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Pond-to-Plate Analysis of the U.S. Farm-Raised Catfish Industry

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Abstract：U.S. domestic production and sales of catfish have declined from 300.3 million kg of processed catfish in 2003 to 213.6 million kg in 2010, while during the same period imports of tilapia, basa, tra, and channel catfish have increased. Several factors contributed to the decline, including lower import fish prices, increasing domestic feed/fuel prices, inefficiencies in U.S. catfish production, and inconsistencies in domestically produced products. A proactive focus on industry improvement at all levels is needed. A Pond-to-Plate project was initiated in 2009, with the goals of improving the competitiveness of the US farm-raised catfish industry and evolving it into a modern livestock industry. Auburn University's Fisheries Department has brought in LEAN trainers from the College of Business to assist in conducting Pond-to-Plate meetings in west Alabama. This project uses the LEAN manufacturing and continuous improvement concept and has been introduced at Pond-to-Plate meetings held in west Alabama. Each meeting includes participant representatives of the value chain; i.e., catfish producers, harvesters, transporters, processors, distributors and consumers. The LEAN enterprise produces more with existing resources by eliminating non-value-added activities. Manufacturers are facing increased worldwide competition and the stakes are high. The winners in this competition work to eliminate overproduction caused by traditional scheduling systems and to only make what customers want when they want it. Lean establishes a systematic approach to eliminate these wastes and create a flow throughout the whole company. It also helps companies develop and implement a long-term plan to streamline their operations for success. Training uses a hands-on approach involving a mixture of the company's management and staff members. This approach was modified to address the fact that the U.S. catfish industry is not one company but is comprised of independent producers with few formal ties to processing plants. Catfish Pond-to-Plate meetings have used LEAN principles to address key issues of industry efficiency at each level of the value chain, increasing demand for catfish products, lack of product/value informational flow, final customer/consumer needs/desires, and non- or misaligned objectives, product quality needs, and incentives/rewards among value chain members to produce consistently high quality products. Meetings have resulted in articulated vision statements addressing the key issues identified and have focused on activities to reach the stated goals of increasing per capita consumption of U.S. farm-raised catfish.

Key words：aquaculture, catfish, LEAN manufacturing, yellow fillets, technology

Introduction

The U.S. farm-raised catfish industry has been declining since 2003. In 2003 there were 300.3 million kg of catfish processed in the U.S. and in 2010 there were 213.6 million kg processed, a decline of 86.2 million kg or 29%. Likewise, there was a similar decrease in pond production area, from 75,757 ha

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in 2003 to 46,458 ha in 2010, a decline of 29,299 or 39%. It is generally accepted that the decline was primarily due to the growth of U.S. consumption of other fish species, which are primarily imported (the U.S. imports 83% of all the fish and seafood consumed). U.S. farm-raised frozen catfish fillet sales have been losing ground to imported frozen catfish fillet sales, but imports of frozen tilapia fillets have also taken market share from the U.S. catfish industry. Also, input costs for feed and fuel have made it more expensive to produce catfish domestically and has added to the decline in domestic sales of frozen product. Another factor is the catfish product image. Many Americans have a negative image of catfish, coming from childhood experiences fishing for bottom dwelling catfish that had a muddy flavor. This is not the case with aquacultured catfish that feed on nutritionally complete feeds that float, but occasionally some fillets with musty or earthy flavors get into the market. Such flavor inconsistencies negatively affect consumer opinions toward catfish, creating an image that is difficult to overcome; thus, it is necessary to engage in standard operating practices and best management practices that provide a high quality product each and every time it is purchased. Processors need a consistent, high quality product to entice consumers to continue to buy their product as consumers have many protein choices from which to choose.

Pond to Plate Project

The Pond-to-Plate approach uses multiple funding sources to work on all objectives simultaneously as they are interconnected. The project is advised by a seven-member task force and a 25-member core industry group of producers, harvesters, haulers, processors, wholesalers, retailers, researchers, and extension workers in a cross-disciplinary research and extension effort. The project has utilized the services of LEAN manufacturing experts to facilitate Pond-to-Plate meetings. The choice of LEAN manufacturing and continuous improvement techniques was chosen as one of many approaches used to reach our project goals and is the focus of this report. LEAN manufacturing is defined as "… a systematic approach to identifying and eliminating waste, i.e., non-value-added activities, through continuous improvement by flowing the product at the pull of the customer in pursuit of perfection." By the end of 2010, six Pond-to-Plate meetings had been held with catfish producers, harvesters, transporters, processors, and buyers participating.

The six workshops resulted in a characterization of the industry value chain, literally from pond production to consumption by final consumers (production, processing, distribution, retail). In this process, wastes (inefficiencies) along the value chain as well as identification of strengths, weaknesses, opportunities and threats to the industry were identified. These exercises allowed participants to work together to see how standards and management practices must be developed with the next levels product needs in mind to achieve the ultimate goal of providing what the consumer desires. To reach this goal the U.S. catfish industry must be transformed into a modern livestock industry taking advantage of U.S. strengths in technology and innovation. Ultimately, growing the U.S. farm-raised catfish industry in size and profitability will require improvements in production/processing efficiency to reduce costs, identifying and eliminating wastes, improving product quality and consistency to compete with substitute (imported) products, and promotion at each value stream level. A market pull situation where consumers demand products with recognized attributes is desired as opposed to the current market push approach that "pushes" processed products into the market place whether they are in high demand or not. There are many seafood and other protein choices in the marketplace and farm-raised catfish is competing against each and can be measured through consumer's vote which is done through their purchase decisions.

From the Pond-to-Plate meetings, five teams were created to address critical issues along the market/value chain, including: 1) product quality, consistency, and production systems; 2) consumer awareness; 3) packaging and product development; 4) branding and imaging; and 5) byproduct development and utilization. Meeting attendees began to see that they are all participants in the

entire value chain, whether they be producers, harvesters, transporters, processors, distributors, or retailers and their actions in developing best management practices (BMP) and standard operating procedures (SOP) at critical control points are important to the overall health of the industry.

The teams have become active in identifying priority issues. For instance, the yellow fillet problem has quickly become a top priority of the product quality, consistency, and production system (Team 1) and survey efforts are underway to connect product quality with production management strategies. Finding a solution to the yellow pigment problem in the short term will provide a model for expediently addressing other problem areas that challenge the industry. In this manner other problem areas will be addressed and BMPs and SOPs will be developed through industry input to achieve efficiencies in production and consistent quality products leading to a competitive industry that can compete with world seafood imports. In the following sections a brief summary of some of the research efforts being conducted at each level of the industry market value chain are described.

Production Efficiency

Yield verification trials are being conducted on commercial farm ponds and in small-scale experimental ponds at the E.W. Shell Fisheries Station (Auburn University research ponds). Trials are being conducted according to the protocol developed using currently best-known production practices and compared to current farm practices. At present, there are three west Alabama catfish farms participating in this program. The goal is to compare and evaluate existing farm management strategies to BMPs developed by researchers and extension personnel. The difference between this approach and prior yield verification studies is this research is measuring product quality data such as yellowness in the fillet as well as production efficiency. Both areas must be addressed to reach the final goal of meeting or exceeding customer expectations.

A yield verification protocol was established for use in farmer participant ponds and Auburn University experimental ponds in early 2010. Data were collected on initial stocking, feed input, tractor/aeration/feeding labor hours, and weekly water quality data from each pond. Additionally, data on chemicals applied, labor used, other operating inputs, and pounds harvested/sold will be collected. Note that catfish stocked as 15.24 cm fingerlings can take 18-24 months to reach 1.8 kg harvest size, so no results on production data will be reported. A data spreadsheet has been developed to enter data that will calculate ongoing production expenses and receipts to provide accumulated costs that will be useful for catfish farm managers who take the time to enter data and use the information to assist them in making management decisions. The overall goal is to biologically and economically compare and demonstrate the efficiency of BMP management strategies with previous management protocols and to involve producers in the process.

New Technology

A second area of industry modernization involves the introduction of new technologies to the pond production process through on-farm demonstrations. Technologies introduced during the project include a bar grader for use with hybrid catfish. The technology can have significant impacts on the industry as it allows for ease in sorting hybrid channel catfish (a faster growing, disease resistant fish) compared to the traditional harvest seines and live cars where hybrid fish get hung up in the net, requiring many additional hours of work. The hybrid catfish is relatively new to the industry though its advantages have been known for 30 years. Only in the last 5-10 years have enough hybrids been produced annually that producers have been able to purchase them on a regular basis. Yet, as of 2010 only 35 million hybrid fingerlings were produced compared to the one billion fingerlings required by the industry annually. The bar grader net is one of the yield verification requirements for harvesting fish on participating producer ponds. The net allows smaller fish to escape through the bars and remain in the pond until the right harvest size is reached, while taking out larger fish that need to be harvested for the sake of efficiency. In addition,

the new bar grader works well with channel catfish. The bar grader and accompanying seine net have been made available on a check-out basis to all catfish producers in west Alabama. Producers who have used the grader/net have begun to use it on a routine basis. This is progress, as word of mouth on the effectiveness of the gear is being passed on to other producers.

The second new technology being introduced to west Alabama aquaculture producers is the in-pond raceway system (IPRS) concept (Brown *et al.* 2010). The system can use existing pond infrastructure and has the potential to provide producers with inventory control, a critical factor missing in the multiple-batch pond production system. Other benefits, such as improved feed conversion ratio and higher production levels occur from tighter control over inventory and rapid, efficient control of diseases through providing medicated feed only to fish that show disease signs. Fish can also be segregated by size, allowing higher protein feeds to be provided to smaller fish without competition from larger fish, as occurs in traditional pond aquaculture. Issues from multiple batch production systems can be ameliorated by IPRS: lower mortalities from bird depredation can be achieved; starvation or malnutrition of smaller fish can be avoided; losses from other predators can be avoided; diseases can be effectively treated in a much smaller area; and reduced harvesting costs can be achieved. Overall, these systems can be more efficient to operate resulting in a lower cost of production and these systems are more flexible to operate than pond systems. Raceways can be completely harvested (100%) or fish can be harvested, graded, and moved to an adjoining raceway. Both are pathways to resetting the U.S. catfish industry onto a more profitable, competitive, and sustainable future and moving the pond aquaculture industry in the U.S. into a modern livestock industry.

Yellow Fillet Coloration

An emerging research area this project has fostered is investigation into the root causes of yellow fillet coloration. It appears that bioaccumulation of pigments coming from feed and consumed forage fish that have ingested pigmented algae are accumulated in the catfish flesh resulting in yellow coloration (Li *et al.* 2007, 2009; Lovell 1984). Inconsistent coloration of catfish fillets, either yellow or red (from stress), when whitish coloration is desired, was identified as a major detrimental issue by processors as it restricted them from maintaining or expanding fresh fillet sales to grocery store outlets. Critical control point effectiveness affecting product quality and consistency has focused on yellow fillet reduction at the production, harvesting, transporting, and processing phases.

Research into yellow and red fillet pigmentation causation will allow the U.S. to develop management strategies to deal with this issue at the pond level. Collection of yellow fillet information from processing plants and producers began in early 2010 and is continuing to obtain a full year of data for analysis since seasonality affects the yellow coloration. Correlation of catfish production variables and processor identified yellow fillet percentages by pond harvest is the measure being used to identify significant production factors affecting fillet coloration. Producer surveys were initiated for each batch of fish delivered to two processing plants in west Alabama and are matched up to processor records on percentage of yellow fillet occurrence. The producer and processor data are entered into a database for statistical analysis. Detection of significant variables will be used to develop hypotheses and research plans to reduce and/or eliminate fillet color quality issues.

A second approach to the yellow fillet coloration issue has investigated bio-film development to stop or retard additional yellow fillet color intensification of the fresh (ice/refrigerated) product during the period from completion of processing to final purchase by consumers in the grocery store outlet. Ongoing efforts to chemically diminish and retard color development with an FDA approved wash solution are continuing. Preliminary results show promise though yellow color has not diminished enough to satisfy grocery store patrons. It should be noted that not all grocery store buyers and their customers see the yellow coloration as a problem. However, consumers do ask whether fillets that are white, yellow, and red in the same seafood display

case are safe; i.e., are yellow fillets rancid? They are not, but perception is the basis for purchasing decisions and thus the need for consistent products.

Yellow coloration is not as great a concern for restaurant and institutional buyers as they further process or cook the catfish product and no yellow coloration remains. Thus, methods to detect fillet coloration, measure the discoloration, and sorting the range of colored fillets has been identified as a constraint to efficiently selling the right product to the right buyers.

Quantifying the yellow coloration level to a numerical scale is being developed and used to grade filet color using colorimetric equipment (Leggett 2008, Schmehling 2008, Leon *et al.* 2006). Installation of color measurement equipment into the catfish processing line to select fish for acceptable colors for different markets would be beneficial (Misimi *et al.* 2007). However, real issues of expense and what to do if one portion of the sorted fillets cannot be easily sold need to be addressed.

Pond-to-Plate follow-up meetings with processor employees involved in daily examination of catfish products for quality assurance (aroma and color) occurred and the digital color index developed in this project resulted in classification of a fillet color chart for testing with processors. The chart has a range of fillet color photos sorted into three categories or degree of coloration. Any individual fillet may have several colors present making classification difficult and variable due to the different requirements by buyers. The categorization of fillet colors is quantified using a numerical scale.

Color rating experiments in which 100 catfish fillets were to be sorted by color and put into one of the three color categories (gold/dark yellow, some light yellow, and white) was conducted. Each fillet was numbered and each participant wrote down into which category each fillet should be placed. After compiling the rating data there was only 69% agreement. This indicates that the ideal fillet color is not standardized. Training of processor employees in color rating is needed, and variation in color within a single fillet is high. There is great interest in future efforts to investigate colorimetric equipment being used on the processing lines — as is currently being done in the salmon industry — to select fish with acceptable colors for different markets.

Live Fish Quality and Rapid Improvement Event

Another area of concern is ensuring live catfish product quality as fish are harvested, held for grading, and transported to the processing plant. When fish are stressed during this process, red coloration can be imparted to the fish flesh. The red filet issue is being investigated by fish pathologists with the objective of determining its root cause, quantifying the red coloration for grading purposes, and looking at pre-harvest, harvest, and in-pond holding stresses for strategies to avoid the occurrence of the problem. To address this issue the project implemented a rapid improvement event (RIE) over a three-day period at one processing plant with the goal of reducing dead-on-arrival fish, punctures, and necrotic tissue through improved handling. The RIE team of 8-10 employees identified factors that contributed to the reduced quality of the fillet during the harvesting/transport phase and developed plans to reduce product defects.

This event was led by LEAN manufacturing experts and facilitated root cause analysis by team members to identify and develop methods to improve practices resulting in an increased percentage of higher quality fish arriving at the plant. The harvest/holding/transport/receiving process can produce stress in the fish and result in red fillets once processed, which is another characteristic of a degraded product. Stressed fish can produce a pink/red fillet coloration and injury can result in red splotches. In addition, dead fish can have necrotic tissue redness. The goal of the RIE was to reduce those occurrences and the number of such cases arriving at the processing plant. The process was important because it was the team of participants that found ways to improve the product. Awareness by employees that they can impact and improve product quality is empowering, especially when the knowledge is linked to the success of the business and continued operation of the plant.

Processed Fish Defects and Rapid Improvement Event

Consistency of high quality product must be ensured during the processing of catfish. Another RIE example involved a three-day RIE at a west Alabama processing plant focused on reducing defects at a limited section of the catfish processing line. Defects can be either color variation, remaining fins, holes, incorrect cuts, or low yields. The event involved plant personnel from line workers to the plant manager and took advantage of the cumulative knowledge of the participants. Root cause analysis was used to draw out information about the problem areas. Practices to address the issues and develop a protocol for doing so were discussed. The result was a program of monitoring and sampling that reduced miscuts and improved yield through incentives. Before the RIE event, processing lines were monetarily awarded weekly bonuses based on the quantity of fish processed. After the RIE event the processing line with the most processed fish *and* fewest defects was awarded with the incentive bonus. This small change resulting from the RIE significantly increased the quality of the product coming from the plant as line workers were encouraging fellow workers to get it right so their bonus would not be endangered.

Catfish Traits Desired by Wholesaler/Middlemen/Retailer

The December 2010 Pond-to-Plate meeting included catfish producers, harvesters, transporters, processors, and buyers. The results of a market value chain survey, including results on what catfish attributes retail buyer's value, and potential profitability through delivery of desired products through "pull" marketing rather than "push" marketing were discussed. Preparation for the meeting involved surveying wholesalers and retailers of catfish products to determine what they and their customers wanted in terms of size, coloration, and so forth. Interesting additional comments from the surveys indicated that more in-store promotion and more contact with producers and processors were desired. Additionally, it was found that the catfish product being put on the market was not all bad; in fact, it was found that there was tremendous U.S. product loyalty and buyers liked the current products, though that varied by outlet type. In the end, Pond-to-Plate participants better understood why their production methods matter, why their attention to quality mattered, and that there is the possibility of increased producer and processor sales resulting from their individual farm and processor-level actions. Again, they saw that improvements can be achieved through BMPs and SOPs at each level and at critical control points along the value chain.

Summary and Conclusions

Pond-to-Plate meetings and spin-off events such as the RIEs and other processor-producer events have been very important in identifying, researching, and developing improvements in the U.S. farm-raised catfish industry, including product quality and consistency, improving efficiency at each value step, and improving the understanding among industry participants that one link in the value chain does affect the next level and vice versa. Meetings have brought industry participants together to find common ground and common goals. All are seeing the need for BMPs and SOP's for efficiency, quality control, competitiveness, and profitability.

This is a long-term effort and initial activities and successes are building momentum and empowering producers, harvesters, transporters, and processors with the understanding that standardization and BMPs are key to consistent products and industry competitiveness and growth. Furthermore, the need to produce a product with the attributes that consumers demand is crucial for the industry to make strides toward a modern livestock industry. The support from several funding sources for this initiative has been pivotal to bringing disjointed biological, economic, and marketing studies into a meaningful Pond-to-Plate effort. Under the LEAN manufacturing and continuous improvement philosophy an industry will never reach perfection, but instead a process of chipping away at specific problems across the market channel span will continuously pay off as improvements in efficiency,

quality consistency, and pull marketing occur.

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