EXTENSION NEWSLETTER

Using Google Search Data to Analyze U.S. Public Interest in Catfish

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In recent years, internet search queries have been used to quantify public interest in various topics, including health and nutrition, sustainable food production, and climate change, among others. The change in relative search volumes over time for specific terms can be used to measure public interest[1]. We are utilizing Google's search data platform, Google Trends, to analyze public interest in catfish by state, product form, and market channel. The data is indexed from 1-100, where 100 represents the maximum search interest for a given time and location.

Relative search volume of catfish has shown a steadily increasing pattern over the last decade, but it has been highly concentrated in the southeastern United States, particularly in Mississippi and Louisiana, and to a smaller extent in Arkansas, Alabama, Tennessee, Oklahoma, and Texas (Figure 1A). This contrasts with search volume for other species, such as shrimp and tilapia (shown in Figure 1B), in which interest is more widespread across U.S. states. Tilapia's success in the U.S. market partly stems from product development and marketing that have increased consumer familiarity with tilapia products. In the last decade, however, the popularity of tilapia has drastically declined, providing a potential opportunity for U.S. farm-raised catfish to gain some of this market share by expanding sales outside the southeastern region. Potential challenges for increasing catfish sales outside of the southeast region include consumers' lack of familiarity with catfish, which could be addressed through marketing, and the increased transportation cost passed on to the final consumer.

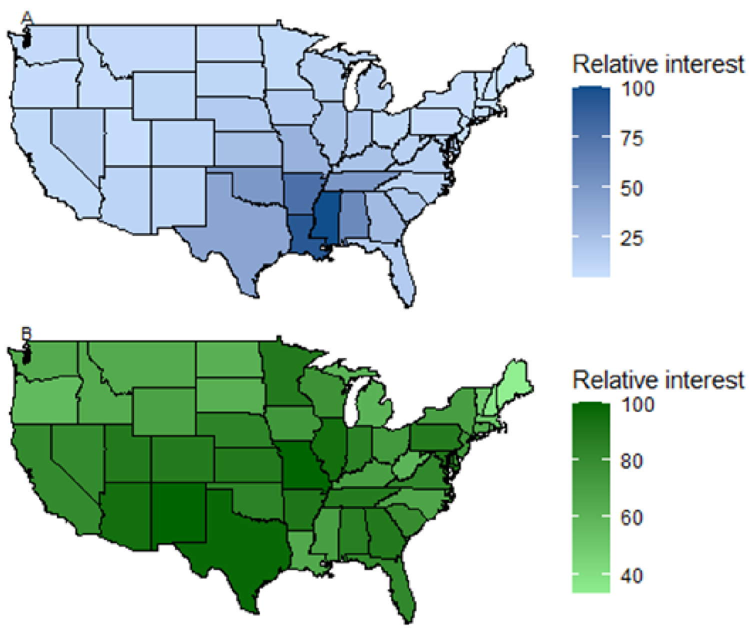

Figure 1. Relative search volume for A) catfish and B) tilapia by state from October 2019 to September 2024.

[1] Google Trends data is collected from a random sample of Google searches, and thus absolute search volume is not available. The data is indexed and normalized, meaning that search interest is reported as a percentage of searches for a given topic as a proportion of all searches at that time and location.

Average monthly search volumes for fresh and frozen catfish are shown in Figure 2. Relative search volume for fresh catfish was higher than for frozen catfish, and the difference was most pronounced during summer. Relative search volume for frozen catfish remained steady throughout the early part of the year, with a slight increase in March, likely associated with Lent, and during the summer months of June and July. Searches for fresh catfish increased during the spring and showed a peak in June similar to frozen catfish, indicating this is a popular time of year for catfish consumption. Relative search volume for fresh and frozen catfish showed a decline in the fall months, with an increase in December, likely due to the popularity of seafood dishes during the holidays.

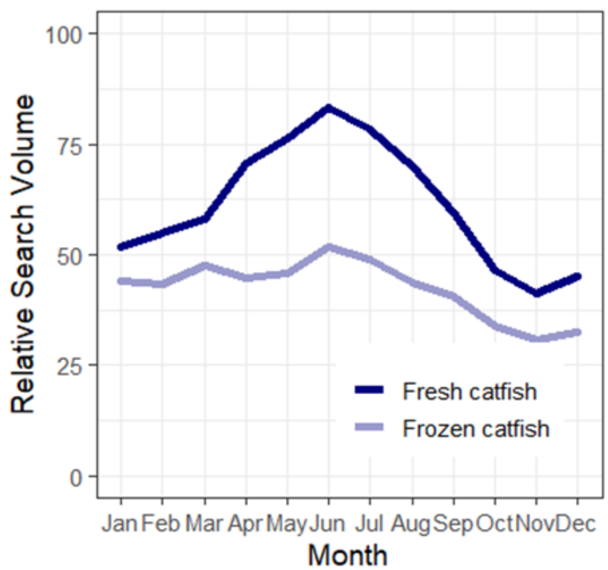

Figure 2. Average monthly search volumes for fresh and frozen catfish.

We also examined the relative search volume of fresh and frozen catfish by state. We found that most coastal states had a higher percentage of searches for fresh catfish compared to frozen catfish, whereas most inland states had a higher percentage of searches for frozen catfish. There were some important exceptions, including Mississippi, the largest producer of U.S. catfish, and some coastal states in the Pacific Northwest and New England region, where the percentage of frozen searches was higher.

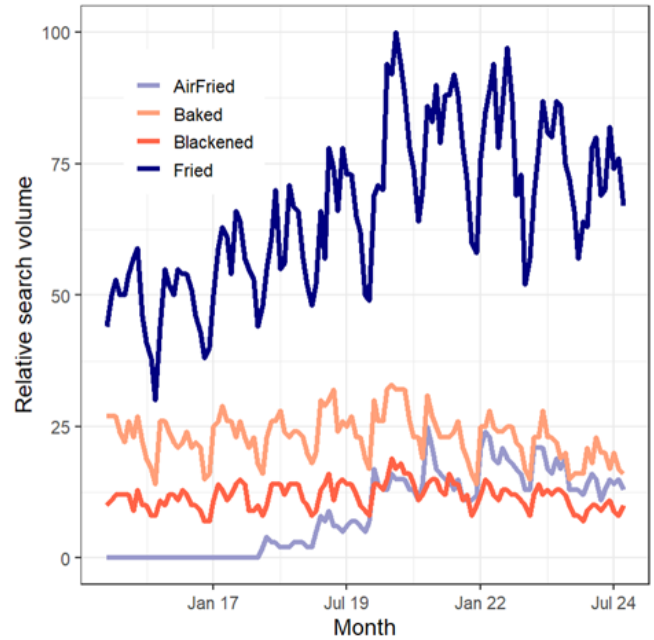

Figure 3. Relative search volume for catfish by form of preparation.

We also examined searches for common catfish preparation methods, such as fried catfish and baked catfish (Figure 3). Not surprisingly, fried catfish was the most searched, followed by baked catfish. Relative searches for fried catfish saw a major uptick in months following the onset of the COVID-19 pandemic and, to a lesser extent, in baked and blackened catfish. Air frying became a popular cooking method in the U.S. in 2017, largely driven by convenience and health benefits. Catfish were not an exception to this. Relative search volume for air fried catfish rapidly increased from 2017 through 2020, surpassing relative search volume for blackened catfish and approaching baked catfish. Six of the top 10 rising search terms related to catfish (i.e., those with the largest increase in search frequency in the past five years) were related to air frying (e.g., “catfish in the air fryer”, “air fry catfish nuggets”). The interest in air frying is consistent with growing interest in convenience products as well as more health-conscious consumers. Relative searches for air fried catfish have been on a slight downward trend since 2021, but this was also true for the other preparation methods, suggesting lower demand across the board due to inflationary pressure.

We also used search data to gauge interest in catfish for consumption at-home or at restaurants by examining search volumes for catfish recipe and catfish restaurant, respectively. Before the COVID-19 pandemic, relative search volumes of catfish recipes and catfish restaurants were similar (Figure 4). At the onset of the pandemic, there was a sharp decline in relative searches for catfish restaurants and a sharp increase in searches for catfish recipes, reflecting a shift to cooking at home during restaurant closures.

The initial decline in relative searches for catfish restaurants was short-lived, while the initial spike in catfish recipes persisted longer. By 2021, relative searches for catfish restaurants returned to pre-pandemic levels and were similar in magnitude to relative searches for catfish recipes. However, searches for catfish recipes and restaurants have diverged since early 2023 as relative searches for catfish restaurants have declined, suggesting that interest in consuming catfish at home is growing relative to consumption at restaurants. This is consistent with consumption trends more broadly as we are seeing consumers eat at home more frequently. This may be advantageous for the U.S. catfish industry as competition from imported pangasius is less intense in the retail sector.

Relative search volume for catfish recipes and catfish restaurants by state are shown in Figure 5. Mississippi and Louisiana had the highest relative search volume for catfish recipes (Figure 5A), whereas Mississippi and Arkansas had the highest relative search volume for catfish restaurants (Figure 5B). Searches for catfish restaurants were concentrated in the southeastern U.S., and catfish recipes were as well, but to a lesser extent. States with a higher percentage of searches for catfish restaurants compared to recipes included Tennessee, Arkansas, Florida, Alabama, Mississippi, Oklahoma, Missouri, and Illinois. Notably, all but three of these states, Oklahoma, Missouri, and Illinois, are part of the industry's Catfish Trail.

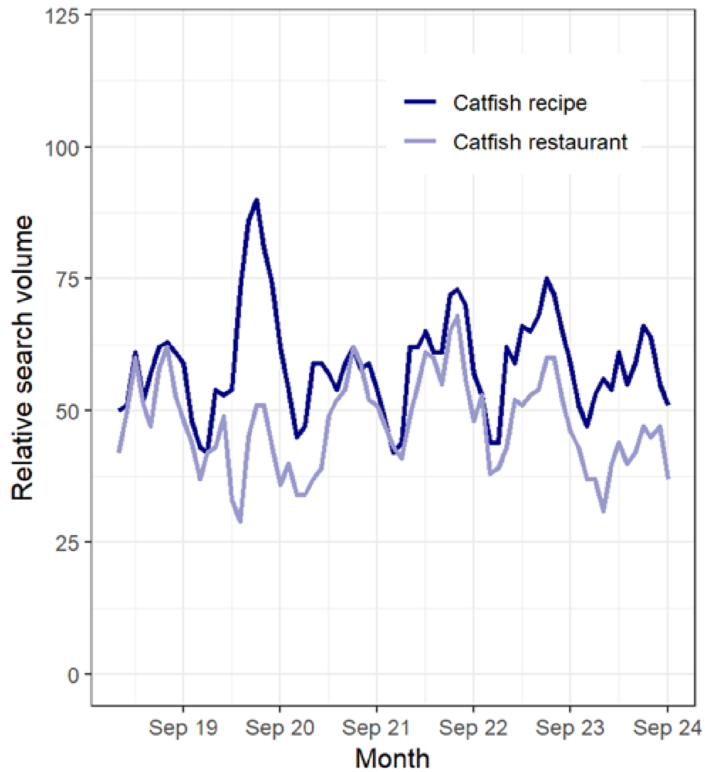

Figure 4. Relative search volume for catfish recipe and catfish restaurant.

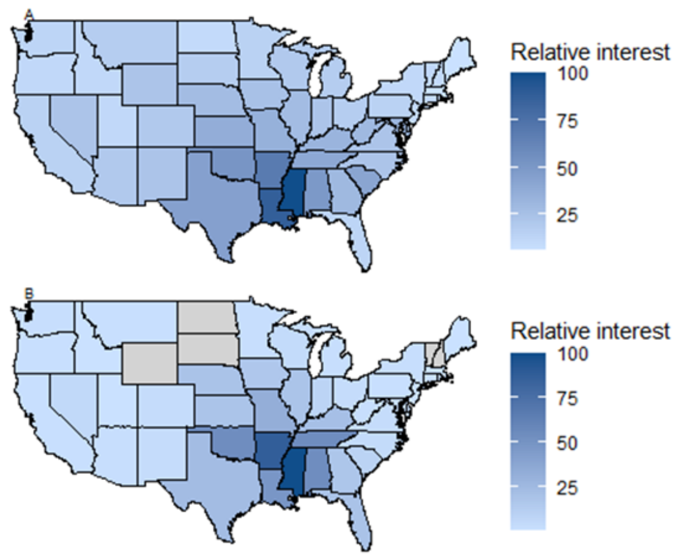

Figure 5. Relative searches for A) catfish recipe and B) catfish restaurant from October 2019 to September 2024. Gray indicates there is not enough data to show.

Overall, we found that online search data are an emerging source of information that can be used to understand trends in public interest. The analysis showed that interest in catfish is highly concentrated in southeastern states, where most of the production occurs, suggesting that efforts are needed to market catfish in other regions of the U.S. We also observed that interest in fresh catfish was higher than frozen catfish, and this was more pronounced in the summer months when interest in catfish peaked. About 37% of U.S. catfish is sold fresh, and thus, there is likely an opportunity to expand sales of fresh catfish. Given the cost of transportation, fresh sales are more likely to expand close to production locations.

Management of Recreational Fishing Ponds in the Fall

Rusty Wright, SFAAS

Figure 1. Fall is a good time for pier construction or maintenance.

The basic principles of managing recreational fishing ponds for high-quality fishing, in this case, largemouth bass and bream ponds, involve proper construction, maintaining fertility, stocking the right fish, controlling weeds, and harvesting fish, particularly largemouth bass. For a full understanding of these approaches, go to the fisheries publications on the Alabama Cooperative Extension System website at www.ACES.edu. The specific tasks that should be done to create a quality fishing pond vary depending on the season of the year. Autumn is a particularly important time for maintenance that will help set the pond up for better fishing the following year. Below, I'll step through the most important pond management tasks to do in the Fall.

Construction. September and October are typically the driest months of the year in the Southeast (unless, of course, we have a tropical storm!). This dry period is an opportunity to lower the water level in the pond to give access to the pond edge and any piers or other structures that might need repair (Figure 1). Years of erosion can lead to areas of the pond becoming quite shallow. These shallow areas promote weed growth and are areas where larger fish won't go during the hot summer months. The edge should have a 2:1 or 3:1 slope (1 foot of drop for every 2 to 3 feet from shore) out to a depth of 3 to 4 ft (Figure 2). Reshaping the pond

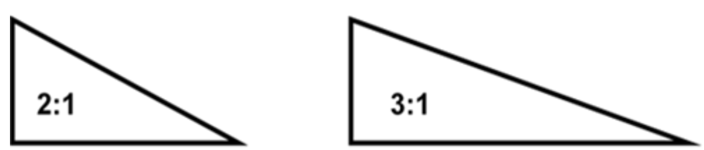

Figure 2. Typical slopes of pond edges

edge requires heavy equipment such as excavators and, therefore, experienced operators.

Fertility. For ponds that are fertilized, the last application of fertilizer is usually applied in mid to late September, if needed. However, fall is a good time to test either the water or the pond bottom soils to see if the pond would benefit from the addition of agricultural lime (Figure 3). Testing in the fall allows the lime, if needed, to be applied in the winter when it won't cause oxygen depletion and will dissolve into the water before the spring. Many areas of the Southeast have soils that are low in alkalinity and tend to be acidic. Ponds built in these soils can be infertile. Applying lime to ponds can increase the alkalinity and hardness of the water, which has many benefits, including keeping the pH in an acceptable range for the fish and other living things in the pond. Lime also has nutrients such as calcium and micronutrients that plants and animals need. Most importantly, keeping alkalinity above 20 ppm allows phosphorus, the most important nutrient required by algae in most ponds, to be available and not tied up in the sediment.

Figure 3. Test your water for alkalinity so that lime can be applied in the winter.

Testing for lime needs can be done either by testing a water sample or a mud sample from the bottom. See Extension publication ANR-0232, Adding Agricultural Lime to Recreational Fishing Ponds, available at www. ACES.edu, for approaches to collecting water and mud samples. County Extension personnel or Regional Extension Agents can either test water samples or provide an appropriate contact for the test. Both mud and water samples can be tested at the Auburn University Soil, Forage & Water Testing Laboratory. Contact the Soil Testing Laboratory (telephone: 334-844-3958) for further instructions and a schedule of charges.

Figure 4. Nuphar or cowlily unlike other waterlilies respond well to herbicide application in the fall.

Weed control. It might not seem logical but fall is the best time to apply herbicides to control weeds (Figure 4). As the water cools and the days get shorter, plants and algae tend to die back, and many are completely gone during the winter without

Figure 5. Fall is a good time to harvest bass.

any treatment. For plants that regrow in the spring from extensive root systems, rhizomes, or tubers, fall is a very good time to treat with systemic herbicides such as 2,4-D, triclopyr, and glyphosate, depending on the plant. During fall, these plants translocate nutrients into the underground structures and move herbicides into these structures. Plants that respond well to fall treatment include American lotus, waterlilies, cattails, alligator weed, and watershield. Do not apply herbicides after the water temperature drops below about 60 degrees or when the leaves of the plants begin to yellow and fall off. A fall application of herbicide for these plants can significantly reduce the coverage and productivity of the weeds the following spring. Extension professionals can provide recommendations for the appropriate herbicide and application approach for the specific weed in the pond.

Harvest. Pond owners often do a very good job with most elements of good pond management but may lack the time to fish enough to harvest enough largemouth bass to keep the pond from becoming bass crowded. Overcrowded bass grow slowly and may never reach the desired sizes that an owner would hope to catch. Autumn is a great time to harvest largemouth bass sufficiently to help keep the pond in balance (Figure 5). Ideally, 20-25 lbs. of bass per acre in ponds that are fertilized or are naturally very fertile and 10 lbs of bass per acre in less fertile ponds should be harvested each year. We recommend primarily taking out bass 14 inches and under for most ponds. Fall is second only to spring for the catch rate of largemouth bass. As the water cools in the fall, the bite really picks up from mid-September through early November. Keeping records of pounds of bass harvest throughout the year will help pond owners target the bass needed to meet their harvest goals especially during the fall and spring when catch rate is at its highest.

If a pond is bluegill crowded, fall is a good time to correct that condition. Bluegill crowded ponds are dominated by almost entirely small bluegill mostly 3-5 inches long or smaller. There are few largemouth bass in these ponds although the few that are present may be large. Bluegill crowding is quite uncommon and is usually caused by a fish kill or improper bass stocking. Correcting bluegill crowding can involve an application of rotenone, a fish toxicant, to kill off a large amount of small bream followed by stocking 6-10 inch bass. Pond owners with a problem with crowded small bream, can contact either your county Extension office or a fisheries consultant to help you work through this process.

Summary. Fall is a great time to do some maintenance in a pond. During this time of cooling waters and usually dry weather, construction, fertility, weed control, and harvest should be on the agenda to be checked and addressed if possible to set the pond up for great fishing experiences the following year.

For more information see the following Extension publications available at www.ACES.edu.

ANR -577 Management of Recreational Fish Ponds

ANR-1114 Pond Building: A Guide to Planning, Constructing & Maintaining Recreational Ponds

ANR-0232 Adding Agricultural Lime to Recreational Fishing Ponds

Alabama Catfish Conference '25

Thursday, January 9, 2025

8:00am

Blackbelt Research & Extension Center

Marion Junction, Alabama

Big Fish Continue to Cause Problems for Farmers in West Alabama

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Big fish continue to cause problems for catfish farmers in west Alabama, particularly those raising hybrid catfish. Big fish is a term widely used to describe catfish that weigh more than the premium market size (1.25 – 4 lbs) preferred by processing plants. While big fish have been a problem in the catfish industry before, in recent years, it has become a more pronounced and widespread issue across the catfish industry in west Alabama (Figure 1).

Delays in harvest are becoming more common. During times of oversupply, many processing plants will harvest their own supply first before purchasing catfish from independent farmers. Farmers that have had difficulty moving fish in the last several years have noted that the large maximum size and fast growth rate of hybrid catfish make it a disadvantage when they cannot sell their fish to the processor in a timely manner. If hybrid catfish are not seined and harvested routinely, the number of big fish in the pond can often reach extreme levels, resulting in large profit losses due to dockage at the processing plant. It is difficult to predict how many big fish are in a pond until it is seined multiple times. Several farmers have experienced frustration at still finding significant numbers of big hybrid catfish in ponds that have been seined 6-7 or more times in a single batch production run. While seining efficiency is an obvious issue, the biggest problem is that many ponds with hybrids are not getting harvested since many farmers have been struggling to sell their market size fish.

Figure 1. Big fish continue to be a problem in west Alabama. This hybrid catfish was collected in Hale County, Alabama, and weighed 46 lbs.

Processing plants set dockage rates according to the individual plant's supply needs, and thus, dockage rates vary widely across the industry at any given time. Dockage rates have also fluctuated substantially in time according to supply and demand dynamics for oversized fish. The resulting variation in dockage rates creates uncertainty and risk for farmers. It makes it difficult for producers to determine optimal production and harvesting strategies, and should prompt farmers to stay up to date on processors' current pricing and dockage fees. This year's average prices for large (4-6 lb), very large (6-8 lb), and extra-large (8+lb) size categories have been discounted \$0.17, \$0.29 and \$0.91, respectively, below the premium price per pound, and about 10% of processed catfish (by volume) were oversized. Thus, dockage can have significant impacts on farm revenue.

A recent study published in the North American Journal of Aquaculture (see *Further Reading* below) quantified the age structure of carryover hybrid catfish in commercial catfish ponds in west Alabama. Hybrid catfish typically arrive from the hatchery when they are 10 months old, so most catfish at a grow-out operation will be close to a year old when stocked. This study sampled approximately 1000 hybrid catfish from 12 commercial ponds and found that hybrid catfish fell within the premium size category when 2 years old, but by the time they attained 3 years old, most fell within the 4-8 lb range. Nearly all fish sampled in the study that were older than 3 years (4-11 years old) were above 8 lbs. This highlights the importance of removing big fish from ponds before restocking for the next production cycle due to their reduced value and problems they can cause farmers and processors.

Farmers raising hybrid catfish report big fish problems more than those raising channel catfish, however, channel catfish can also attain sizes above the premium size in which processors will dock. The lack of seining efficiency over time, particularly in irregularly shaped watershed ponds and ponds with suboptimal pond bottom conditions, can lead to big fish problems for channel catfish producers. The Fish Center is leading an effort to quantify the age structure of big channel catfish in commercial ponds. We are also continuing to explore the issue of cannibalism in big fish and will be carrying out several studies in 2025 to investigate this issue further.

RESEARCH ROUNDUP

Feather Meal and Shrimp Feeds: Are they compatible?

Magida Tabbara, Sidra Nazeer, and D. Allen Davis
SFAAS

Plant proteins are considered nutritious, affordable, and readily available protein sources for aquaculture. Because of its balanced amino acid content and availability, soybean meal is the most used plant protein source in aquaculture feed. However, worldwide soybean meal prices are increasing mainly because demand is outstripping supply. One mitigation approach would be to replace traditional feed ingredients with by-products. Aquaculture nutritionists have long resorted to alternative feed-ingredient supplementation to produce cost-effective feeds.

The terrestrial meat industry generates a lot of nutritious by-products that could be an important source of protein for use in aquaculture. The poultry sector is significantly larger than any other animal production system, generating large quantities of by-products. Among the by-products, feather meal is a keratinous protein source with a high protein content (75-87%). In most cases, feathers are hydrolyzed to break down keratin and enhance digestibility, resulting in hydrolyzed feather meal (HFM). HFM is a readily available animal protein source and less expensive than most other proteins. It is similarly priced to solvent-extracted soybean meal on a cost per unit of protein. Previous studies evaluated the use of HFM as a feed ingredient in diets of commercially important aquaculture species, including channel catfish and Pacific white shrimp (*Litopenaeus vannamei*). However, information about the use of HFM in shrimp diets is limited, and many of these studies evaluated the use of HFM as a replacement for fishmeal, which is not the best comparison. The present work evaluates the use of HFM, with and without coagulated chicken blood, on growth and proximate composition of Pacific white shrimp offered diets with low fishmeal and high soybean meal content.

Figure 1. Hydrolyzed feather meal without chicken blood used in the preparation of the experimental feed.

Research design

Seven isonitrogenous (equal levels of protein) and isolipidic (equal levels of fat) experimental diets were formulated. The basal diet contained 6% fishmeal and 49% soybean meal. The remaining six diets were modifications of the basal diet, using HFM with coagulated chicken blood (Figure 1; HFM-CCB; River Valley Ingredients, Tyson Food Inc.) or without blood (HFM-WCCB; River Valley Ingredients, Tyson Food Inc.) to replace SBM at 3, 6, and 9% of the diet on an isonitrogenous basis (Table 1). The experi-

Ingredients (%)	Basal	3% HFM-CCB	6% HFM-CCB	9% HFM-CCB	3% HFM-WCCB	6% HFM-WCCB	9% HFM-WCCB
Fishmeal	6.00	6.00	6.00	6.00	6.00	6.00	6.00
HFM-CCB	-	3.00	6.00	9.00	-	-	-
HFM-WCCB	-	-	-	-	3.00	6.00	9.00
Soybean meal	48.65	42.80	36.96	31.12	43.23	37.82	32.40
Corn protein concentrate	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Fish oil	2.40	2.40	2.40	2.40	2.40	2.40	2.40
Soy oil	3.72	3.60	3.49	3.37	3.48	3.23	2.99
Lecithin	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cholesterol	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Corn starch	0.33	3.30	6.25	9.21	2.99	5.65	8.31
Whole wheat	24.43	24.43	24.43	24.43	24.43	24.43	24.43
Premix	2.60	2.60	2.60	2.60	2.60	2.60	2.60
Calcium phosphate	1.75	1.75	1.75	1.75	1.75	1.75	1.75

Table 1. Formulation of the experimental diets (g/100g; as is) including three levels of HFM with (CCB) or without (WCCB) coagulated chicken blood as a partial replacement for soybean meal. All diets were formulated to 36% protein and 8% lipid and prepared in the Aquatic Animal Nutrition Laboratory at Auburn University.

mental diets were prepared in the Aquatic Animal Nutrition Laboratory at Auburn University (Figure 2). *Litopenaeus vannamei* post-larvae were obtained from a commercial hatchery (HomeGrown Shrimp, Indiantown, FL, USA) and raised in an indoor nursery system at E. W. Shell Fisheries Center in Auburn, Alabama. The experiment was performed in an indoor recirculating aquaculture system consisting of 132-L glass aquaria connected to a common biological filter, a physical bead filter (Aquadyne Filtration Systems, Hartwell, GA, USA), and a sedimentation sump. Shrimp were size sorted by hand to ensure uniformity, and 15 shrimp were stocked per aquarium. Diets were randomly assigned to the aquaria, allowing four replicate tanks per diet. The grow-out period was 42 days, during which the shrimp were fed manually four times daily. The feed ration was based on a laboratory standard feeding protocol. The protocol assumed a weekly doubling in weight until shrimp attained an average weight of 0.8g, then growth of 0.8g per week for the remainder of the experiment. The protocol also used an expected feed conversion ratio (FCR) of 1.8. The feed ration was adjusted weekly after the shrimp count and survival assessment. At termination, shrimp were counted and group weighed to assess survival, growth, and FCR. Subsequently, four shrimp from each tank were preserved and analyzed for whole-body proximate composition.

Figure 2. Preparation of the experimental feed in the aquatic animal nutrition laboratory at Auburn University.

Results and Outlooks

The present growth assessment results suggest that incorporating HFM, with or without coagulated chicken blood, does not significantly impact shrimp growth or survival. The average shrimp survival in the present work was around 82%, within the acceptable survival range of shrimp raised in clear water systems in our laboratory. Additionally, shrimp exhibited similar growth when offered the basal diet

Figure 3. Pacific white shrimp offered one of the seven experimental diets in the research system.

or any remaining diets containing HFM with or without coagulated chicken blood. We did note that despite not being statistically significant, the percentage weight gained by shrimp tended to decrease with the increased HFM inclusion in the diet (Figure 4). This suggests that 9% inclusion of the HFM is close to the maximum inclusion level in low fishmeal shrimp diets. This is likely due to the nature of hydrolyzed products. A similar trend was observed by Guo et al. (2020), who reported that when comparing salmon by-product meal to hydrolyzed salmon by-product meal as shrimp feed ingredients, shrimp performance was impaired when the hydrolyzed by-product was used at 12% of the diet. Hence, Guo et al. (2020) recommended a maximum inclusion of hydrolyzed products at 6% of the formulation. Even if feed producers were to use only 6% inclusion levels of HFM in their shrimp diets, that would increase feed ingredient supply by 6%, which is substantial. Hydrolyzed feather meal is an interesting and relatively inexpensive protein source from poultry industry waste that can be used as a protein source in shrimp feeds. As it is a hydrolyzed product, the results suggest limiting its inclusion to 6% of the feed is best. Nevertheless, the results of the present work are promising and indicate that *L. vannamei* diets can comprise up to 9% HFM without compromising shrimp survival, growth, or whole-body proximate composition. In a rapidly growing industry where resources are limited, using HFM in aquaculture feeds is an excellent method of bio-circulation that reduces waste, reduces the carbon footprint of aquaculture, and reduces the price of shrimp to the consumer.

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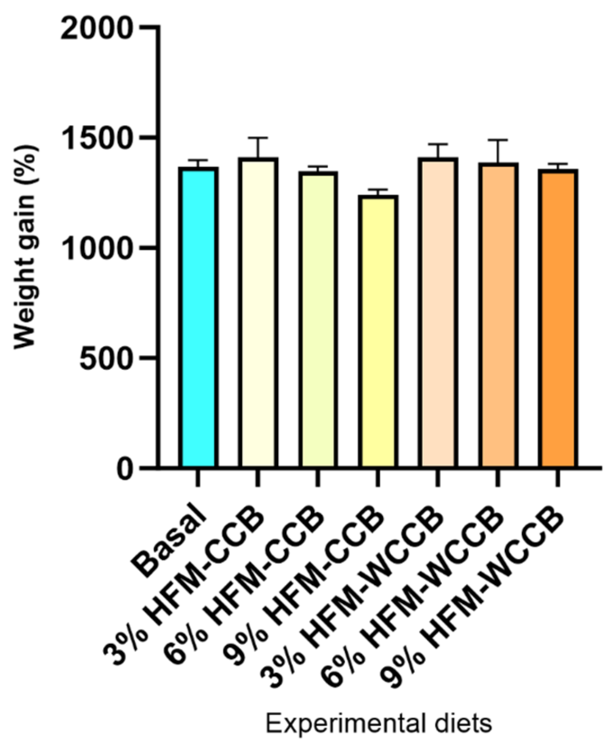

Figure 4. Weight gain of Pacific white shrimp offered the various diets containing HFM with or without coagulated chicken blood for 42-day growout period.

Gypsum Increases Soluble Reactive Phosphorus and Blue-green Algae in Catfish Production Ponds

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Gypsum (calcium sulfate; typically, as a by-product of flue gas desulfurization) is commonly applied to ponds to increase hardness (i.e., concentration of calcium and magnesium in water) that supports the development of and physiological maintenance in fish. However, relatively little is known regarding the influence of gypsum additions on water quality. To understand how an application of gypsum (500 mg/L) affected water quality in active hybrid catfish production ponds, we conducted a replicated, six-month, whole pond experiment at a catfish farm in west Alabama from May to November 2022. The results showed significant effects of gypsum on several important water quality parameters, such as hardness (↑), alkalinity (↓), phosphorus (↑; including total and dissolved forms), and blue-green algae (↑). Such impacts of gypsum on available nutrients (e.g., phosphorus) that promote toxic and/or off-flavor producing blue-green algae (also known as cyanobacteria) could harm aquaculture production and reduce profitability, as the presence of off-flavors in fish flesh results in product waste and decreased market value.

To further explore the influence of gypsum on water quality in ponds, we used data from a recent experiment to show pond-specific dynamics in hardness (Figure 1A,B), alkalinity (Figure 1C,D), soluble reactive phosphorus (SRP) (Figure 1E,F), and blue-green algae (Figure 1G,H) after applying gypsum. In general, the untreated control ponds showed consistent patterns during the experiment. The exception to this pattern included two ponds that had spikes in blue-green algae (measured as the photosynthetic pigment, phycocyanin) at the start of the experiment (Figure 1G). By late June 2022, the control ponds stabilized for the remainder of the study.

Interestingly, ponds treated with gypsum showed both expected and some unexpected, undesirable impacts. First, hardness in ponds treated with 500 mg/L gypsum increased by 106% (average increase of ~130 mg/L $CaCO_3$) to ~250 mg/L $CaCO_3$ in the week following treatment, which is close to the expected hardness increase of 147 mg/L $CaCO_3$ given our gypsum dose (Figure 1B). Hardness quickly dropped to ~200 mg/L $CaCO_3$ and tended to stay at this concentration for the rest of the experiment.

Second, alkalinity in ponds treated with 500 mg/L gypsum rapidly decreased by 30% (with an average decline of ~36 mg/L $CaCO_3$) to ~83 mg/L $CaCO_3$ in the week following treatment (Figure 1D). Such a decline in alkalinity after increasing hardness with gypsum is expected due to calcium carbonate precipitation. Alkalinity continued to increase for the remainder of the experiment to an average of nearly ~200 mg/L $CaCO_3$.

Third and most surprisingly, the dissolved form of phosphorus that is used by phytoplankton to grow (soluble reactive phosphorus; SRP) increased in treated ponds by an average of ~455% to ~0.85 mg/L SRP from mid-June to October 2022 (Figure 1F). The control ponds only increased by 24% to ~0.16 mg/L SRP during the same time period (Figure 1E). Such an increase in available phosphorus can lead to more algae, including undesirable blue-green algae (Figure 1H). Curiously, one treated pond (H) showed no obvious effect of gypsum on soluble reactive phosphorus concentration. Such a high increase of available phosphorus after adding 500 mg/L gypsum in ponds was not expected (Wu and Boyd 1990); therefore, laboratory and field studies will be conducted to understand the factors that lead to SRP release from the sediments.

Lastly, although blue-green algae were increasing in most of the ponds before gypsum was applied in June 2022, blue-green algae doubled to ~771 µg/L phycocyanin the week following gypsum treatment and continued to increase to ~1100 µg/L phycocyanin by mid-August 2022 (Figure 1H). Although two of the treated ponds showed little change in blue-green algae over time (ponds 2 and 11; Figure 1H), the other three treated ponds had maximum blue-green algal concentrations that ranged from ~1,600 to ~2,400 µg/L phycocyanin during the experiment. There was relatively little change in blue-green algal concentrations in the untreated control ponds from July to November 2022 (Figure 1G).

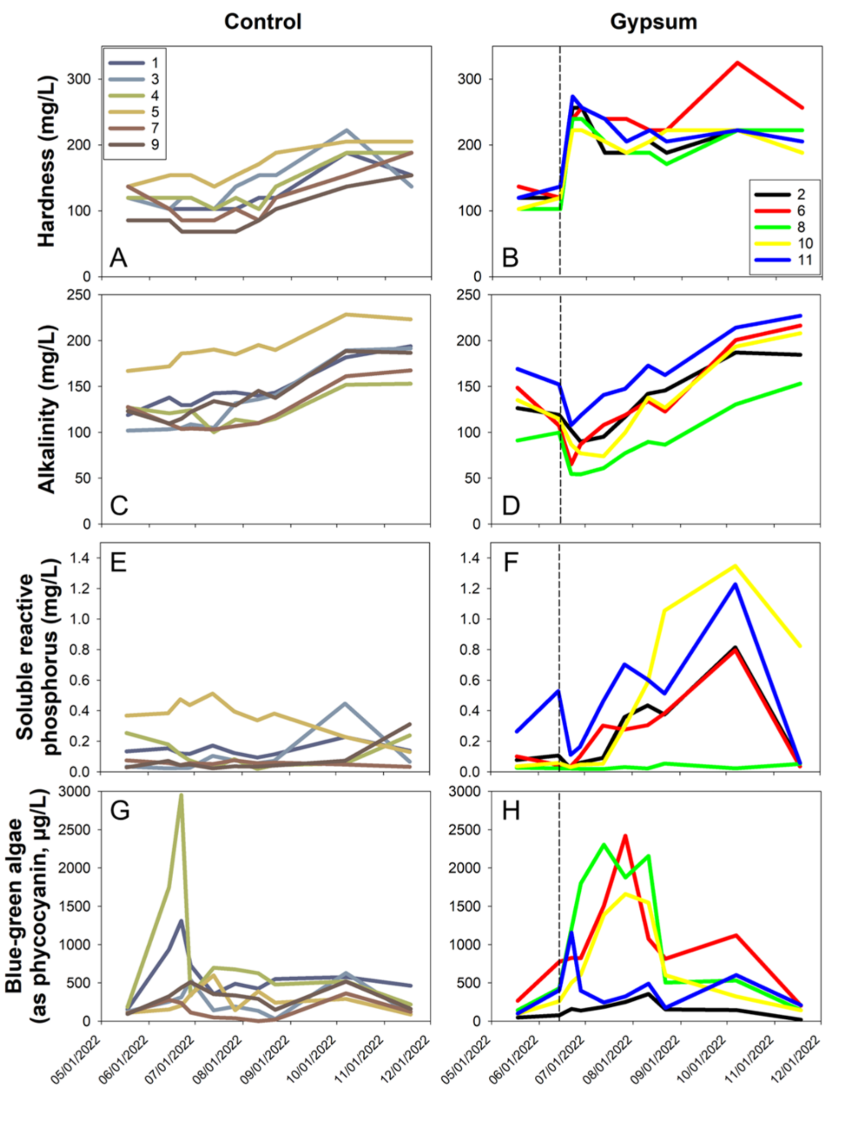

Figure 1. Water quality dynamics in catfish production ponds at one farm in west AL that were either left untreated (control) or treated with 500 mg/L gypsum on 14 June 2022 (dashed vertical line). Impacts of gypsum includes increased hardness (panels A,B), decreased alkalinity (panels C,D), increased soluble reactive phosphorus (panels E,F), and increased blue-green algae (panels G,H). Ponds are numbered 1-11.

Although gypsum applications to production ponds can benefit fish by making more calcium available for fish development and maintenance, the unexpected and dramatic increase in soluble reactive phosphorus following gypsum additions is likely due to the release of phosphorus from nutrient-rich pond sediments that subsequently promoted blue-green algae in most of the treated ponds. Since soluble reactive phosphorus is a dissolved form of phosphorus used by algae to grow, high soluble reactive phosphorus concentrations most often occur in ponds with little algae. However, we showed that gypsum additions led to both increased soluble reactive phosphorus and blue-green algae, suggesting that some other resources, such as nitrogen or light, were limiting algal growth in catfish production ponds.

In summary, we are actively conducting research to understand the interactions between gypsum and water quality and encourage aquaculture farmers to consider the pros (e.g., increased hardness) and cons (e.g., increased blue-green algae) of gypsum in advance of treatment to make sure that the desired results are achieved, and that plans are in place if water quality worsens.

The Use of Corn Fermented Protein with Yeast as an Alternative Protein Source in Practical Diets for Pond Production of Pacific White Shrimp (*Litopenaeus vannamei*)

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Figure 1. The study was carried out in ponds at Claude Peteet Mariculture Center in Gulf Shores, Alabama.

Background: Based on previous work, we have transitioned from hand feeding to the use of automated feeding systems reducing our cycle from 120 days to < 90-day while producing a larger biomass and shrimp of larger size resulting in improved economic efficiencies. The acoustic monitors allow feeding activity to be monitored to provide real time adjustment of feed input based on the shrimp demand. Based on laboratory and outdoor green water trials we have had good success with the use of various ethanol by-products. Hence, we are extending our work under controlled conditions to that of demonstration in the field. This trial aimed to determine the effects of the partial replacement of soybean meal and corn gluten meal with increasing inclusion rate of corn fermented protein with yeast (CFPY) in shrimp diets under commercial type pond production conditions.

Previous Results: The primary messages from past production data would be that there were no significant differences in production when comparing various high soy feed formulations including all plant, 8% poultry meal or 8 and 16% fishmeal-based diets or in soy-optimized diets, consisting of an all plant diet by itself or supplemented with three different attractants (2% krill meal, 2% squid meal, or 4% fish hydrolysate). Additional work looked at various levels of dietary protein (25, 30, 35 and 40%) using fishmeal free, soy-optimized formulations. The data validates the concept of daily nutrient intake (combined feed input and nutrient content of the diet) being the primary driver of performance in shrimp across several production technologies. The use of low levels of dietary protein in general resulted in higher costs, lower levels of production but more efficient use of protein. Pushing the production limits with either the high protein feed or lower levels of protein fed at higher rates; in general, was not the most effective. The results clearly demonstrate that the nutrient content of the diet and feed management are interrelated. In order to further improve plant-based diets this year we evaluated the use of CFPY as a complimentary protein source to soybean meal.

This year's production: Shrimp post-larvae were obtained from Homegrown Shrimp (Indiantown, FL). After a short two-week nursery period, juvenile shrimp (~0.001 ounces) were stocked at a density of 101,215 shrimp/acre into 16 ponds which were 0.247 acre ponds for a total of 25,000 shrimp/pond. Ponds were fed a commercial 1.5mm diet (PL Raceway 40% protein, 9% lipid) until day 14, after which they were fed one of four diets with 0, 5, 10 or 20% inclusion of corn fermented protein with yeast (CFPY) for the rest of the cycle. These feeds were commercially produced by Zeigler Brothers Inc. (Gardners, PA). After 30 days, feed was applied to ponds using AQ1 passive acoustic monitoring system using feedback from the shrimp; thus, allowing them to feed on demand from 8am to 8pm daily, max daily input of 35 pounds/pond (~142 pounds/acre/day). In summary, at the end of the 11-week trial, no significant difference (p>0.05) was found for most production parameters except for electrical use (p=0.027) and feed cost/pound shrimp (p=0.004). All parameters were found to be within acceptable ranges for profitable production (Figure 2).

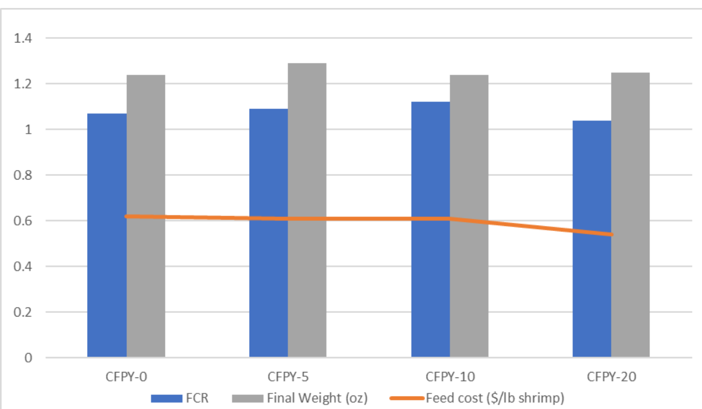

Figure 2. Final weight (g), FCR and cost of feed per pound of shrimp produce in outdoor ponds and fed one of four diets with varying levels of corn fermented protein with yeast (0, 5, 10 and 20% of the diet).

The results for final yield and feed cost per acre are presented in Figure 3 with no differences across treatments. In general, the loading of the system was within the limits of the ponds to process the nutrients. The water quality variables (including DO, temperature, total ammonia nitrogen, pH, nitrate, nitrite, phosphate, calcium, magnesium, alkalinity and secchi depth) were not significantly different between

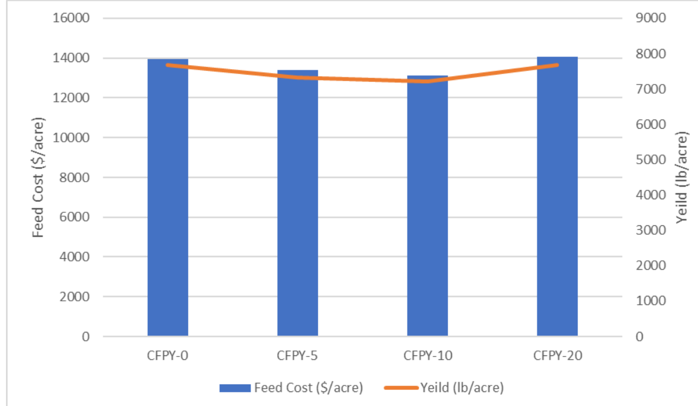

Figure 3. Feed costs per surface acre and total shrimp yield on a per acre basis for shrimp produced in outdoor ponds and fed one of four diets with varyng levels of corn fermented protein with yeast (0, 5, 10 and 20% of the diet).

treatments and were maintained within acceptable ranges for culture of this species.

In addition to the pond trial, an additional 8-week greenwater tank trial was conducted using the same diets used in the pond trial. It was set up with 16 tanks (200 gallon) stocked at 30 shrimp per tank and initial weight (0.0071 oz). Feed inputs were estimated with FCR of 1.2 and doubling growth until week 3 after which an assumed growth of 0.099 oz/week. Shrimp in the culture tanks were hand-fed four times per day. Results from this trial showed no significant differences for any growth parameters, final weight ranged from 0.71-0.73 oz with FCR ranging from 0.98-1.00. This confirmed the pond results that CFPY inclusion did not impact growth performance but reduced the cost of feed.

Conclusion

Results from these trials demonstrated that it is possible to use up to 20% inclusion of CFPY in the diets of Pacific white shrimp without compromising growth or health. From a nutritional perspective, we did not manipulate the mineral level of the diets. Since there were shifts in both P and Cu retention, this should be followed up as it could be either improved nutrient availability or simply different levels in the feed due to ingredient shift. Overall, we recommend up to 20% inclusion of CFPY which reduced the cost per unit of shrimp produced significantly.

Humic Substance Combined with Butyric Acid Could Promote Resistance to Bacteria Co-infections in Channel Catfish Production

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Interactions between two or more bacteria can drive diseases and increase mortality in catfish ponds and complicate treatments. The most frequently reported bacterial diseases in catfish production ponds are caused by *Flavobacterium covae* (columnaris disease), virulent *Aeromonas hydrophila* (vAh), or *Edwardsiella ictaluri* (enteric septicemia of catfish (ESC) or hole-in-the-head disease). Previous studies have revealed that these bacteria can remain in catfish ponds and can work together causing higher mortality rates. Many of the catfish disease cases diagnosed at the Alabama Fish Farming Center have more than one bacterial infection occurring at the same time. While antibiotics are applied to treat specific bacteria, interacting bacteria could also be enhanced. As co-infection cases persist in commercial catfish farming environments and research efforts continue to study this interaction, producers need a cost-effective sustainable alternative to effectively manage these occurrences and maintain catfish production in the United States.

Previously, including a humic substance (HS), which is a natural, environmentally friendly compound, in catfish diets improved the survival of fish cultured in commercial pond water. These findings established that HS stimulated the immune system of catfish, allowing them to fight off bacterial infections. To evaluate this further on fish with more than one bacterial infection, we examined the effects of a short-term feeding study with the inclusion of an improved humic extract (humic substance with butyric acid; HS&BA) as a single supplement or combined with the yeast cell wall (YCW). YCW is a common organic supplement that promotes fish health, and it was included to determine how its addition to HS in the diet might increase a catfish's ability to fight multiple bacterial infections. We assessed the immune-stimulating effects of these substances against coinfection with columnaris and ESC. We fed channel catfish (43 lbs/1000) for 45 days. Fish were offered a 32% protein diet with no additional supplements (Basal), a diet supplemented with an HS & BA blend at 2g/kg (IFC4), a diet supplemented with yeast cell wall at 0.5g/kg (YCW), or a diet supplemented with IFC4 at 1g/kg combined with YCW at 0.25g/kg (IFC4+YCW).

Figure 1. Channel catfish fingerling mortality recovered post-infection with A) ESC and B) Columnaris x ESC.

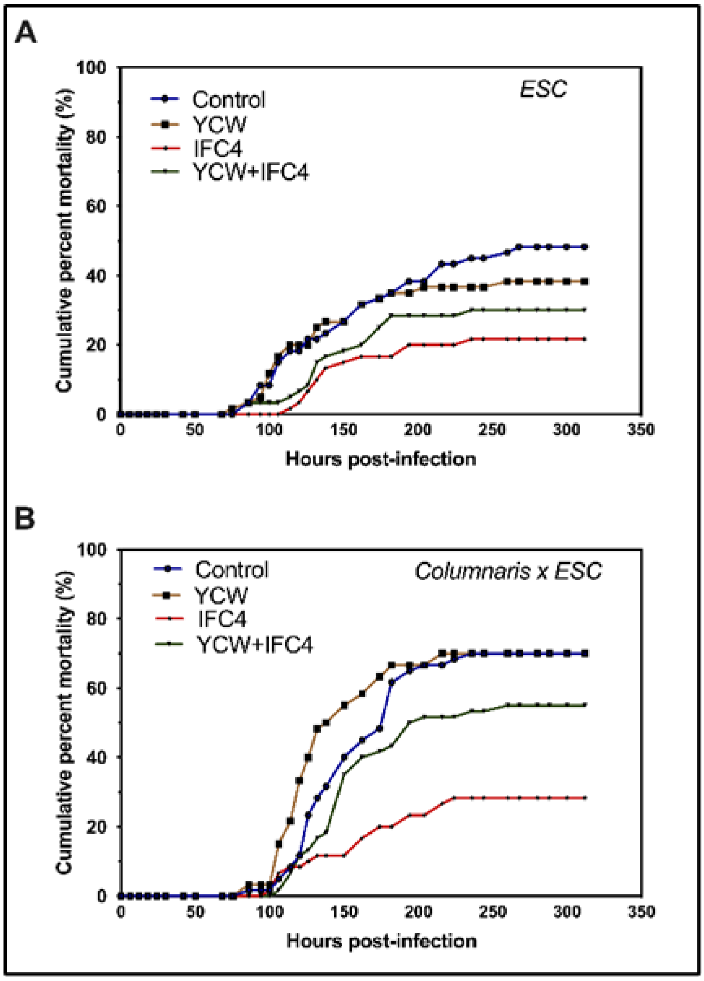

Figure 2. Cumulative percent mortality of catfish infected with (A) *E. ictaluri* and (B) *F. covae x E. ictaluri.* Control=Fish fed with no supplement, YCW=yeast cell wall, IFC4=humic extracts, and butyric acid, YCW+IFC4=Both YCW and IFC4.

Also, fish offered IFC4+YCW showed increased lysozyme activity in body mucus compared to the fish fed the basal diet (Figure 3B). Fourteen days after exposure to the bacteria, no mortality was observed in the columnaris infected group; the cumulative mortality of fish exposed to just ESC were IFC4 (22%), YCW (30%), IFC4+YCW (38%), and Basal (48%) (Figure 2A). While the single columnaris group did not induce any mortality, overall mortality increased in the co-infected group (IFC4 (28%), YCW (55%), IFC4+YCW (70%), and Basal (70%)) (Figure 2B). However, in both single ESC and co-infected cases, the lowest mortality occurred in the IFC4-fed catfish.

This study clearly shows that co-infection could significantly increase mortality in catfish-rearing systems. While a single bacterial infection is often targeted for treatment, severe disease outbreaks could occur in commercial catfish ponds due to co-infection from multiple bacteria. Moreover, using humic substances blended with butyric acid as a feed supplement could be a management tool to improve catfish's natural immunity against multiple infections.

Following the feeding trial, body mucus and blood samples were taken from fish to evaluate the natural immune response. The catfish were placed into smaller aquaria, and then dosages of bacteria were introduced for 1 hour with a single infection of columnaris or ESC (Figure 1a) or co-infection with simultaneous additions of columnaris and ESC (Figure 1b). The result showed that catfish fed a diet supplemented with IFC4 had elevated blood lysozyme activity (Figure 3A). which means an improved natural immune response. Lysozyme is an enzyme that kills bacteria. It is found in the blood and mucus of fish and increases when bacterial infections occur.

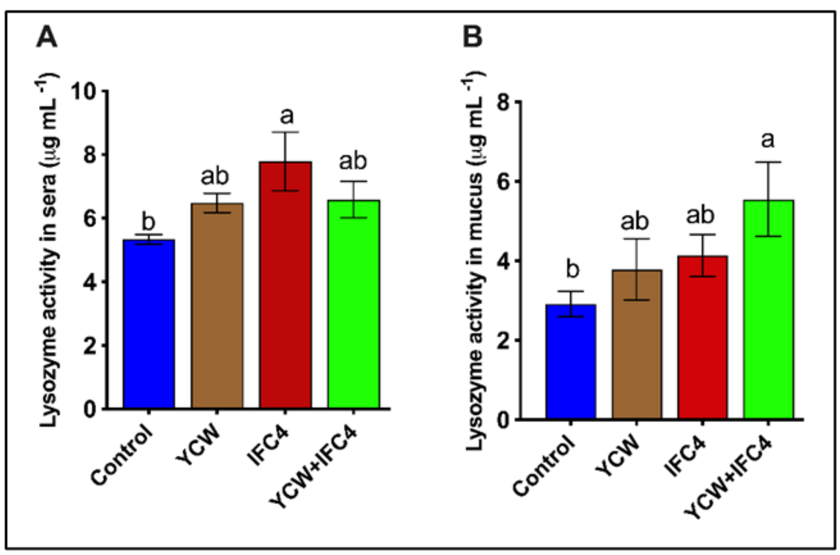

Figure 3. Lysozyme activity of blood serum (A) blood serum (B) body mucus after 45 days of feeding. Control=Fish fed with no supplement, YCW=yeast cell wall, IFC4=humic extracts, and butyric acid, YCW+IFC4=Both YCW and IFC4.

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