Sensory Preference and Discrimination of Wild-caught and Cultured Yellow Perch (*Perca flavescens*)

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ABSTRACT: Wild-caught and cultured yellow perch (*Perca flavescens*) were compared for overall difference and preference. Judges (n = 52) completed 2 replications each of both a paired preference and a triangle test. Results were analyzed using the β-binomial model. Findings indicate that samples were significantly different from each other (P = 0.0001) but there was no significant preference for either sample (P = 0.1167). For both tests, overdispersion, or panelist variability, was very low, indicating judges were acting similarly and the binomial model better fit the data. Judges' comments were contradictory and inconsistent, making it impossible to determine the exact nature of the difference.

Keywords: *Perca flavescens*, yellow perch, aquaculture, sensory, β-binomial

Introduction

Research comparing sensory properties and consumer preference of aquacultured and wild yellow perch is now outdated. Early producers of perch used trout diets because perch dietary requirements of protein and lipid were unknown. While Lindsay (1980) found aquacultured and wild yellow perch to be equal in firmness and overall preference, anecdotal reports would suggest that differences in flavor and preference do exist, with wild-caught being preferred (Bennett 2002). Wild-caught perch are generally described as having a flavor that is stronger and less bland than cultured perch. There also have been many changes, environmental, technological, and so forth, that potentially impact the quality of both aquacultured and wild perch. Undoubtedly, pollution has affected the rivers and streams where the wild perch grow, suggesting a potential decrease in quality. In addition, diet formulations for cultured perch have changed for the better to more closely match perch dietary requirements for protein and lipids. These modern diets incorporate the findings of Brown and others (1996), who defined many of the nutritional requirements of perch, and feed manufacturers are formulating feeds that are more suited to the nutritional requirements of perch and mimic the ideal diet of wild fish.

Yellow perch are traditionally cultured in open ponds in the North Central region of Ohio, but several commercial facilities culture perch indoors using recirculating water aquaculture systems. Due to the different management and husbandry requirements, differences such as feed type and quantity, frequency of harvesting and grading, and water quality may influence the final consistency and taste of perch, as well as lead to differences in appearance, flavor, and texture between the 2 sources. Culture conditions remain relatively unchanged, as living conditions of wild perch are difficult to match. Regardless, fish farmers routinely monitor water quality, feed intake, and behavior of fish, which helps in approaching optimal growing conditions and allows for the growth of larger fish in shorter time as compared with wild-caught fish. Comparative research of aquacultured and wild-caught yellow perch is warranted.

Wild-caught yellow perch continue to dominate the available market, however, fluctuations in year classes and catch totals from year to year offer the opportunity for cultured perch to gain a significant foothold in the market. Comparative studies are expected to aid in the development of practices that result in the quality of cultured perch matching or exceeding that of wild-caught perch. Results from these studies can be used to refine the prepared diets used when raising perch and may also provide evidence for the need to change or adjust management practices (for example, water quality adjustments, depuration periods, and so on). Furthermore, the establishment of standardized testing protocols will allow future comparisons of other commercially competing species such as European perch (*Perca fluviatilis*) and zander (*Stizostedion lucioperca*).

In addition, new sensory methodologies have been developed with increased validity. Traditionally, paired difference and preference tests have utilized a guessing model and have thus utilized the binomial distribution for the evaluation of 2 products. However, the binomial model assumes that there exists only 1 source of variation, the samples. In fact, the panelists are also a source of variation and this variability among panelists is known as overdispersion. This overdispersion cannot be ignored as the variability in the data may exceed binomial variability (Cox 1983; Anderson 1988), resulting in misleading analysis of the results and subsequent arrival at the wrong conclusion (Vuataz and Sotek 1978; Ennis and Bi 1998). To account for the variability of both parameters, that is, samples and panelists, the β-binomial model was developed. When overdispersion exists, the β-binomial model provides a better fit to the data than the binomial model, improving the validity of the test (Ennis and Bi 1998). This model has been used successfully in a variety of areas, including chromosome research (Skellam 1948), market research (Chatfield and Goodhardt 1970), and policy change (Gange and others 1996). However, its use in sensory evaluation has not been fully realized (Ennis and Bi 1998).

The objectives of this research are to provide a scientifically

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based investigation into the possible sensory differences between wild-caught and cultured perch, as well as the possible differences in preference that may exist due to these differences.

Materials and Methods

Stimuli

Wild-caught and cultured yellow perch (*Perca flavescens*), also known as lake perch or ring perch, were studied. The diet of the cultured perch was Purina AquaMax series, 5d04, in 0.5-cm pellets containing 42% protein and 16% fat. Perch were fed 3% body weight over 2 feedings per day. At time of harvest, temperatures ranged from 22 to 24 °C, and dissolved oxygen was 8 to 10 ppm. Perch were cultured in open ponds with no flow through at The Ohio State Univ. South Centers in Piketon, Ohio. Fish were harvested live by seine net in early November 2002 and moved to holding tanks provided with pond water at a flow rate of 19 L/min. Perch were held approximately 2 wk and fed a maintenance diet of 1% body weight per day during holding. Forty-eight hours prior to processing, food was withheld to clean out the belly. No drugs were used except 1 ppt salt in tanks to minimize stress at handling. This is standard procedure for the aquaculture industry, as harvested fish were randomly sampled from a large tank. Withholding food prior to harvesting improves the water quality in the tank and allows for quicker recovery of the remaining fish. Harvested perch were killed by immersion in ice-water slurry (2 °C), packed on ice, and immediately transferred to the HACCP-certified seafood processing operation in Lorain, Ohio. They were 2 y of age, approximately 20 to 25 cm in length and 175 g in weight.

Wild-caught perch were caught on Lake Erie (approximately 3 km off-shore at Lorain, Ohio) in early November by trapnet. They were feeding and not starved, and approximately 25 to 30 cm in length and 200 g in weight. The approximate age of the perch was 4 to 7 y old. Once caught, fish were immediately stored on ice in a cooler at 4 °C in the whole and processed within 3 d at the same facility as above.

Wild-caught perch at 3 d post-harvest and cultured perch harvested earlier that day were processed at the same time. Processing began by passing the fish through a mechanical descaler in the whole condition before filleting, during which all organs, lining, and so on were removed. Fish were deboned and butterfly filleted by hand on a table in batches of approximately 5 kg, remaining off ice no more than 2 min. Skin was left on and thickness of the fillets was 1.25 to 2 cm in the pectoral region and reduced toward the tail. A cut was made behind the anus, then around through the tail region. The belly flap (ventral side, behind pectoral fins and before anus) was left to attach the 2 sides forming the butterfly fillet. Butterfly filleting was done for 2 reasons. First, this is standard preparation for the Great Lakes region, where the fish were collected and assessed by consumers. Second, it provided additional control over the test stimuli because all like pieces, that is, wild-caught or cultured, within a task (preference or discrimination), could be sampled from the same fish. Fish were then placed in ice slurry until bagged in plastic bags each weighing 2.2 kg. Bags were then transported 2 h on ice in a cooler and placed into frozen storage at –20 °C for approximately 3 min until thawed and prepared for panel assessment.

Perch was thawed in its original packaging at 4 °C for 2 d. After thawing and removal from packaging, each fillet was patted dry with a paper towel. Both sides were then dusted in a mixture made up of 85% all-purpose, bleached, enriched flour (Kroger Co., Cincinnati, Ohio, U.S.A.) and 15% salt (Topco Associates Inc., Skokie, Ill., U.S.A.). All surfaces were covered and excess was removed by gentle shaking. Next, fillets were submerged in an egg wash consisting of 65% Grade A egg (Kroger Co., Cincinnati, Ohio, U.S.A.) and 35% bottled spring water (Ice Mountain Water Co., Hilliard, Ohio, U.S.A.). Finally, fillets were dusted on both sides with yellow, enriched, degerminated corn meal (The Quaker Oats Co., Chicago, Ill., U.S.A.). Again all surfaces were covered and excess was removed by gentle shaking.

Frying was chosen as the preparation method because perch is typically consumed in this manner in the Great Lakes region. Fillets were fried in an electric deep fryer (Natl. Presto Industries, Inc., Eau Claire, Wis., U.S.A.) filled with 100% natural vegetable (soybean) oil (Hunt-Wesson Inc., Fullerton, Calif., U.S.A.). Once filled with oil, the fryer was separated into 2 equal compartments by a solid divider where transfer of oil between the compartments was minimized. The oil in both compartments was heated to 190 °C with a common heating element before fillets were immersed. Both types of fish were fried and served at the same time to eliminate differences in serving temperature. Oil temperature during frying was approximately 150 °C. Fillets were fried for 3 min and final internal temperature was approximately 90 °C. Fish were removed from the fryer using metal tongs and placed on wire racks to drain for approximately 60 s.

Fillets were then transferred to a cutting board where they were cut into pieces for serving. To control for fish-to-fish variability, all like pieces (wild-caught or cultured), within a task (preference or discrimination), were sampled from the same fish. Number and size of pieces varied depending upon the experimental task. Specifically, for the paired preference task, 2 pieces were needed, while for discrimination, 3 pieces were needed (Figure 1). Pieces for preference testing were approximately 6 cm × 6 cm, and pieces for discrimination testing were approximately 4 cm × 5 cm. Each piece was placed into a 3.25-oz translucent plastic soufflé cup (Solo Cup Co., Urbana, Ill., U.S.A.) labeled with a 3-digit code.

Judges

Fifty-two judges (23 males and 29 females; ages 19 to 42) evaluated wild-caught and cultured perch samples. Judges were recruit-

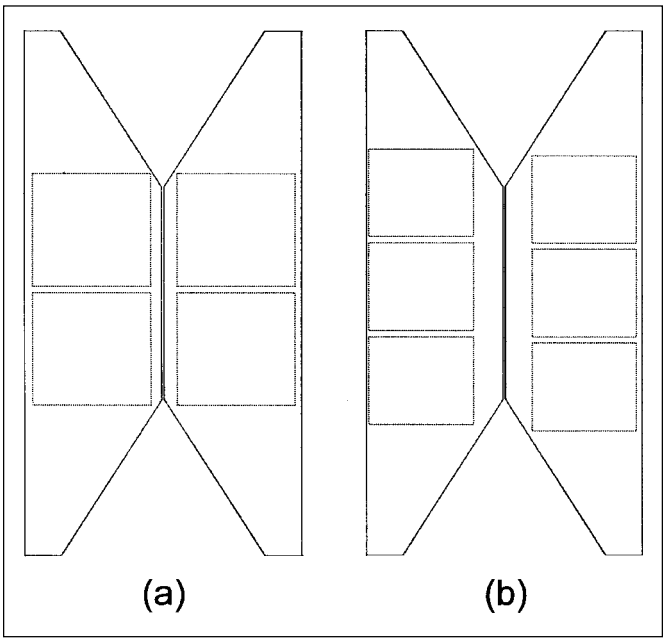

Figure 1—Wings are connected via the ventral belly flap, caudal-side down. (a) Diagram showing portions cut for preference testing; (b) diagram showing portions cut for discrimination testing. Portions served to a judge came from the same wing.

ed via intercept from the lobby of the Parker Food Science & Technology Building on the Columbus Campus of The Ohio State Univ. The only panel selection criteria were that judges liked and were willing to assess fried fish. Judges gave informed consent to participate and were compensated with a gift certificate to a local eatery.

Procedure

The Office of Responsible Research Practices at the Ohio State Univ. approved all methods and procedures. Judges evaluated samples in individual booths at a central location and responses were entered directly utilizing Compusense® 5 version 4.4 data collection and analysis software (Compusense Inc., Guelph, Ont., Canada). Judges were allowed to swallow or expectorate samples, as each desired, and re-tasting was allowed. Spring water was provided for rinsing (Ice Mountain Water Co.). Judges proceeded at their own pace.

Judges began by giving their informed consent for participation, as well as gender and age information. A tray of samples containing 2 sample sets, numbered 1 and 2, was then presented. They were instructed to taste the 2 samples in row 1 from left to right and indicate which sample they preferred. Once a sample was selected, judges were asked to comment on why the sample was preferred. Judges then tasted the 2 samples in row 2 and responded in identical fashion as before. The tray was then removed from the booth. The order of samples was counter-balanced within and across judges.

After a minimum interstimulus interval of 2 min, a second tray containing 2 sample sets, numbered 3 and 4, were served to each panelist. Judges were told that the 3 samples in row 3 were a triangle test where 2 were the same and 1 was different. They were then instructed to taste the samples in row 3 from left to right and indicate which sample was different. Once a sample was selected, judges were asked to comment on why that sample was chosen. Judges then tasted the 3 samples in row 4 and responded in identical fashion. For every judge, wild-caught perch was the odd sample in 1 set and cultured perch was odd in the other set. Additionally, the position of the odd samples was counter-balanced both within and across judges.

Statistics

Frequencies of responses for each judge and each method were tabulated and input into IF Programs™ software, along with the null probability and the 1- or 2-tailed nature of each method, the α level, and the number of judges and replications. The output gave a *P* value indicating whether there was significant panelist variability, as well as a second *P* value indicating whether the samples were significantly different from each other. When panelist variability was significant, the β-binomial model was used to determine if a significant difference existed; when panelist variability was not significant, the binomial model was used. The amount of overdispersion (γ), or panelist variability, was estimated by:

$$\frac{n_R S}{\bar{p}(1-\bar{p})N_J(n_R-1)} - \frac{1}{n_R-1}$$

where n_R = the number of replications per judge, $\bar{p}$ = the mean probability of a choice response, N_J = the number of judges, and by:

$$S = \sum_{i=1}^{N_J} \left(\frac{x_i}{n_R} - \bar{p}\right)^2$$

where x_i = the number of choice responses in the *i*th trial. Equivalent sample size was then calculated using $\frac{N_J n_R}{1+(n_R-1)(\gamma)}$. The IF Programs™ software was again used to calculate the power of each test based on the number of judges and replications, the α level, the null probability, and the 1- or 2-tailed nature of the method, the γ (overdispersion), and the actual proportion of choice responses observed (Rousseau 2002).

Table 1—Summary of statistics for paired preference of wild-caught and cultured perch

Number of judges	52
Number of replications	2
Null probability	0.5000
Hypothesis	2-tailed
α level	0.05
Gamma	0.1333
Judge *P* value	0.1682
Proportion of choice responses (choosing wild-caught)	0.5769
Sample *P* value	0.1167
Equivalent sample size	92
Power	0.311

Table 2—Summary of statistics for triangle tests of wild-caught and cultured perch

Number of judges	52
Number of replications	2
Null probability	0.3333
Hypothesis	1-tailed
α level	0.05
Gamma	0.0381
Judge *P* value	0.3917
Proportion of correct judgments	0.5096
Sample *P* value	0.0001
Equivalent sample size	100
Power	0.976

Results and Discussion

In both the 1st and 2nd replications of the paired preference question, 30 of 52 judges preferred the wild-caught perch to the cultured perch. Analysis of frequencies of choice responses, based on choosing wild-caught perch, showed that panelist variability was not significant ($P = 0.1682$) at a γ of 0.1333, indicating that the binomial model better fits the data. Based on the binomial model, there was no significant difference in preference for wild-caught and cultured perch ($P = 0.1167$). With an equivalent sample size equal to 92, the power of this test is 0.311 (Table 1).

In each of the 1st and 2nd replications of the triangle test, respectively, 26 and 27 of 52 judges correctly identified the odd sample. Analysis of frequencies of correct judgments showed that panelist variability was not significant ($P = 0.3917$) at a γ of 0.0381, again indicating that the binomial model better fits the data. Based on the binomial model, a significant difference between wild-caught and cultured perch was found ($P = 0.0001$). With an equivalent sample size equal to 100, the power of this test is 0.976 (Table 2).

Judges' open-ended comments included appearance, aroma, taste, flavor, texture, and aftertaste terms. These comments were widely varied and inconclusive. For example, during preference testing, 5 of 52 judges stated that wild-caught perch was saltier, but only 1 judge stated this for both replications. One judge said wild-caught perch was saltier during preference testing, contradicting his/her later comment that wild-caught perch was less salty during

discrimination testing. These types of contradictions and inconsistencies were evident both within and across judges.

Conclusions

While judges can distinguish between wild-caught and cultured yellow perch in this research ($P < 0.05$), there is no statistically significant preference ($P = 0.1167$) for one type over the other. The age, size, and weight difference between the 2 groups of perch may have influenced the results, as well as the fact that fish were harvested from only 2 sources. Due to the experimental design, it was not possible to determine the attributes responsible for perceived difference between wild-caught and cultured yellow perch. More research is needed to better quantify the sensory differences between wild-caught and cultured perch, as well as other marketplace competitors (for example, European perch [*Perca fluviatilis*], zander [*Stizostedion lucioperca*], and others).

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