687-709.
41. Sadiq, S., Bhatti, H.N., Hanif, M.A. (2008). Studies on chemical composition and nutritive evaluation of wild edible mushrooms. Iran Journal of Chemistry and Chemical Engineering, 27(3),151-154.
42. Safwat, M.S.A., Al Kholi, M.A.J. (2006). Recent trends, reality and future in the production, manufacture and marketing of medicinal and aromatic plants. The Egyptian Association for producers, manufacturers and exporters of medicinal and aromatic plants (Asmap.), Giza, Egypt. 76 pages. (In Arabic).
43. Santos JF, Castro PF, Leal ALG, Freitas ACV Jr, Lemos D, Carvalho LB Jr, Bezerra RS., 2013, Digestive enzymeactivity in juvenile Nile tilapia (Oreochromis niloticus, L.) submitted to different dietary levels of shrimp protein hydrolysate. Aquac Int 21:563– 577.
44. Stevens, J.R., Newton, R.W., Tlusty, M., and Little, D.C., 2018, The rise of aquaculture by-products: increasing food production, value, and sustainability through strategic utilization. Mar. Policy 90: 115–124.
45. Song Z.D., Li, H.Y., Wang, J.Y., Li, P.Y., Sun, Y.Z., and Zhang, L.M., 2014, Effects of fishmeal replacement with soy protein hydrolysates on growth performance, blood biochemistry, gastrointestinal digestion and muscle composition of juvenile starry flounder

(Platichthysstellatus). Aquaculture, 426-427, 96-104. http://dx.doi.org/10.1016/j.aquaculture.2014.01.002

46. Van Doan H, Hoseinifar S.H, Esteban M.Á, Dadar M, Thu T.T.N., 2019, Mushrooms, Seaweed, and Their Derivatives as Functional Feed Additives for Aquaculture: An Updated View, In Studies in Natural Products Chemistry. ; 62:41-90.
47. Wafer L.N., Jensen V.B., Whitney J.C., Gomez T.H., Flores R, Goodwin B.S., 2016, Effects of Environmental Enrichment on the Fertility and Fecundity of Zebrafish (Danio rerio). J Am Assoc Lab Anim Sci.; 55(3):291-4. PMID: 27177561; PMCID: PMC4865689.
48. Wu S., 2020, The growth performance, body composition and nonspecific immunity of Tilapia (Oreochromis niloticus) affected by chitosan. Int. J. Biol. Macromol. 145:682- 685. doi: 10.1016/j.ijbiomac.Epub Dec 27. PMID: 31887376.
49. Xu et al., (2015)Xu, H., Wang, H.L., Zhou, Q.L., Jiang, Y., Quan, W.F., Zhang, D.S., and Xie, J., 2015, Studies on the preparation of functional and high protein feeds from mushroom bran by the stepwise fermentation. Feed Industry, 36(10): 47-52.
50. YeJ.-D. Ye, J.-C. Chen, K. Wang., 2016, Growth performance and body composition in response to dietary protein and lipid levels in Nile tilapia (Oreochromis niloticus Linnaeus, 1758) subjected to normal and temporally restricted feeding regimes, J. Appl. Ichthyol. 32:332–338 https://doi.org/10.1111/jai.13004.
51. Zhang M, Cui SW, Cheung PCK, Wang Q., 2007, Antitumor polysaccharides from mushroom: a review on their isolation, process, structural characteristics and anti-tumor activity. Trends Food Sci. Technol. 18: 4-19.
52. Zhang, J.J., Ma, Z., Zheng, L., Zhai, G.Y., Wang, L.Q., Jia, M. & Jia, L. (2014). Purification and antioxidant activities of intracellular zinc polysaccharides from Pleurotuscornucopiae SS-03. Carbohydrate Polymers,111, 947–954.
53. Zhang, Dongsheng and Zhang, Yiping and Liu, Bo and Jiang, Yi and Zhou, Qunlan and Wang, Jie and Wang, H. and Xie, Jun and Kuang, Qun., 2017, Effect of replacing fish meal with fermented mushroom bran hydrolysate on the growth, digestive enzyme activity, and antioxidant capacity of allogynogenetic crucian carp (Carassius auratus gibelio). Turkish Journal of Fisheries and Aquatic Sciences. 17. 1043-1052. 10.4194/1303-2712-v17_5_20
54. Zou HK, Hoseinifar SH, Miandare HK, Hajimoradloo A., 2016, Agaricusbisporus powder improved cutaneous mucosal and serum immune parameters and up-regulated intestinal cytokines gene expression in common carp (Cyprinus carpio) fingerlings, Fish and shellfish immunology; 58:380-386.