AQUACULTURE PRODUCT QUALITY ISSUES: MARKET POSITION OPPORTUNITIES UNDER MANDATORY SEAFOOD INSPECTION REGULATIONS

Peter B. Johnsen
Food Flavor Quality Research, USDA Agricultural Research Service, Southern Regional Research Center, New Orleans, LA 70179

ABSTRACT
Impending legislation for a mandatory seafood inspection program will be important in shaping the consumer's perception and expectation of quality in seafood products. Because aquacultured species are produced in controlled environments, fed special diets, and processed under optimum conditions, they possess unique product characteristics. The perception by the consumer that these products could be safer, fresher, more wholesome, and better tasting may lead to a competitive marketing position relative to captured products.
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Introduction
Quality has been defined as "the composite of those characteristics that differentiate individual units of a product, and have significance in determining the degree of acceptability by the buyer" (Kramer and Twigg, 1970). The assessment of quality attributes is made at three levels of perception (Shewfelt, 1990). "External" quality characteristics, those that can be perceived by the sense of sight and touch, without ingesting the product, are important in product differentiation, particularly in the initial purchase decision. "Internal" quality, characterized by the senses of taste, smell, and texture, combine with visual appearance in determining acceptability and often influence the decision to purchase that product again. Technical characteristics, such as nutritional value, wholesomeness, and safety often require sophisticated equipment to measure and are not readily determined by most consumers. However, perceptions of these important attributes by the consumer affect both differentiation and acceptability of a product.

Quality and Seafood
The dramatic rise in seafood consumption described by Broussard (1991) is likely due to consumers' perceptions of product image more than to actual sensory experiences dictating a change in eating habits. This positive image of seafood is based on the perceived quality of seafood relative to the image of competing muscle foods. Consumption of fish has increased dramatically at the expense of red meat market shares, but the slight dip in seafood consumption during 1988 has been attributed by some observers to concerns about product quality and safety. The production of food from aquatic sources has reached record levels worldwide. Although commercial fishing has stalled, United States aquaculturists have increased production dramatically in the 1980s. If aquacultured species are going to continue in popularity with the public, the consumer must have confidence in both the quality traits that can be sensed by looking at and testing the product and more technical attributes such as nutrition, wholesomeness, and safety.
Most observers agree that some form of mandatory National Seafood Inspection Program will become law. Even if this is a Hazard Analysis Critical Control Point (HACCP) system designed to address "safety" issues only, supporters and critics alike agree that this legislation will be very important in shaping the consumer's perception and expectation of quality in seafood products. This paper addresses the issue of perceived quality in aquacultured products and the unique position that such products could occupy in the marketplace relative to conventionally captured fisheries products.

**What Is Quality and Who Is Responsible for It?**

To determine quality, an expert would consider postmortem biology, processing workmanship, and initial condition (Bisogni et al., 1987). Time and temperature of holding and storage influence the final appearance, safety, color, texture, and flavor of the product.

It is clear that the consumer determines the quality of fisheries products based on both assessed and perceived attributes. The consumer's view of quality is based on product characteristics not usually considered by experts. Consumers indicate that they possess limited abilities to assess quality, and often the knowledge and reputation of the retailer have a significant impact on their perception of quality (Bisogni et al., 1987). Most often "freshness," judged by retail setting and absence of odor, is the principal attribute indicating quality. Other technical attributes are impossible for the consumer to evaluate but are of concern.

This concern is expressed by a consumer quoted in the report of Bisogni et al. (1987):

> ... to what extent do grocery store chains bear the responsibility for our getting fresh fish? ... Do I as the consumer have to sniff every bottle of milk? No, I don't. I shouldn't have to. I shouldn't have to do that with any other food. Are those same kinds of standards maintained for fish or do I need to examine each piece? I take responsibility for buying fish to a much greater extent than I would take responsibility for buying other things in the store.

Responsibility is at the heart of the matter for the proposed national seafood inspection programs. Consumer groups such as the Center for Science in the Public Interest have published specific complaints about the quality and safety of seafood products (Lefferts, 1988), indicating that inspection by the Food and Drug Administration (FDA) is inadequate in scope and that action levels for safety hazards are inadequate to protect the consumer. This publicity has led to greater interest in legislation governing inspection and surveillance of the nation's seafood industry (Garrett, 1988). The Library of Congress, Congressional Research Service (Mazur, 1989) reports that the meat and poultry industries have shown strong interest in seafood safety, and seven separate bills have been introduced into Congress during the 101st session calling for a mandatory national seafood inspection system. The Senate passed legislation (S2924) calling for mandatory fish inspection under the jurisdiction of the USDA. However, the House of Representatives failed to pass a similar bill, so mandatory seafood inspection legislation must wait until the next session of Congress. The primary conflict centers on which Federal agency will be given primary responsibility for the inspection program. The industry and principal consumer group, Public Voice for Food and Health Policy, supports administration by the USDA, but a Bush Administration policy statement indicates a presidential veto if Congress transfers the duty to the USDA (Cloud, 1990).

Although fish products are not required to pass unified, continuous federal inspection, seafood production and processing practices are regulated by several federal authorities. In addition, numerous state authorities are responsible for regulation and inspection of seafood products. The FDA regulates seafoods, including aquacultured products and production practices. The FDA's responsibility for seafood products involves periodic inspections of processing plants to assess compliance with good manufacturing practices (GMP) and regulations governing product adulteration and misbranding. The GMP are recommended and required guidelines concerning quality and sanitation during food processing, manufacturing, packaging, distribution, and storage (Ottowall, 1989). The U.S. Department of Commerce, National Marine Fisheries Service (NMFS) operates the National Seafood Inspection Program for inspection and certification, but participation is voluntary and limited. This
service for a fee operates to ensure safety and grade quality of products. The certificates issued by the U. S. Department of Commerce are accepted legal documents in any U.S. court.

**Aquaculture and Quality Seafood**

A study prepared for the NMFS (ICF Inc., 1986) suggested that benefits to the consumer of a national seafood inspection program might involve three areas: 1) reduced health risks from contaminated seafood, 2) reduced likelihood of economic fraud, and 3) improved quality of seafood. Aquaculture products may have specific advantage over captured fisheries products in addressing these consumer concerns by nature of the controlled production system and current processing practices.

**Safety**

Proponents argue that a national inspection system could reduce health risks caused by the presence of pathogenic microorganisms, contaminants, or toxins resulting from production in contaminated environments or improper handling and processing.

The FDA estimates that the risk of illness from a 113-g (4-oz) serving of any seafood is 1 per 250,000 servings, whereas the risk from chicken is 1 per 25,000 servings. The risk of illness from finfish and crustaceans is 1 per 5,000,000 servings, compared with 1 per 250 servings from raw or partially cooked molluskan shellfish (Archer, 1989).

Most health problems arising from mollusks are associated with contaminated effluents and subsequent contamination of the product. The production of oysters, mussels, clams, abalone, and scallops by aquaculture has the advantage that water quality can be monitored, if not controlled, to reduce health problems. Appropriate site selection and knowledge of the origin of mollusks delivered to the marketplace can minimize these problems.

To date, very few microorganism-related health problems have been identified from finfish production practices. The greatest concern relates to postharvest processing and handling. For the traditional capture fishery, fish are placed on ice for shipment to the processing plant. Typically, problems of contamination and spoilage can begin at this point. By contrast, cultured organisms are produced adjacent to the processing plant or are transported live to the plant. It can take several hours or even days to transport captured fish for processing, whereas, most cultured fish are processed and packaged in as little as 1 h from the time of killing (Brooks, 1986).

Consumer advocates express concern that uninspected seafood may contain unacceptable levels of various chemical contaminants such as pesticides, polychlorinated biphenyls, and heavy metals. Without knowing the source of the product, continuous monitoring would be required to ensure compliance with regulations. Because fish produced in aquaculture are from known origins, it is possible to sample a relatively limited environment to make sure no health risks exist. Additionally, because cultured fish are produced in the same environment and fed the same feed, it would be possible to sample a few representative fish from each production unit. For this reason, continuous inspections would not be necessary, and appropriate lot sampling would be sufficient to ensure that safe and wholesome fish are delivered to market.

Farm-raised catfish were cited by the Center for Science in the Public Interest (Lefferts, 1988) as being unacceptable because they are raised in agricultural areas where chemicals are used on row crops. However, extensive sampling during a 1-yr period failed to detect hazardous chemicals at action levels (Nettleton et al., 1990). Mississippi catfish contained no detectable amounts of polychlorinated biphenyls, heptachlorepoxide, toxaphene, or hexachlorobenzene. Chlorinated hydrocarbon residues, if present, were in amounts approaching the detection limits of the method and were well below FDA tolerance levels for such substances. Levels for the heavy metals arsenic, cadmium, lead, and mercury were at the limits of detection in amounts too small to be reliably measured.

Ciguatera toxin is produced by particular dinoflagellates found in tropical marine waters and is restricted to a limited number of fish species. As with contaminant and microorganism monitoring, cultured fish could be monitored much more easily than captured species. Culturing in controlled or monitored situations does not exclude the possibility that the product can become toxic, however. Cultured mussels contaminated with domoic acid produced by a marine alga were believed to be responsible for an outbreak of illness in...
Salt and fresh fish have been demonstrated in Mississippi catfish fillets (Joseph, 1986). Culture systems because diets and fish sizes are generally different between wild and cultured products, consumers are assured of species identification and proper handling during processing can eliminate this health concern.

**Fraud and Labeling**

The seafood industry encompasses one of the largest and most diverse collections of edible species of all food product categories. These conditions help to support an undesirable situation wherein mislabeling and substitution are often the only ways to successfully introduce unfamiliar and underused species and derivative products (Doyle, 1988). Although far from being a major factor in marketing seafood, substitution has occurred with enough frequency to draw the attention of regulatory agencies, particularly the FDA.

There are more than 3,000 commercial aquatic species throughout the world, and more than 250 in the U.S. (Martin et al., 1978). On the other hand, only a few dozen species are currently under cultivation. When purchasing cultured products, consumers are assured of species identification. The aquaculture industry makes significant investments of time and money to reach a point at which it can bring a species to market. Therefore, species recognition is an extremely important component of the marketing strategy of cultured species.

Another aspect of the issue is product labeling. Recently, the Bush administration has proposed regulations that would require nutrition labeling for almost all packaged foods and for fresh produce and seafood (Federal Register, 1990). Because the proposal includes only those foods regulated by the FDA, fish would be included but meat and poultry would not. The task of nutrient determination for 250 commercial species of seafood will be formidable, particularly because size, sex, season, and location of capture can affect an individual species' nutrient content (Deng et al., 1976; Joseph, 1985).

Nutrient variations could be reduced in culture systems because diets are controlled and fish are generally harvested at particular sizes and before sexual maturation. This has been demonstrated in Mississippi catfish fillets from .5 to 1.0-kg fish. Samples were collected at approximately quarterly intervals throughout the year and no statistically significant variations in nutrient composition from season to season were observed (Nettleton et al., 1990).

**Quality**

Numerous surveys suggest that consumers would view improved seafood quality as a complementary benefit of a seafood inspection program. In this instance, quality does not refer to safety issues, but rather to the nutritional value, freshness, and desirable flavor characteristics of the product. Nutritional content and flavor are established before harvest. It has been well documented that genetics, diet, and environment all affect these attributes, and aquaculture is in a unique position to manipulate these influences.

A California marketing promotion claiming "raised by aquaculture experts and inspected by medical professionals in the field of human nutrition" implies that aquaculture can be used to enhance the nutrient quality of fish (cited by Nettleton, 1990). Farmed and wild fish have essentially the same amount of protein, although only a few species have been compared. Fat content does differ. Farmed fish are generally fatter than their wild counterparts and, although the amount of fat is important, the composition of the fat is more significant.

The headline-grabbing omega-3 fatty acids and their potential to reduce chances of developing heart disease are of great health and marketing interest to fish consumers. Farmed rainbow trout have more omega-3 fatty acids than wild fish, making it clear that, under practical conditions of aquaculture, omega-3 fatty acid content can be retained, and even boosted. Similar results have been obtained for farm-raised catfish (Mohammed and Lovell, 1988) and cultured red drum (Jahncke et al., 1988) by manipulating the fatty acid content of the diet. However, increasing levels of fish oils in the diet to boost the omega-3 content led to fish flavors in the catfish that are generally disliked by consumers. In addition, greater amounts of unsaturated fatty acids also increase the likelihood of oxidative rancidity during storage.

In examining consumer perception of quality as it relates to freshness, Connell and Howgate (1971) concluded that flavor was a more important criterion of quality than...
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texture. Similarly, Hamilton and Bennett (1983, 1984), in studies using different species of white fish, concluded that flavor was the most significant positive determinant of acceptability.

Although diet and environment are the most studied influences on flavor quality, the role of genetics is gaining importance for the aquaculturist. Cultivation of three species of catfish under similar conditions with the same diet produced fish with different fat deposition patterns and different flavors (Manthey et al., 1988). Recent work with farm-raised catfish has suggested that important, desirable flavors in these fish may be under genetic control to a greater extent than previously thought (Johnsen, 1989; Johnsen and Kelly, 1990; Johnsen and Dupree 1991).

Johnsen and Dupree (1991) produced fish in the laboratory fed 21 experimental diets that incorporated the major feed ingredients used in the industry. A trained sensory panel found that flavor differences were relatively minor, suggesting that the distinctive catfish flavor complex is derived from the fish itself. Current research involves identifying the compounds responsible for these flavors so that genetic improvements to the catfish will maintain or improve quality, rather than simply enhance production efficiency at the expense of flavor quality.

Genetics can also have an impact on fish size, uniformity, and processing yield, as has been seen in the poultry industry. With increasing amounts of seafood consumed out of the home, emphasis will be placed on piece count and uniformity of serving size for portion control. Institutional buyers for the retail and further processing industries may well begin to drive the marketing process as the primary customers of aquacultured products.

Because culture systems most often involve intensive feeding resulting in nutrient enrichment of the water, a number of flavor quality problems have arisen. Significant blooms of microorganisms are also produced in these environments and numerous off-flavors that can adversely affect the product have been identified (Lovell, 1983; Johnsen et al., 1987). The farm-raised catfish industry considers these environmental off-flavors their most significant problem, but they are also a problem in cultured shrimp (Lovell and Broce, 1985), clams (Hsieh et al., 1988), trout, and tilapia (personal observation). Similar off-flavors have been identified in captured species as well (Thayson, 1936; Persson, 1979; Yurkowski and Tabachek, 1980).

The potent odors geosmin and 2-methylisoborneol are produced by bluegreen algae and actinomycetes. These compounds are excreted into the water (Wu and Juttner, 1988) and are concentrated in the lipid tissues of fish. A .5 ppb concentration of 2-methylisoborneol in water can be biocconcetrated by the catfish to render it off-flavor in < 2 h (Johnsen, 1989). Similar observations have been made for geosmin.

To ensure that only fish of acceptable quality reach the marketplace, the catfish industry maintains trained flavor testers at the processing plants to reject fish taken from off-flavor ponds. Unlike captured species, cultured fish are flavor-checked before harvest. If the samples are found to be off-flavor, fish are left in the production system or held in tanks or raceways until the flavor quality returns.

Impact of Inspection on Seafood Marketing

Mandatory inspections boosting consumer confidence in seafood combined with continued promotion of seafood's health benefits could lead to increased consumption. A Congressional Research Service study, "Mandatory Seafood Inspection: an overview" (Becker, 1983) speculated that inspection could prove to be a "double-edged sword" for those in the beef and poultry industry who share the "if I have to be subject to inspection, so do you" attitude. To the extent that mandatory fish inspection would enhance product integrity, increase consumer confidence, and, therefore, promote additional consumption, red meat and poultry could suffer further erosion of market shares. A USDA Economic Research Service report (Blaylock and Smallwood, 1986), which examined population changes in age, race, and income, estimated that at-home per capita food expenditures for seafood products would increase more than 27% between 1980 and 2005, well above the projected increases for beef, pork, and poultry.

It has been demonstrated that improvement in seafood quality will result in increased sales, providing benefits to consumers and suppliers alike. The NMFS showed that a dramatic
increase in seafood sales occurred in six supermarkets from three different chains due to the marketing of U.S. Grade A quality fish fillets (Ronsivali et al., 1981). Similar results were reported in a 26-store supermarket chain in Arizona (Ziebach, 1978) and in an Australian industry project (Watson, 1979).

Advantages of Aquaculture

Only on a limited basis are farmed shrimp being differentiated from captured products in the marketplace. The reverse is the situation in the salmon market. Named origins are touted without exception because above-average prices are sought. Marketing is also more sophisticated than in the case of farmed shrimp. Emphasis on production quality, premium packaging, and speed in delivery is important in establishing and maintaining markets. Individual grower and processor standards are being emphasized in marketing strategies.

Producers own about 50% of the catfish processing capacity in the United States. No other fishery sector has comparable cooperation between producers and marketers. This link brings reality to the theory of controlled, quality production touted for most aquaculture systems. Funded by a check-off system based on feed sales, the Mississippi catfish farmers have established an inspection standard for appearance, workmanship, flavor, packaging, and labeling. Specially trained U.S. Department of Commerce inspectors are contracted to operate the inspection system. Called the Mississippi Prime system, and identified by a special logo, this inspection system is marketed through an extensive advertising campaign. Following the initial year, standards were tightened, reflecting an improvement in product quality and a recognition by participants that quality sells.

In addition to these efforts in product identification, brand identification is increasing as the larger agribusiness firms enter the aquaculture marketplace. Already, advertisements in the trade publications promote the notion that not all farmed fish are the same. This strong product differentiation is indicative of vertically integrated operations that control genetic characteristics of the fish, feed formulations, feeding schedules, processing practices, and, finally, branded marketing.

Implications

Aquacultured products will affect seafood marketing programs by emphasizing consistent supply, quality, freshness, and, possibly, a narrower price range. A recent advertisement for an aquacultured fish claimed that “this award-winning product has overwhelming advantages over wild-caught fish; raised in a pollution-free environment, flavor enhanced by diet control, year-round availability, long shelf life, high fillet yield and immediate air shipment worldwide.” This demonstrates that aquaculture recognizes an opportunity in an otherwise uncertain time for seafood.

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