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HIGHLIGHTS

OF AGRICULTURAL RESEARCH

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On the cover: The Wetlands Project, shown here, at the Sand Mountain Substation in Crossville has proven successful in cleaning water from swine lagoons. See story on page 13.

UPCOMING EVENTS

January 26-27	Fertilizer and Pesticide Conference, Auburn
January 30-	Southern Association of Agricultural Scientists Annual
February 3	Meeting, Tulsa, Oklahoma
February 6	Horse Science Short Course, Auburn
February 15	Alabama Crop Improvement Association Annual Meeting, Auburn
February 17-18	Alabama DHIA/ADA Annual Meeting, Montgomery
February 23	AU Ag Alumni Annual Meeting and Hall of Honor Banquet, Auburn
February 24	Home Landscape Field Day, E.V. Smith Research Center
February 25-27	Alabama Cattlemen's Association Annual Meeting, Montgomery
March 18	Livestock/Forage Field Day, Piedmont Substation

DIRECTOR'S COMMENTS

To most of us GATT and NAFTA are meaningless acronyms that are verbally tossed around by politicians. However, to peanut and cotton farmers and milk producers in Alabama, the General Agreement on Tariffs and Trade (GATT) and the North American Free Trade Agreement (NAFTA) are dirty words indeed. Though complex in their implication to agriculture as a whole, implementation of these trade treaties would likely cause the rapid demise of Federal subsidy programs for peanuts, cotton, tobacco, and dairy products. In Alabama, loss of peanut and cotton subsidies would be catastrophic in areas of the State in which these crops are heavily concentrated.

Threats to two of our largest commodities create great challenges in 1993 for the Alabama Agricultural Experiment Station. Researchers continue to find ways to produce more for less, yet without damaging our environment or over-using our natural resources. The challenge, and the opportunity, for the Experiment Station is to be ready with alternative production methods should farmers lose government support programs. Research also must strive to develop agronomic-based alternative fuel sources, and to contribute to the good health of our environment. In terms of challenges and opportunities, we are preparing for an exciting and prosperous 1993. As always, we need your support, and we welcome your input into the research program of your Alabama Agricultural Experiment Station.

W i n t e r 1 9 9 2 V o l u m e 3 9 N u m b e r 4

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CALCIUM AFFECTS QUALITY OF PEANUT SEED

CALCIUM (Ca) is the soil nutrient most likely to be deficient for peanut production. A Ca deficiency results in lower yields, reduces percentage of sound mature kernels (SMK), and also decreases seed quality by inhibiting development of the plumule, which is essential for germination.

Although field experiments in Alabama during the last two decades have defined the soil Ca concentration required for maximum yield and SMK of Florunner peanuts, no work has been done to determine Ca requirements for producing high quality seed. An Alabama Agricultural Experiment Station study was initiated to identify soil Ca concentrations required for maximum yields and to demonstrate the role of supplemental gypsum in the production of high quality seed of the Florunner cultivar.

On-farm experiments were conducted at 13 sites from 1987 to 1989. Treatments included (1) gypsum, a common soil amendment used to increase Ca concentrations, topdressed over the row at the early bloom stage at 500 lb. per acre, (2) and no gypsum. Farmers followed their normal production practices, except for the Ca supplements and harvesting.

Yields were significantly increased when gypsum was added at these sites if soil Ca concentrations were less than 300 lb. per acre. Yield did not increase for any experiment when soil test Ca concentrations of the check plots were more than 300 lb. per acre. An increase in SMK percentages also was seen at most sites that experienced yield increases resulting from added gypsum.

Gypsum topdressing at early bloom generally increased seed Ca concentrations, even on soils testing high in Ca. Seed Ca concentrations ranged from 210 to 500 parts per million (ppm) for check plots and 198 to 622 ppm for gypsum-treated plots. Only two sites did not exhibit increased seed Ca concentration when gypsum was applied.

Results of a standard germination test showed that seed germination ranged between 55 and 99%. Supplemental gypsum either had a positive effect or no effect on

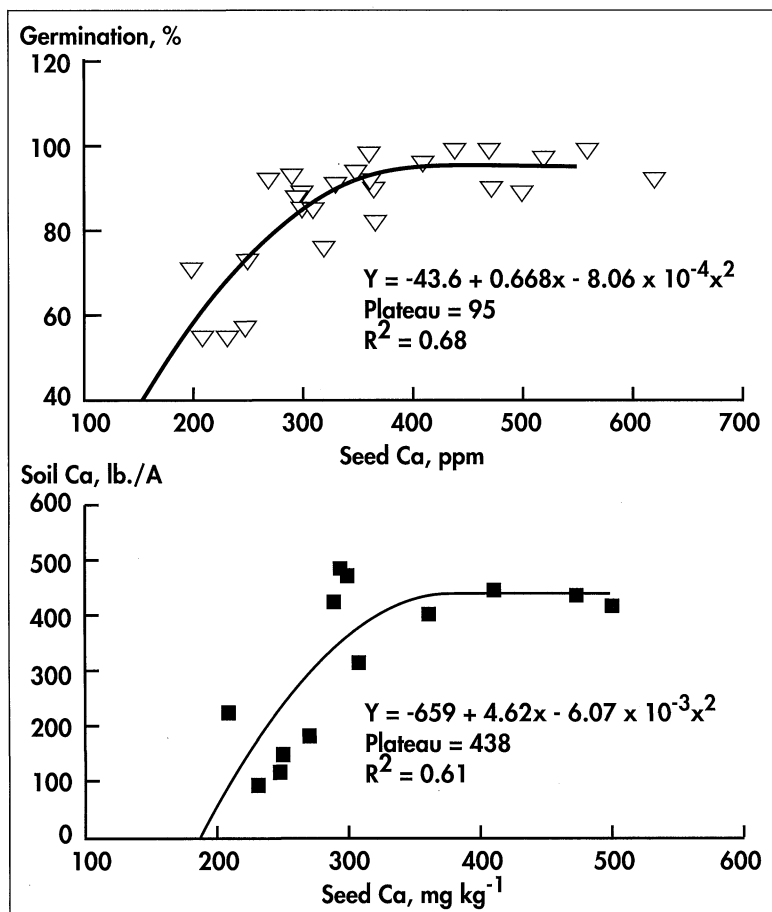


Fig. 1. (Top) Effect of seed calcium on germination. Fig. 2 (Bottom) Effect of soil calcium on seed calcium.

germination. Germination increased due to gypsum at each site that exhibited increased yield from gypsum. Higher germination rates also were observed at five additional sites where no yield increases were seen. Maximum germination was achieved at a seed Ca concentration of 414 ppm, as shown in figure 1.

These experiments also suggest that more soil Ca is needed to produce high quality seed than is needed to achieve maximum yield. Since the data demonstrates the influence of seed Ca on germination, seed Ca of the check plots was compared to soil Ca. Data in figure 2 suggest that soil Ca will affect seed Ca up to a specific concentration and then other environmental factors, such as moisture, may have a

greater influence on seed Ca. For example, seed Ca will increase until the soil Ca reaches 438 lb. per acre, then variations in seed Ca at this soil concentration or higher may be largely due to moisture variations.

Germination from the check plots also was correlated against extractable soil Ca. The critical soil Ca was estimated to be 492 ppm. Because of limited data and few soils that are high and extremely high in extractable soil Ca, this value of soil Ca may be too high. Further research may identify a critical soil Ca concentration necessary to predict whether peanuts grown on these soils will produce seeds of high germination.

Hartzog is Professor and Adams is Associate Professor of Agronomy and Soils.

DO YOUNG LARGEMOUTH BASS COMPETE WITH FUTURE PREY FOR FOOD?

GIZZARD and threadfin shad are preferred prey for adult largemouth bass, and the presence of shad sometimes leads to improved bass growth. However, efforts to increase bass growth rate by stocking of gizzard and threadfin shad often fail. Though frequently attributed to competition for food between larval shad and larval bass, recent Alabama Agricultural Experiment Station (AAES) research indicates this is not the case.

All fishes undergo tremendous changes in size during their lives, beginning life as extremely small larvae just a few millimeters in length. At this size fish are restricted, at least for a period of time, to feed on small microscopic organisms, such as zooplankton, in the water. Because largemouth bass, as well as shad, must pass through a gape-limited larval stage, these species may compete for zooplankton at this time. Auburn fisheries researchers examined this potential for competition, and the potential for shad to have a negative impact via competition on their future predator, in two Alabama reservoirs, Weiss Lake and West Point Lake, during 1991.

Larval shad, larval largemouth bass, and zooplankton were collected inshore and offshore 1-2 times per week in both lakes, beginning in mid-March (before fish spawned), and continuing until larval fish densities declined to zero. In the lab, larval fish and zooplankton were identified, counted, and measured, and prey items for a subsample of each fish species were identified using a microscope.

Larval gizzard shad were collected first in early April in West Point Lake and in mid-April in Weiss Lake, with peak density occurring in mid-April (0.66 fish/m³) in West Point Lake and during May (0.33 fish/m³) in Weiss Lake. Larval threadfin shad first appeared in mid-April in West Point Lake and in late-April in Weiss Lake. Peak larval threadfin shad densities were 4.2 fish/m³ in West Point Lake in late-April and 0.78 fish/m³ in Weiss Lake in early May.

Larval bass were first collected in West Point Lake on April 23, and on April 28 in Weiss Lake. Thus, the potential for competition for zooplankton clearly existed. In both lakes zooplankton densities dropped to near zero within a week of peak larval shad densities, most likely due to the tremendous predation pressure exerted on zooplankton by larval shad. This further suggests the potential for competition between larval shad and largemouth bass.

To directly assess the potential for competition, researchers used a diet overlap index (Schoener's index) that ranges from 0 (no diet overlap) to 1 (complete diet overlap). Typically a value of 0.6 or higher suggests that competition for resources might be important, assuming that resources are limiting. In both study lakes, diet overlap values between shad and bass never exceeded 0.27, and were usually much less than this, indicating that diet overlap is not extensive, and that the potential for competition is not great.

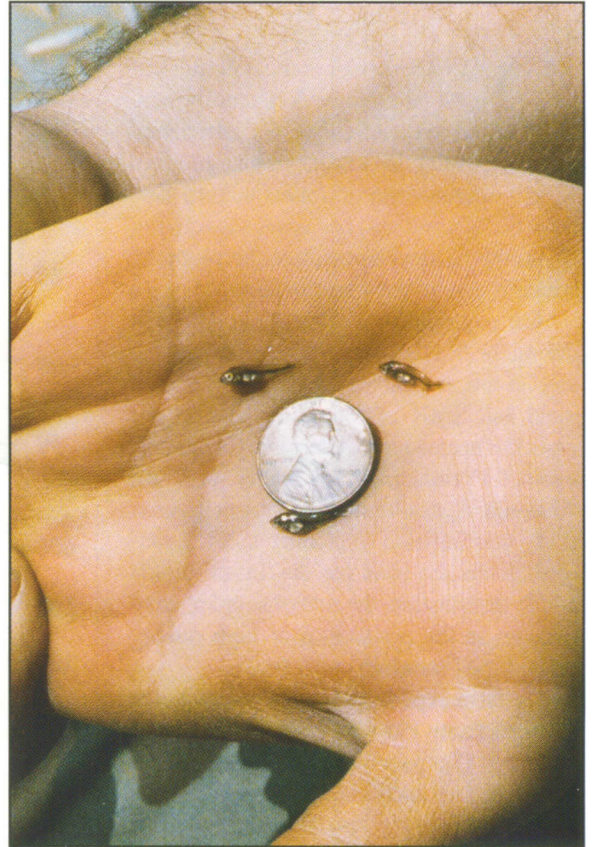
Several factors likely reduced the potential for competition between largemouth bass and shad. First, the greatest diet overlap occurred when zooplankton densities were highest in the lakes, such that resources were least limiting at that time. Second, larvae of these species tend to occupy different areas of a lake, with young bass remaining in the shallow inshore areas while shad are more abundant in the offshore areas. Finally, when shad and bass co-occurred, bass ate significantly larger prey items than did shad, further reducing diet overlap even on those prey taxa on which they overlapped.

Based on AAES results, the negative effects of gizzard shad and threadfin shad that

are sometimes seen in lakes and ponds can *not* be attributed to direct competition. Because shad and largemouth bass tend to feed on different prey taxa during the period of time that they both feed on zooplankton, direct competition is not likely to be an important regulatory force for largemouth bass in systems with shad. However, because previous research has indicated the importance of competition between shad and bluegill (another important prey fish for young bass), shad may have an indirect negative effect on largemouth bass, by reducing the availability of small bluegill as a prey item for young largemouth bass.

Researchers continue to study these complex indirect effects in research supported by the Game and Fish Division of the Alabama Department of Conservation.

Hirst is Graduate Student and DeVries is Assistant Professor of Fisheries and Allied Aquacultures.



Larval shad do not directly compete with larval largemouth bass (shown here).

ON-FARM TESTS DEMONSTRATE VALUE OF AU-PNUTS

RESULTS obtained on farms throughout the peanut-growing region of Alabama indicate AU-Pnuts, a rule-based system for timing fungicide applications for leaf spot control on peanuts, can result in better disease control and higher yields for Alabama's peanut farmers than calendar-based applications.

Leaf spot advisories have been developed in Virginia and North Carolina, and many other states are developing systems to reduce fungicide usage and make applications more timely. Fungicide-timing systems can improve financial returns directly through reduced application costs, often with improved disease control, and indirectly through reduced vine damage from tractor traffic.

With these facts in mind, AU-Pnuts was developed by the Alabama Agricultural Experiment Station. Designed to trigger fungicide applications based on need, as opposed to a set schedule, AU-Pnuts often reduces the number of applications during a peanut-growing season.

AU-Pnuts utilizes two activities with which every farmer is familiar: checking weather forecasts on a regular basis and using a rain gauge. The system is so simple that only a calendar and a rain gauge are needed to run the program.

The AU-Pnuts system was tested in four southern states from 1989-1991. Results indicated that AU-Pnuts is responsive to varying climates. In addition, use of AU-Pnuts allowed control of both early and late leaf spot. Though AU-Pnuts had performed well in these small

¹Ten producers started in the demonstration, but three dropped out due to failure to follow AU-Pnuts advisories and other technical problems.

plot tests, there was no information on its use in actual farm situations. In 1991, on-farm studies were conducted with seven peanut producers¹ in five counties in Alabama.

On-farm evaluations required coordination and training of county agents and volunteer producers. The National Weather Service provided weather forecast information for the predictive portion of AU-Pnuts, and this information was delivered to producers via a toll-free phone service and an answering machine. AU-Pnuts plots consisted of 1-10 acres of peanuts. Each

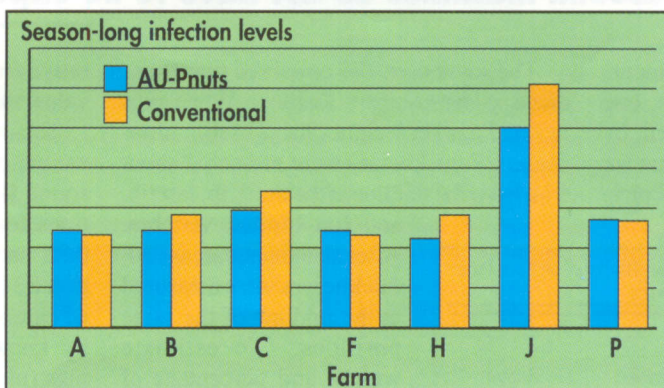
plot was compared to the remainder of the field treated by farmers using their conventional fungicide program.

During the 1991 test season, spring rains triggered early applications with AU-Pnuts. Initial sprays were made on average at 33 days-after-planting (DAP) in nonrotated fields and 36 DAP in rotated fields, compared to an average of 42 DAP for the conventional program. Earlier applications, when requested by AU-Pnuts, often resulted in major differences in disease control. Subsequent applications were coordinated with infection periods. The average number of fungicide applications with AU-Pnuts and conventional programs was 5.6 and 6.0, respectively.

On the farms in which AU-Pnuts was successfully utilized, the combination of earliness and timeliness resulted in significantly improved season-long disease control (see graph). On average, AU-Pnut plots had 10% less infection by end-of-season. No failures of the AU-Pnuts system were reported, and yields were higher (258 lb. per acre) in four of five fields in which yields were compared.

The strength of the AU-Pnuts system may be its ability to help in making wise decisions. Under "normal" weather conditions, AU-Pnuts may often save sprays due to timeliness. In heavy rainfall years, AU-Pnuts may call for more sprays than a conventional 14-day schedule. Based on research results and suggestions from producers, AU-Pnuts was revised for limited release in 1992. For information on use of AU-Pnuts in 1993, contact your local county Extension Service office.

Brannen is a Graduate Research Assistant and Backman is Professor of Plant Pathology.



AU-Pnuts versus conventional scheduling of leafspot fungicides.



AU-Pnuts helped peanut producers more efficiently time leaf spot fungicide applications.

A SIMPLE ULTRASOUND INSTRUMENT IS EFFECTIVE IN PREDICTING BODY COMPOSITION OF LIVE PIGS

ASSESSING the body composition of live pigs is important in making selection and marketing decisions and in swine research.

At present, ultrasound instruments can be used for this purpose, and research indicates that these machines do not have to be expensive or complex to be effective.

For routine application of ultrasound instruments, practicality and efficiency of operation can be as important as predictive precision. Although ultrasound measurement of cattle may need more complex, real-time instruments that produce cross-sectional images, one or two backfat measurements taken by simple machines are likely to account for most of the variation in carcass lean of pigs.

Therefore, less expensive instruments that are easy to operate may be well suited for application in the swine industry.

A recent Alabama Agricultural Experiment Station study evaluated the use of a simple, digital readout ultrasound instrument that is capable of measuring only backfat (BF). The results were compared with recently published reports that used more elaborate real-time ultrasound instruments.

These results were similar to values reported for real-time ultrasound BF and actual carcass values (0.44 to 0.94, -0.62 to -0.83, and -0.27 to -0.35 for carcass BF, percentage, and weight of lean, respectively).

One use of BF measurements is to include these values in prediction equations to estimate important carcass traits, such as weight and percentage of lean. The usefulness of such equations can be evaluated by estimating coefficients of determination, which

Ultrasound machines do not have to be expensive to be effective.

The study used 177 crossbred pigs (Landrace x Hampshire x Duroc). When pigs reached market weight (201-274 lb.), ultrasound BF thicknesses were measured about 2 in. from the midline at the third rib, last rib, and last lumbar vertebra.

After slaughter, carcass BF thicknesses were measured at the midline of the same positions. To estimate weight and percentage of carcass lean, warm carcass weight and BF at the tenth rib and loin muscle area (LMA) also were determined.

Carcass traits of the study animals are presented in table 1. To evaluate the effectiveness of an instrument, carcass BF and lean meat were related to live BF using mathematical correlations. Correlations range from 0 to ± 1 , with correlations closer to ± 1 indicating the two measurements are very closely related.

In this study, average ultrasound BF was highly correlated with average carcass BF (0.82) and percentage of lean (-0.79), and modestly correlated with weight of lean (-0.32).

range from 0 to 1. In general, the larger the value, the better the equation.

Examples of prediction equations for weight of lean based on average live ultrasound BF are presented in table 2. Equations for gilts and barrows had values of 0.83 and 0.78, respectively, indicating that 83 or 78% of the variation in weight of carcass lean can be accounted for just by knowing ultrasound BF and weight of pigs (plus age for barrows). Other equations to predict carcass BF or percentage of lean had similar values.

Values for recently published equations based on real-time ultrasound BF varied from 0.31 to 0.64, 0.39 to 0.63, and 0.34 to 0.83 in predicting carcass BF, weight, and percentage of lean, respectively. Measuring ultrasound LMA is not likely to improve prediction equations.

In summary, the relationships between live ultrasound BF and actual carcass values observed in this study were similar to those reported for real-time ultrasound instruments. Likewise, prediction equations based on ultrasound BF measured by a simple instrument were equal to or better than those reported. The results indicate that the use of a simple ultrasound instrument capable of measuring only BF is a practical and effective means to estimate carcass traits and composition of live pigs.

Chiba is Assistant Professor of Animal and Dairy Sciences.

TABLE 1. MEANS AND RANGES FOR ULTRASOUND BACKFAT OF LIVE PIGS AND THEIR CARCASS TRAITS

Item	Mean		Range
	Gilts	Barrows	
No. of pigs	88	89	
Average backfat ¹ , in.			
Ultrasound	0.86	0.91	0.51 - 1.38
Carcass	1.19	1.23	.83 - 1.68
Carcass LMA ² , sq. in.	5.52	5.18	3.85 - 7.60
Carcass lean, lb.	87.7	84.9	69.8 - 108.2
Carcass lean, %	53.8	52.4	46.7 - 59.9

¹Average of measurements at the third rib, last rib, and last lumbar vertebra.

²LMA = loin (longissimus) muscle area.

TABLE 2. EXAMPLES OF PREDICTION EQUATIONS BASED ON LIVE ULTRASOUND BACKFAT MEASUREMENTS TO ESTIMATE WEIGHT OF CARCASS LEAN^{1,2}

Item	Equation	R ²
Gilts		
Lean (lb.) =	$-1.53 - 36.78 \times \text{ultrasound backfat (in.)} + 0.527 \times \text{slaughter weight (lb.)}$	0.83
Barrows		
Lean (lb.) =	$4.43 - 26.93 \times \text{ultrasound backfat (in.)} + 0.404 \times \text{slaughter weight (lb.)} + 0.078 \times \text{age (days)}$.78

¹R² = coefficient of determination; can range from 0 to 1, and it measures how much variation in the dependent variable (lean) can be accounted for by the model or by knowing the values for the independent variables (ultrasound backfat, slaughter weight, and age in this table).

²Standard deviations for the regression models were 2.96 and 3.10 lb. for gilts and barrows, respectively.

BULL MEAT HAS POTENTIAL AS A RAW MATERIAL FOR LOW-FAT GROUND BEEF

CONSUMER demand for low-fat meat products has prompted the beef industry to seek alternate sources of lean meat. Meat from young bulls is extremely lean, but it has not been widely used in the United States for a variety of reasons. However, research has shown that bull meat may be a feasible source of lean meat for ground beef formulations.

Producing young bulls can be less expensive than producing steers because of reduced management requirements (castration, etc.). However, producers have been reluctant to raise young bulls in feed lot situations because they are concerned that aggressive behavior among the animals might increase other management inputs. Packers also have been unwilling to pay premium prices for this meat because of inconsistent supply and because consumers have indicated negative perceptions about the sensory qualities of steaks and roasts derived from young bulls. However, little information has been available about the acceptability of bull meat as a raw material for ground beef formulations.

An Alabama Agricultural Experiment Station study was initiated to compare sensory properties of low-fat ground beef from raw materials containing the same amount of fat but derived from steers or heifers, cows, and bulls.

For the study, four low-fat ground beef products were manufactured: special (steer and heifer) trimmings, cow trimmings, bull trimmings, and a combination of (50/50) bull and cow trimmings. All low-fat ground beef treatments were formulated to standard AU LEAN™ specifications (10% added water, 0.5% carrageenan, 0.4% encapsulated salt, and 0.2% hydrolyzed vegetable protein). After manufacture, patties from each treatment were evaluated by an untrained consumer sensory panel and a trained sensory panel. Tenderness and color stability measurements were taken.

No differences were found among treat-

ments for consumer acceptability ratings. The trained sensory panel found no differences among treatments for juiciness or tenderness, but rated the 100% bull meat treatment greater in off-flavor. However, panelists expressed no preference for cow meat over a combination of bull and cow meat. Trained panelists also found no differences among treatments for toughness (connective tissue), flavor intensity, and overall acceptability. The typical (steer and heifer trimmings) low fat ground beef was tougher when compared to other treatments.

The standard low fat ground beef was rated lower in subjective lean color scores, while other treatments did not differ from each other. Treatments containing bull meat were rated lowest in percent discoloration, while the typical low fat ground beef was rated highest in percent discoloration.

Results of this study indicate that bull meat can be used as a raw material for low-fat ground beef, particularly when mixed with other raw materials. This may open

new markets for Alabama cattle producers interested in producing young bulls for meat.

Bullock is former Graduate Research Assistant, Huffman is Professor, Mikel is Assistant Professor, and Jones is Professor of Animal and Dairy Sciences.

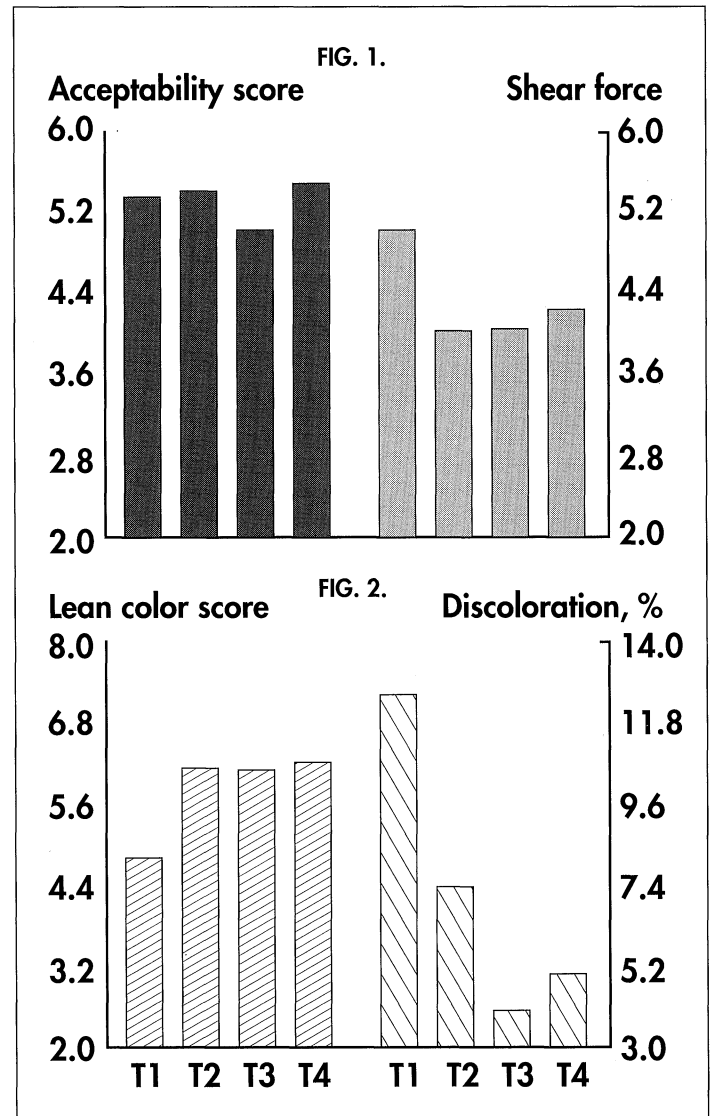


FIG. 1. (Top) Consumer acceptance scores (1 = extremely dislike, 10 = extremely like), and Kramer shear force values (kg force/g sample) of low-fat ground beef treatments. Treatments; T1) lean special trimmings, T2) cow trimmings, T3) lean bull trimmings, T4) 50/50 bull and cow trimmings.

FIG. 2. (Bottom) Lean color scores (8 = extremely red, 1 = extremely brown), and percent discoloration for low-fat ground beef treatments. Treatments; T1) lean special trimmings, T2) cow trimmings, T3) lean bull trimmings, T4) 50/50 bull and cow trimmings.

ECONOMICS OF PRODUCING AUSTRALIAN CRAYFISH IN ALABAMA PONDS



Male (back) and female red claw.

REDCLAW, an Australian crayfish, has the potential to be a commercial aquacultural crop in Alabama. It has several advantages over native crayfish in that it is larger, is available in summer and fall, and has higher meat yield. However, recent Alabama Agricultural Experiment Station (AAES) research indicates stocking rate will be critical to maximize profit.

A focus of AAES pond trials was to determine an appropriate stocking density for red claw in ponds. Finding the right stocking density is a complex problem in crayfish culture because crowding slows growth rate, causing more size variation at harvest. Variation in size also complicates the economic analysis because consumers will pay much more per pound for large shellfish than for small ones.

well as the total weight and market prices by size class. Survival averaged over 70% at all three densities. The size classes were chosen with considerable care in an attempt to accurately represent the market for a crayfish species that has not been sold extensively in the U.S. and for which there are no established market prices yet.

Peeler, live-market, and export classes correspond to those used in Louisiana crayfish markets. Currently there is little information to suggest that red claw would receive higher prices than Louisiana crayfish at these sizes. The jumbo size has no close substitutes so prices were set midway between the two nearby classes. Small lobster prices were established from limited information on red claw sales in the New England area and from published market prices for scampi and other small lobsters.

A fairly detailed economic analysis (including estimated market prices by size class of crayfish) is necessary to convert the biological data into a decision about which stocking density is most profitable. Tables 1 and 2 are a much abbreviated summary of one such economic analysis.

Table 1 shows the weight harvested in each of six size classes for the three different stocking densities tested, as

Analysis of the harvest data from table 1 indicates that red claw culture likely would not be profitable under the conditions of the 1991 pond trials, which were handicapped by the small size of juveniles at stocking (about 0.01 oz.) and the relatively short growing season (158 days). However, these constraints probably can be overcome either by stocking larger juveniles (0.25 oz.), or by extending the growing season using covered nursery ponds or locating production ponds in more southerly counties (to add 20 or more growing days).

Because this was an exploratory analysis of the potential for commercializing red claw, a second analysis was conducted under the assumption that the production constraints could be sufficiently overcome to allow a one-size-class increase in the distribution at harvest. The results are summarized in table 2, which shows a much more promising outlook for commercial culture of red claw. Using the 12,000 per acre stocking density scenario, net returns to management would be roughly \$45,000 a year for a red claw farm of about 50 acres. This would require an investment of over \$100,000 and annual operating costs of \$145,000 on 50 acres. Again it should be emphasized that production costs and profits are hypothetical, but research is currently underway at the AAES to refine these estimates.

Nelson is Assistant Professor of Agricultural Economics and Rural Sociology; Rouse is Associate Professor of Fisheries and Allied Aquacultures; Hatch is Associate Professor of Agricultural Economics and Rural Sociology; Medley is former Graduate Research Assistant and Pinto is Graduate Research Assistant of Fisheries and Allied Aquacultures.

TABLE 1. HARVEST WEIGHTS AND MARKET PRICES BY SIZE CLASS AND STOCKING DENSITY

Market class	Weight	Avg. market price	Harvest weights		
			4,000 young/a	12,000 young/a	20,000 young/a
	Oz.	Dol./lb.			
Peeler.....	0.3-0.5	0.35	0	2	29
Live-market.....	.5-.8	.68	4	34	175
Export.....	.8-1.7	1.36	76	525	748
Jumbo.....	1.7-2.8	3.02	243	294	270
Small lobster.....	over 2.8	6.05	82	63	39
Total weight, lb/a.....			405	918	1,261

TABLE 2. POTENTIAL AVERAGE PROFIT PER ACRE FOR EACH OF THREE STOCKING DENSITIES IF HARVEST IN EACH SIZE CLASS IN TABLE 1 COULD BE INCREASED TO THE NEXT LARGER SIZE CLASS AT NO ADDITIONAL COST

	Harvest yield and stocking density		
	4,000 young	12,000 young	20,000 young
	Lb./a	Lb./a	Lb./a
Total revenue, dol./a.....	2,204	3,795	4,392
Total cost, dol./a.....	1,737	2,900	4,033
Profit, dol./a.....	467	895	359

HUGE WEIGHT GAIN INCREASE FROM DEWORMING CATTLE ON INFECTED FESCUE

SEVERAL management tools are available to help producers offset the negative effects of fescue toxicosis in cattle, but most have not been widely adopted or successful. Current research at the Alabama Agricultural Experiment Station indicates a more economical and effective tool may be treating cattle with ivermectin, which reduces the negative effects of fescue toxicosis.

Tall fescue pastures infected with the fungus *Acremonium coenophialum* are toxic to cattle and cause low weight gains. Fungus free varieties and management techniques that dilute the ill-effects of infected fescue are available, though these options are not always practical for producers.

In experiments at the Black Belt Substation (BBS), Marion Junction, and the Sand Mountain Substation (SMS), Crossville, increased weight gains in cattle grazing tall fescue and treated for worms with ivermectin seemed larger than could be expected from reduction of worm counts in the animals. This led researchers to take a closer look at ivermectin, which is a broad spectrum deworming agent that is available in injectable or pour-on formulations.

In 1991 and 1992 steers with an initial weight of 500-600 lb. were grazed on highly infected fescue (over 90% of the plants contained the fungus) at the BBS. Each of four 2-acre pastures was grazed by three crossbred steers, providing a stocking rate of 1.5 steers per acre. Steers in two of the pastures were treated for worms with ivermectin pour-on prior to initiation of grazing and 56 days later, while steers in the other two pastures were not treated for worms. Animals had free access to mineral blocks but received no feed supplement. Grazing started in March and continued for 99 and 84 days in 1991 and 1992, respectively.

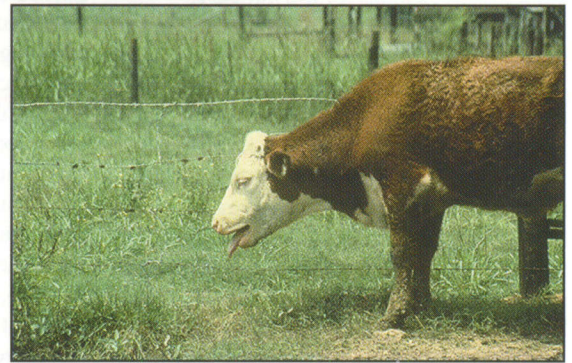
Another experiment was conducted in 1992 at the SMS where similar Angus and Angus x Hereford steers grazed 2-acre fescue pastures at the same stocking rate. This experiment included untreated control ani-

mals, and animals treated with either ivermectin injection or fenbendazole administered orally immediately before grazing started and 56 days later on both infected and fungus-free pastures. Grazing started in February and ended 140 days later. There were two replicate pastures for each treatment. In both experiments, animals were weighed every 28 days and samples of manure were obtained from each animal for worm egg counts (which reflect worm burdens in the animals) at the end of the experiment.

In previous experiments at the BBS, average daily gains (ADG) typically have been around 1.0 lb. Treatment of steers with ivermectin increased ADG by, on average, 0.87 lb. (2.21 lb. with ivermectin vs. 1.38 lb. without ivermectin).

Treatment with ivermectin reduced worm egg counts by, on average, 89% (10 worm eggs per gram of manure with ivermectin vs. 88 eggs per gram without ivermectin). Even though ivermectin reduced worm burdens, worm egg counts of control animals in this study are considered low from a clinical point of view (200 eggs per gram is commonly the threshold above which treatment for worms is economically feasible), and the response of ADG to treatment with ivermectin seems larger than would be expected from worm control alone.

At SMS ivermectin increased ADG by 0.66 lb. (1.35 vs. 0.69 lb.) on infected fescue and by only 0.22 lb. (1.44 vs. 1.22 lb.) on fungus-free fescue. In contrast, fenbendazole did not provide similar results. Furthermore, animals treated with ivermectin on infected fescue showed reduced visual signs of fescue toxicosis. This suggests that ivermectin could have some anti-fescue toxicosis effect besides its anthelmintic action, and conversely, infected fescue could reduce the efficacy of fenbendazole.



Ivermectin-treated (top) and untreated steers both grazing fungus infected fescue.

Worm egg counts also were low in the SMS experiment and showed no clear response to treatment, although there was a tendency for lower counts on fungus-free fescue. Once again, increases in ADG were considerably larger than would be expected from worm control alone.

In conclusion, treatment of steers grazing infected fescue with ivermectin provided large increases in weight gain: on average, animals treated with ivermectin on infected fescue at the BBS were 80 lb. heavier than untreated animals by the end of the experiment, and at the SMS they were 92 lb. heavier. Weight gain response to ivermectin on fungus-free fescue and to fenbendazole on infected fescue was much smaller. Further research is necessary to establish consistency of these results with steers and to determine whether similar responses can be expected with nursing calves.

Bransby is Professor of Agronomy and Soils; Holliman is Superintendent, Black Belt Substation; Eason is Superintendent, Sand Mountain Substation.

CATFISH ADVERTISING IS PAYING OFF

FOR the last 5 years, the catfish industry has been conducting advertising campaigns aimed at increasing awareness and consumption of catfish. A recent Alabama Agricultural

Experiment Station study indicates that funding these promotional campaigns has been a valuable investment for the industry.

The promotional campaign began in April 1987 after feed mills in Mississippi agreed to contribute \$6 per ton of feed sold to finance a promotional effort. Additional resources for market promotion became available in July 1989 when Alabama feed mills began a \$2 per ton assessment. Currently, catfish producers spend about \$1.5 million annually on market development activities, primarily media advertising.

To determine the effectiveness of catfish advertising, two separate analyses were conducted. First, cross-sectional data from a nationwide (except Hawaii and Alaska) survey of 3,600 households were used to assess individual consumer responses. The survey was conducted approximately 1 year after the campaign began. The second analysis traced changes in catfish consumption across time, from 1980 to 1989, including 7 years (1980-86) of no industry advertising and 3 years of relatively continuous advertising (1987-89).

The cross-sectional analysis examined various issues related to catfish consumption, including relationships between consumer characteristics and awareness of catfish advertisements, farm-raised catfish, and beliefs about product attributes (whether catfish is considered nutritious). Beliefs about product attributes were linked to the consumer's attitude toward catfish (rating of catfish compared to other

Market level, variable	Unit	Simulated long-run equilibrium values			
		Without advertising	With advertising	Absolute difference	Percent difference
Wholesale					
Price	\$/lb.	1.64	1.75	0.11	6.7
Quantity	mil. lbs./mo.	12.88	13.04	.16	1.3
Revenue	mil. dol./mo.	21.12	22.82	1.70	8.0
Farm					
Price	\$/lb.	.73	.79	.06	8.2
Quantity	mil. lb./mo.	24.76	25.09	.33	1.3
Revenue	mil. lb./mo.	18.08	19.82	1.74	9.5

fish and seafood), and attitude and advertising awareness were linked to purchase frequencies. This approach permitted a detailed analysis of how the promotional campaign affected consumer perceptions and purchase behavior.

Simulations of the cross-sectional model were conducted assuming that consumers were either *aware* or *unaware* of catfish advertising. Results suggest that the advertising campaign in its first year: increased consumer awareness of farm-raised catfish by 15%, improved consumers' perceptions of and attitudes toward catfish by 3-6%, and increased at-home and restaurant purchase frequencies of catfish by 12 to 13%.

The second analysis used equations describing farm-level catfish supply, wholesale-level demand, processor inventory, and farm-wholesale price transmission. Advertising impacts were obtained by simulating the model with no advertising and with advertising equal to the average expenditures for catfish advertising during the 1987-89 period.

Results of this analysis suggest the advertising campaign had a larger effect on price than on quantity, as shown in the table. Specifically, the advertising campaign is estimated to have increased price 6.7-8.2%, depending on market level. The impact on quantity is estimated at a modest 1.3% at each market level. Revenue increases associated with these price and quantity estimates are 8.0% at the wholesale level and 9.5% at the farm level.

Cost/benefit analysis was conducted using a measure of industry profit called producer surplus, which measures the net returns to producers from advertising after all economic costs have been subtracted. Based on the estimated price and quantity impacts discussed earlier, each additional dollar of advertising was estimated to generate about \$13 of additional producer surplus. In other words, the campaign during the 1987-89 period had an estimated benefit/cost ratio of 13:1.

The issue of the optimal advertising spending level was addressed assuming that the industry wishes to maximize producer surplus. Four factors critical to the assessment of optimal spending levels were examined: supply elasticity, demand elasticity, advertising elasticity, and the interest rate that could be earned on alternative investments of advertising funds (opportunity cost).

Results suggest that the advertising program is underfunded. For example, assuming an opportunity cost of 15%, spending levels for advertising during the study period should have been between 18 and 99% higher than the observed level if the program was to maximize producer surplus.

Based on these analyses, advertising has been a profitable endeavor for the catfish industry. Increases in the budget can be justified on economic grounds. To raise the funds needed to maximize effectiveness and to eliminate inequities caused by "free-riders" who do not contribute to the program but benefit from the demand increases, the state-based voluntary contributions can be replaced by a mandatory industry-wide program.

Kinnucan is Associate Professor, Zidack is former Research Associate, Venkateswaran is Post-doctoral fellow, and Hatch is Associate Professor of Agricultural Economics and Rural Sociology.

The advertising campaign in its first year: increased consumer awareness of farm-raised catfish, improved consumers' perceptions of and attitudes toward catfish, and increased at-home and restaurant purchase frequencies of catfish.

MAINTAINING EXPORT QUALITY OF CHILLED VACUUM-PACKAGED BEEF

CONSUMERS around the world are demanding high quality fresh meat products. Exports of fresh beef (beef that has not been frozen after slaughter) produced in Alabama and other parts of the United States to countries overseas are constantly increasing. However, for products to be globally successful, they must maintain their quality for an extended period of time. An Alabama Agricultural Experiment Station study has helped clarify limits and conditions for extended storage of beef products.

aseptically removed from the surface of each cut.

Samples were mixed and two 1-oz. subsamples were obtained and analyzed for populations of spoilage bacteria [aerobic plate counts (APC), and psychrotropic bacteria]. Six steaks, 1 in. thick, were removed from each primal cut for sensory evaluation. All products were cooked to a final internal temperature of 150°F and evaluated for tenderness, juiciness, flavor intensity, odor, and overall acceptability. Tenderness and rancidity values also were determined.

Overall, microbial populations, including APCs, remained steady during the first 25 days of storage, while psychrotroph levels increased from 25 to 35 days and continued to increase thereafter. APC also increased after 35 days, particularly those from the chuck, (see figure 1). Maximum APC values occurred at 82 days for the loin and round and at 128 days for the rib and chuck.

Interestingly, these observed maximum populations are concentrations generally associated with early signs of microbial spoilage. However, it should be noted that factors other than microbial population are responsible for the sensory detection of meat spoilage. Sensory evaluation and shear force measurements both indicated that tenderness was greatest for strip loins and lowest for top rounds and chuck rolls, with all cuts becoming

more tender over storage time. Tenderness of strip loins and ribeye rolls increased at 35 days. Juiciness scores were highest for strip loins and increased at 82 days of storage time. Flavor scores were highest for strip loins and chuck rolls, and increased at 82 days of storage. Overall acceptability was highest for strip loins followed by ribeye rolls, chuck rolls, and then top rounds.

Overall acceptability of all products was least acceptable at 0 and 25 days and most acceptable at 82 days of cooler storage, see figure 2. Detection of rancidity was highest for top rounds and lowest for ribeye rolls and chuck rolls.

In summary, although some initial microbial populations were above desired levels, microbiological and sensory quality remained acceptable throughout the study. Thus it appears that these microbial levels do not necessarily mean meat has spoiled beyond sensory acceptance. However, it is essential that strict temperature control be maintained and that proper sanitation practices be followed to achieve maximum shelf life of products destined for export.

Mikel is Assistant Professor of Animal and Dairy Sciences; Conner is Assistant Professor of Poultry Science; Jones is Professor of Animal and Dairy Sciences.

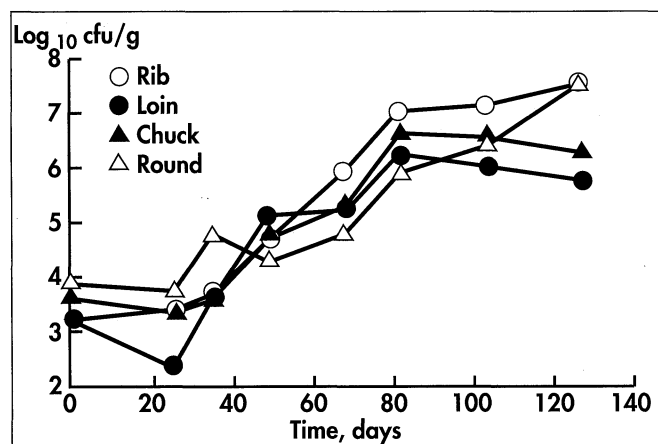


FIG. 1. Aerobic plate counts of primal beef cuts stored at 30°F for 128 days.

Because microbiological quality impacts shelf life, research was initiated to determine the microbiological characteristics and shelf life attributes of vacuum-packaged primal beef cuts during extended storage. Twenty-four cuts each of top rounds, strip loins, ribeyes, and chuck rolls were randomly selected from a processing plant in Alabama, vacuum-packaged, transported to the Auburn University Meat Science Laboratory, and stored at a constant 30°F temperature. At 0, 25, 35, 49, 68, 82, 104, and 128 days, three cuts of each product were evaluated for package integrity (vacuum, air pockets, purge, meat color, fat color, and odor) based on industry standards. Microbial analyses were performed on samples

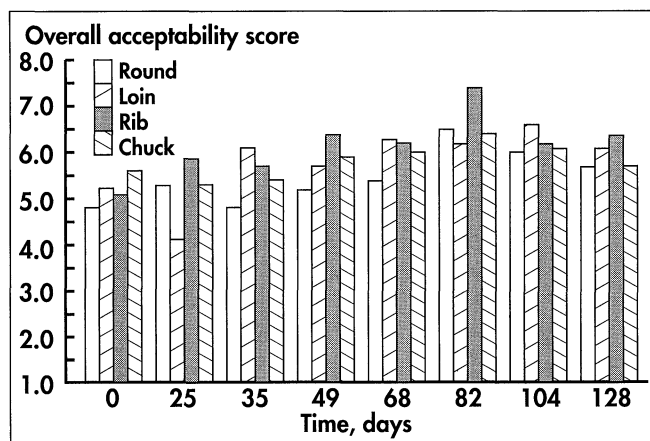


FIG. 2. Overall acceptability of primal beef cuts stored at 30°F for 128 days.

NEW AU PLUM VARIETIES SHOW DISEASE-RESISTANT BENEFITS



AU-Rubrum plums

THE FRESH market for plums is increasing in Alabama and the Southeast, and provides a potential source for canned plums, jams, and jellies. A reason for this increase is the availability of disease resistant, high yielding, high quality plum varieties developed and released by Auburn University.

All the varieties developed by the plum breeding program at Auburn and released by the Alabama Agricultural Experiment Station (AAES) in the past few years have demonstrated good resistance to many common plum diseases. Fruit quality of the Auburn varieties, compared to other popular plum varieties is shown in the table.

Diseases have limited production of plums in Alabama, because most commercial varieties are susceptible to bacterial, fungal, and viral diseases. Sources of resistance to bacterial and fungal diseases in native plums were used in the early crosses, while commercial varieties provided desirable quality attributes. After the plum leaf scald disease was discovered, resistance to the disease found in native plums was used in the breeding program.

Multiple disease resistant varieties and selections have been developed for areas that receive 700-800 hours chilling below

45°F. Approximately seven seedlings are currently being evaluated for possible release by the AAES as named varieties.

Observations on fruit and tree characteristics, disease, injury, and yield were made in test plantings at Auburn; E.V. Smith Research Center, Shorter; Chilton Area Horticulture Substation, Thorsby; Gulf Coast Substation, Fairhope; North Alabama Horticulture Substation, Cullman; and the Wiregrass Substation, Headland.

Au-Amber, AU-Cherry, AU-Producer, AU-Rosa, AU-Roadside, and AU-Rubrum

all are either resistant or only slightly susceptible to bacterial fruit and leaf spot, bacterial canker, and plum leaf scald. AU-Amber was highly susceptible to black knot, while the other varieties showed no susceptibility to this disease. All of the Auburn varieties were slightly susceptible to brown rot. In comparison, Methley, Morris, Ozark Premier, and Santa Rosa were more susceptible to many or all of these diseases.

Recommended pesticide sprays were applied to the test trees, but susceptible trees at all locations showed injury from brown rot, bacterial fruit spot, leaf spot, and canker. However, injury from black knot was severe only on susceptible varieties at the Chilton Area Horticulture Substation. Plum leaf scald injury was recorded on trees that had been infected by double budding with infected wood.

Tree vigor, longevity, and tolerance to plum leaf scald are primary advantages of the Auburn varieties. Trees of these resistant varieties were observed to be vigorous where plum leaf scald was present, whereas trees of susceptible varieties grew much slower. Tree vigor is an important factor in the Southeast, and plum leaf scald is implicated in phony peach disease of plums and peaches. Therefore, disease resistance of these new varieties is particularly important for the development of a stable and profitable plum industry. Short tree life, low productivity, and undesirable fruit characteristics of susceptible varieties make them uneconomical for commercial production.

Promising new plum varieties and seedlings are a result of the plum breeding program at Auburn University. These new varieties have increased productivity and quality obtained by genetic improvement (host plant resistance) from classical breeding strategies. They offer the possibility for developing a commercial shipping industry in the South. Production for home, roadside, and pick-your-own operations also should benefit from these new varieties.

Norton is Professor, Boyhan is Senior Research Associate, Abrahams is Technician, and Huang is Visiting Scientist of Horticulture.

SELECTED FRUIT CHARACTERISTICS OF PLUM VARIETIES AT AUBURN

Variety	Fruit size	Fruit firmness ¹	Soluble solids	Peak harvest date
	<i>In.</i>		<i>Pct.</i>	
AU-Amber	1.5	7.2	18.0	6/2
AU-Cherry	1.3	7.0	18.0	6/23
AU-Producer	1.7	8.0	16.5	6/24
AU-Rosa	2.0	8.0	17.6	6/22
AU-Roadside	1.9	6.8	17.2	6/23
AU-Rubrum	1.9	8.0	15.6	6/19
Crimson	1.6	8.3	16.3	7/10
Homeside	2.2	6.6	18.8	6/22
Methley	1.4	6.6	18.5	6/7
Morris	1.8	7.5	13.4	6/20
Ozark Premier	2.1	6.8	15.7	6/29
Santa Rosa	1.7	7.7	16.7	6/22

¹Fruit firmness: 0-10, 0 = softness; 10 = firmness.

CONSTRUCTED WETLANDS SUCCESSFULLY TREAT SWINE WASTEWATER

ANIMAL wastes can directly affect water quality, particularly in areas where livestock and poultry production are highly concentrated. Developing innovative, low cost, highly efficient waste management technologies is important to minimize water quality problems and still promote profitable agriculture. A model constructed wetland is showing potential for this function.

Constructed wetlands are shallow, earthen detention ponds that have been planted with emergent aquatic plants, such as reed, bulrush, and cattail. The plants serve as attachment sites for microorganisms that aid in wastewater treatment.

Such a wetland was built at the Sand Mountain Substation, Crossville, to evaluate on-farm wetlands technology for treatment of wastewater from swine lagoons. The project is a cooperative effort between the Alabama Agricultural Experiment Station, Tennessee Valley Authority, USDA-Soil Conservation Service, and Alabama Department of Environmental Management.

The constructed wetlands site contains two rows of five cells, or wetlands, with each cell measuring approximately 26 ft. wide by 162 ft. long (0.1 acre). These 10 cells occupy about 1 acre, with an additional 0.5 acre of grassed overland flow area below the wetlands.

Wastewater to be filtered through the wetlands is generated by a 500-pig-per-year farrow-to-finish operation located at the Substation. Wastewater is collected in a two-stage lagoon system but, because lagoon wastewater is high in ammonia that could kill the wetlands' aquatic plants, it is combined with fresh water from a pond before discharge into the wetlands.

Diluted wastewater is distributed con-

tinuously to the wetlands at a rate of 8,600 gal. per day (1,720 gal. to each of the five cells in the first row). Wastewater flows through the first row into the second row of cells.

Treatment efficiency evaluation of the wetlands system during a 22-month period is shown in the table. Nitrogen content of the diluted lagoon discharge was reduced from 80 parts per million (ppm) to 14 ppm

after treatment, an 83% reduction. Ammonia-nitrogen represented 80% of the total nitrogen content of the lagoon discharge. Ammonia at 100 ppm or greater is considered toxic to plants, so dilution of the lagoon water with fresh water appears to be wise. Because the lagoons are deep and exclude oxygen essential for conversion of ammonia to nitrate, all nitrate-nitrogen determinations showed less than 1 ppm.

Total phosphorous was reduced 69% and biological oxygen demand (BOD), which measures oxygen consumption during biological decomposition, decreased 85%. Chemical oxygen demand (COD) decreased 69% and total suspended solids (TSS) decreased 79%.

Although guidelines have not been established for acceptable treatment of swine lagoon wastewater by constructed wetlands, generally wastewater effluent should contain less than 10 ppm nitrate-nitrogen, 30 ppm BOD, and 30 ppm TSS following treatment. Data in the table indicate the wetlands system achieved these measures of treatment.

Heavy rainfall in the spring, high temperatures in the summer, and the lack of vegetation in the winter may affect wastewater treatment by wetlands. During the winter months, when wetlands vegetation is dormant, the wetlands appear to be less effective in removing nitrogen from the wastewater. Discharge from the wetlands was minimal or nonexistent in the fall, when rainfall is minimal.

Constructed wetlands presently are not approved for treatment and discharge of processed animal lagoon wastewater, but the effectiveness of this experimental system implies that these wetlands can be effective and may have potential for approval.

McCaskey is Professor of Animal and Dairy Sciences; Eason is Superintendent, Sand Mountain Substation; Hammer and Pullin are Program Manager and Biologist, respectively, Wetlands Research and Development, Tennessee Valley Authority; Payne is Environmental Engineer, USDA-Soil Conservation Service; and Bransby is Professor of Agronomy and Soils.

	Lagoon discharge	Wetlands		
		Inflow ¹	Outflow	Decrease <i>Pct.</i>
Total nitrogen	172	80	14	83
Ammonia-nitrogen	138	59	8	86
Nitrate-nitrogen	<1	<1	<1	—
Total phosphorus	61	32	10	69
Biological oxygen demand	136	75	11	85
Chemical oxygen demand	606	336	104	69
Total suspended solids	345	140	30	79

¹Two parts lagoon discharge was diluted with 1 part pond water.



Researcher checks water quality monitoring equipment.

WHO DO ALABAMIANS TRUST ABOUT AGRICULTURAL CHEMICALS AND THE ENVIRONMENT?

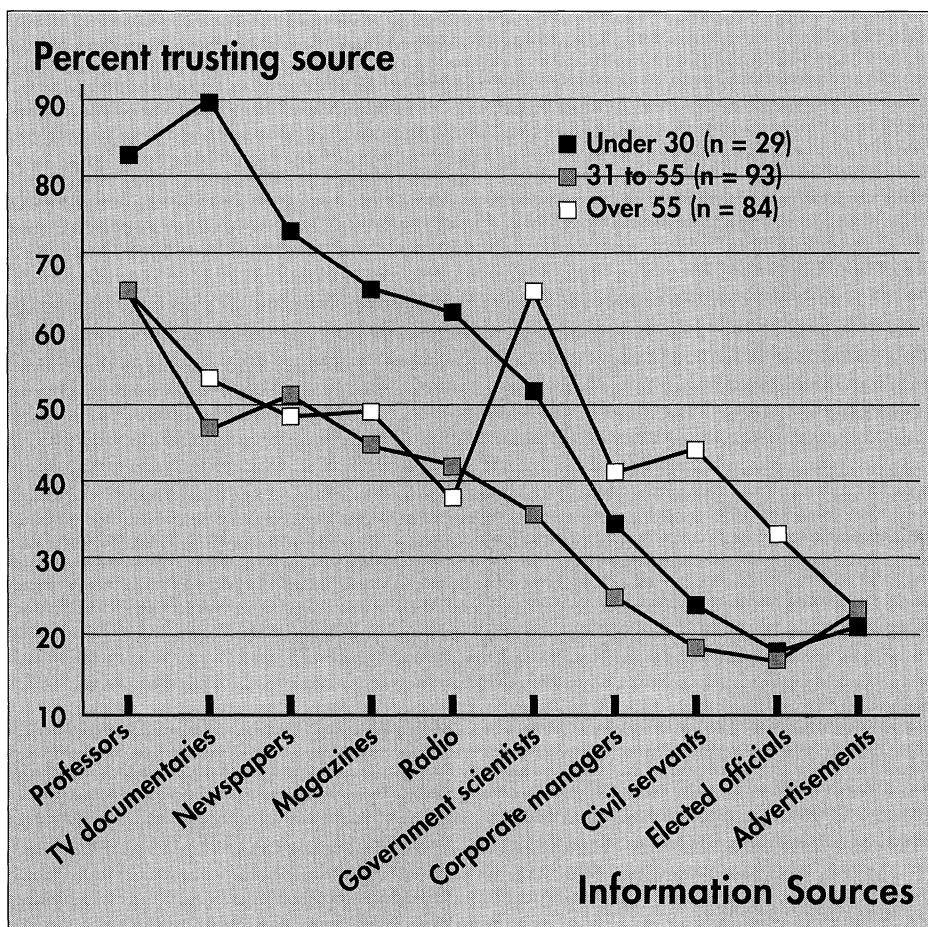
ALABAMIANS care about the safety of the food they eat and the chemicals that enter the environment. Farmers receive training and a great deal of information about the products they use to protect their crops. Nonetheless, media attention to unfortunate events, real fears, and actual risks have heightened concern about farm chemicals. Agricultural chemistry is a complex and difficult topic for most individuals. Thus, it is important to examine the sources of information people use to shape their opinions of and reactions to farm chemicals.

As part of a national effort, a spring 1992 survey asked 213 Alabamians to rate their level of trust in various information sources. About one-third of those actually contacted in the study were asked how much they trusted each source about the impact of agricultural chemicals on the environment. Results show the relative trustworthiness of the various sources.

The figure shows large differences across the 10 sources. The information sources are ranked according to the level of trust rated by respondents. Overall, university professors were the most trusted source. Advertisements were the least trusted. Less than 25% said they trusted civil servants or elected officials.

A number of important differences were observed based on age of the respondent. Young people (18 to 30 years old) tended to trust television, professors, newspaper reports, and radio stories more than their elders did. Ninety percent of young people said they trusted television documentaries for accuracy on this topic—a high level of trust.

Compared to younger respondents, those over age 55 were more trusting of government scientists, corporate managers, civil servants, elected officials, and advertisements. Only about one-third of the sample said they trusted the latter of four sources.



Sources of information and degree of trust by Alabamians.

Each has fairly clear interests in the issue that seem to undermine their credibility among study respondents. Finally, university professors were more trusted than television by the middle-aged and older respondents.

The relative trustworthiness of information sources is important for farmers and agribusiness managers. They are concerned about how their neighbors and customers might react to an unforeseen event or scientific finding about the impact of agricultural chemicals on the environment. The data suggest that balanced television coverage is an important objective, particularly where

young people are forming basic opinions about farming and environmental matters. The findings also point to the relatively low impact corporate managers and public officials can have in shaping public perceptions of risk on this issue. As the nation continues the struggle to reconcile the benefits of agricultural chemicals with risks to human health and the environment, integrity and balance must be central components of the communication process over these issues.

Molnar is Alumni Professor and Traxler is Assistant Professor of Agricultural Economics and Rural Sociology.

IN VITRO FERTILIZATION CAN HELP SALVAGE GENETIC POTENTIAL OF CATTLE

MANY COWS of high genetic merit must be culled prematurely, having produced few or no calves. *In vitro* fertilization (IVF) of eggs collected from these cows now provides a method by which additional calves can be produced, and thus, losses from the genetic pool can be reduced.

In vitro fertilization is the process by which eggs and sperm are joined in an artificial environment for the production of offspring. The technique was originally developed to study factors affecting fertilization and early maintenance of pregnancy. It has been projected that IVF will be used in agriculture for the commercial production of calves and to circumvent infertility in several species of livestock.

Efforts to establish an IVF procedure for cattle at the Alabama Agricultural Experiment Station began in fall 1991 and the system has been operational since January 1992. Early research at Auburn focused on assessing the feasibility of using IVF to produce calves from cows that are classified as involuntary culls. Involuntary cull cows are animals that the producer does not wish to cull but must because they have become infertile, have suffered from infectious diseases, or have terminal traumatic injuries.

Seventeen dairy cows (ages 2.3-7.0 years) culled from the dairy units at the E.V. Smith Research Center, Shorter, and the College of Veterinary Medicine, Auburn University, were used in preliminary studies. Cows were culled for a variety of reasons, including mastitis, injury, and reproductive failure.

Immature eggs were collected from the ovaries of these "donor" cows. The eggs were incubated under special conditions until they were mature enough to fertilize. Highly motile sperm were separated from semen that had been frozen commercially for routine artificial insemination. A portion of this sperm was treated to render it capable of fertilization (capacitation). The mature eggs and capacitated sperm were incubated

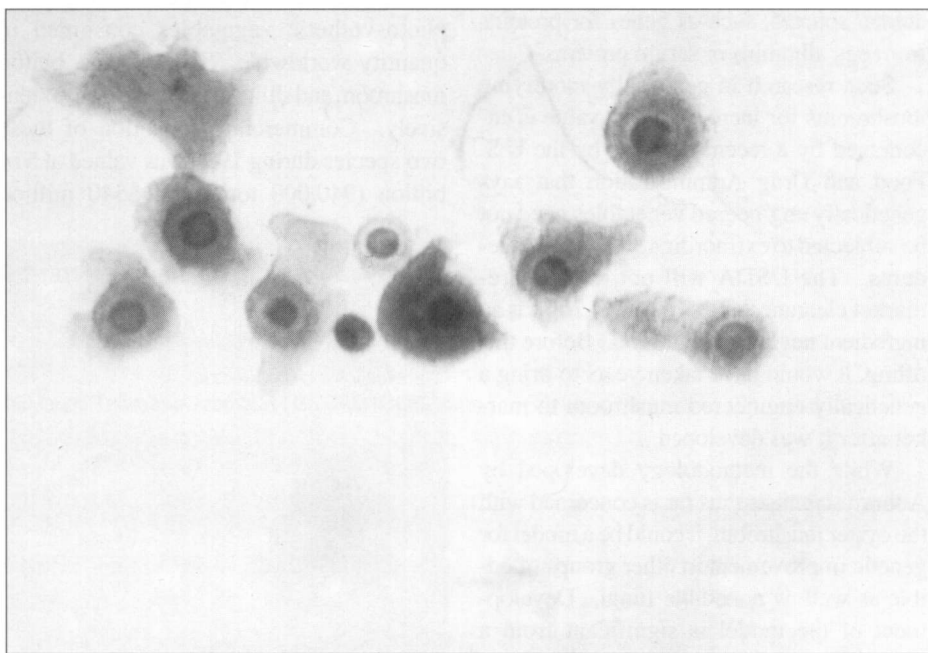
together in a laboratory dish for about 16 hours. Afterwards, the fertilized eggs were washed and incubated in another dish.

An average of 43.9 eggs per cow were collected. Of these, an average of 15.6 fertilized eggs began to develop, and 5.3 developed to a stage that could be placed into recipients without surgery. Transferable embryos were produced from 16 of the 17 cows. Based on the breeding value of five of the donor cows and availability of recipients, the decision was made to transfer nine of the best quality embryos from these cows to recipient cows that had been synchronized so estrous cycles matched the stage of development of the embryos. Two embryos were transferred surgically after 2 days of development, and seven were transferred nonsurgically after 6 or 7 days of development. Nonsurgical embryo transfers were accomplished with an instrument similar to an insemination gun. Four of the nine recipient cows became pregnant, carrying calves from three of the five cull cows.

Although transferable embryos were produced from all but one cow, there was a high degree of variability in numbers of eggs collected and embryos produced from each cow. This individual variability, along with the reason for culling and value of the bloodline all are factors for consideration in determining whether IVF should be used to produce calves from a particular cow.

These feasibility studies are ongoing, but due to the high degree of early success with each phase of the system, IVF is currently offered as a clinical service to Alabama cattle producers through the College of Veterinary Medicine at Auburn University with laboratory support from the Department of Animal Health Research.

Stringfellow is Associate Professor of Pathobiology; M.G. Riddell is Associate Professor of Large Animal Surgery and Medicine; K.P. Riddell is Research Associate of Pathobiology; Carson is Associate Professor of Large Animal Surgery and Medicine; Smith is Superintendent, E.V. Smith Research Center Dairy Unit; and Gray is Professor of Anatomy and Histology.



Eggs (magnified 25 times) that have been collected from the ovary of a cull cow, washed, and are ready to be matured in the incubator. Note the ball of "nurse" cells that surround each egg.

GENETIC ENGINEERING OF AN EDIBLE MUSHROOM SPECIES

SUCCESS in transforming edible species of fungi for improved nutritional value has the potential to impact significantly upon the food industry and to help reduce global hunger. Mushroom cultivation depends on substrates, primarily of biodegradable wastes, requires little land, and the used substrate can be recycled to improve agricultural soil, so land reclamation and pollution abatement also may benefit.

Recently, a novel method of introducing foreign genes into edible mushrooms, involving formation of wall-less cells (protoplasts) receptive to uptake and expression of foreign genes, was developed by Auburn University microbiologists. The introduced gene is carried on a replicative plasmid thereby increasing the level of expression in the transformed mushroom. These results could ultimately lead to the development of mushrooms genetically engineered for increased food value. Candidate genes from plant sources include those for storage proteins, such as phaseolin or zein; or from animal sources, such as genes for proteins from egg albumins or serum proteins.

Such research in genetically modifying mushrooms for increased food value is encouraged by a recent decision by the U.S. Food and Drug Administration that says genetically engineered vegetables need not be subjected to extraordinary testing procedures. The USDA will not require pre-market clearance unless the new crop has an ingredient never found in food. Before this ruling, it would have taken years to bring a genetically engineered mushroom to market after it was developed.

While the methodology developed by Auburn scientists thus far is concerned with the oyster mushroom, it could be a model for genetic improvement in other groups of edible as well as nonedible fungi. Development of the model is significant from a scientific perspective, because fungi are more difficult to transform genetically than bacteria.

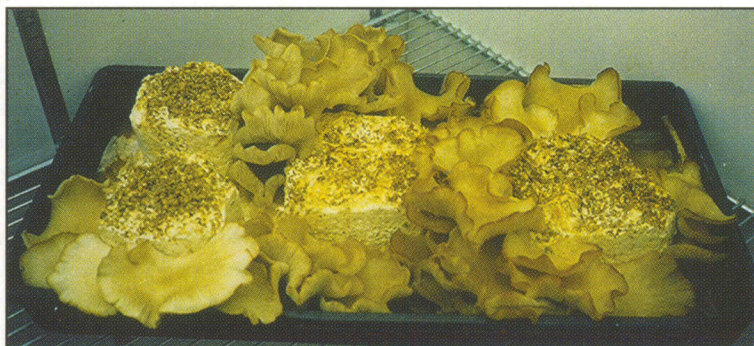
The oyster mushroom has enormous potential for mass cultivation owing to a relatively short 4-5 week cycle for mushroom production and an ability to form mushrooms from several different kinds of substrate, including abundant agricultural and forestry wastes such as straw, sawdust, and nonlumber grade tree species. The oyster mushroom does not require composted substrates for cultivation and is becoming increasingly important as an alternative to traditional mushroom culture. Since new mushroom varieties and species are being increasingly cultivated, it will be necessary to develop superior methods for production of these fungi.

Mushrooms represent the only non-photosynthetic vegetables consumed in quantity worldwide. Two species, button mushroom and shiitake, are cultivated extensively. Commercial production of these two species during 1983 was valued at \$14 billion (940,000 tons) and \$540 million

(192,000 tons), respectively.

The mushrooms produced from agricultural and industrial discards contain 30-50% protein on a dry weight basis and 2-5% on a fresh-weight basis. This percentage is twice that of asparagus or cabbage, but, significantly less than peas, beans, and most animal protein sources. Yet, growing mushrooms for food protein requires less land than producing protein from animal and plant sources and, if mushrooms were genetically improved for protein content, especially with reference to proteins rich in essential amino acids, such as lysine and leucine, then mushrooms might outcompete more traditional agricultural commodities both nutritionally and economically.

Lemke is Professor, Singh is Associate Professor, and Peng is a Graduate Student of Botany and Microbiology.



Laboratory grown mushrooms of *Pleurotus ostreatus* grown on blocks of rye grain. This strain of oyster mushroom has been genetically transformed by Auburn researchers to express a bacterial gene for antibiotic resistance.

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