Spring 2009 • Volume 11 no. 1

# AVIAN Advice

UNIVERSITY OF ARKANSAS
DIVISION OF AGRICULTURE
Cooperative Extension Service



# Evaluation of Different Hydrogen Peroxide Products for Maintaining Adequate Sanitizing Residual in Water

by Tyler Clark, Brookee Dean and Susan Watkins
University of Arkansas, Division of Agriculture

**Introduction**

A clean, safe water supply is essential in poultry production. Yet even producers who take every precaution to ensure that their water supply is safe may experience problems with high bacteria counts and biofilms in their water lines. Thus, it is important to understand the capabilities of water sanitation products, particularly those products capable of reducing or destroying biofilms (Hancock et al., 2007).

Hydrogen peroxide has been used as an antimicrobial agent since the early 1800's. It was used as a disinfectant in milk as early as 1904 and is presently approved by the Food and Drug Administration (FDA) for packaging and surface sterilization in the food industry (Schurman, 2001). Hydrogen peroxide has shown to be effective against biofilms (Carpentier and Cefr, 1993).

Hydrogen peroxide ($H_2O_2$) is a weak acid that works as an oxidizer similar to chlorine. The key by-products formed when hydrogen peroxide is used are water and oxygen which makes it a good choice for treating water with high levels of organic matter such as ponds or rivers. The hydrogen peroxide found in drugstores or pharmacies is only a 3% concentration, while the products commonly used for water disinfection range from 16 to 34% with 50% $H_2O_2$ products available for use in removing biofilms from water systems between flocks. Hydrogen peroxide can also be used to oxidize iron, manganese and sulfur which can then be removed with filtration.

The Environmental Protection Agency (EPA) guidelines recommend 25-50 ppm of residual $H_2O_2$ in drinking water. However, water disinfection products use different stabilizing systems, which brings us to the questions we are attempting to address here:

1. How much of the different $H_2O_2$ concentrates is required to make a 25-50 ppm residual in water? and;
2. How long do different sources of $H_2O_2$ remain effective once they are blended into a stock solution and added to water?

**Materials and Methods**

The following four products were tested: hydrogen peroxide (35%), HydroLine Cleaner® (34% stabilized), Proxy-Clean® (50% stabilized), and Oxy Blast Plus® (34% stabilized). It is important to note that the HydroLine Cleaner®, Proxy-Clean® and Oxy Blast® all contain

EVALUATION — cont'd on page 2

*. . . helping ensure the efficient production of top quality poultry products in Arkansas and beyond.*

additional proprietary ingredients used for stabilization and enhancing effectiveness. Oxy Blast® also has NSF International approval as a drinking water additive.

Each product was mixed with tap water to make four separate stock solutions of: 1 ounce/gallon (oz/gal), 2 oz/gal, 4 oz/gal, and 6 oz/gal for each product. The tap water was tested for residual chlorine before mixing and measured 0 ppm. Next 1 milliliter (ml) of each stock solution was added to 128ml of tap water to create a 1:128 solution. This simulated the ounce of each stock solution that would be added to a gallon of water (128 ounces) by a medicator injecting at a 1:128 rate. After creating each of the final solutions, the parts per million (ppm) of hydrogen peroxide was tested using Oxy Blast® Peroxide Test Strips which measures $H_2O_2$ residual from 0 to 100 ppm. Each solution was covered and then tested again on days 1, 2, 3 ,4 and 5 post preparation.

**Results**

The data in Table 1 indicate that under the conditions of this trial none of the products tested provided 25-50ppm at the 1 oz/gal stock solution level. At 2 oz/gal stock solution, hydrogen peroxide and Proxy-Clean® produced 25ppm $H_2O_2$ solution, while a 4 oz/gal stock solution of HydroLine® was required to produce the same concentration. A 2 oz/gal stock solution of Oxy Blast® produced 50ppm concentration of $H_2O_2$.

Assuming the products tested contained the listed percentages of hydrogen peroxide and no activity was lost in the dilution process, initial $H_2O_2$ activity for the 2 oz/gal stock solution concentration should have been 42.7, 41.5, 61.0 and 41.5 ppm for hydrogen peroxide, Hydroline®, Proxy-Clean® and Oxy Blast®, respectively . However, the data in Table 1 suggest that in 41.5, 75.9 and 59% of the $H_2O_2$ activity was lost in the initial dilution of hydrogen peroxide, HydroLine® and Proxy-Clean®, respectively. These data suggest that, while effective, the activity of hydrogen peroxide can be quickly lost. Therefore, it is imperative that label directions be followed when using such products

By day one or 24 hours post mix of solutions, the hydrogen peroxide at 2 oz/gal had decreased a residual $H_2O_2$ activity of 10ppm and held this concentration till day 5 when it was decreased to 5 ppm. The hydrogen peroxide at 4 oz/gal dropped to 50 ppm by day 2 and then to 25 ppm by day 3 and dropping further by day 5 to 10 ppm. HydroLine® at 4 oz/gal gave a 25 ppm residual reading till Day 3 when it dropped to 10 ppm and then finished day 5 with a 5 ppm reading. The Proxy-Clean® 2 oz/gal gave a 25 ppm reading till day 2 and then on day 3 it had dropped to 10 ppm for the rest of the measurement time period. The Oxy Blast® 2 oz/gal mixture dropped to 25 ppm by day 1 and this held till day 3 when the residual dropped to 10 ppm. These

**Table 1. Residual $H_2O_2$ Activity from Different Products over a 5 Day Period**

| Product; Concentration | Day 0 | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 |
|---|---|---|---|---|---|---|
| | ←— $H_2O_2$ Concentration (ppm) —→ | | | | | |
| 35% H. Perox.; 1oz/gal | 10 | 10 | 10 | 10 | 10 | 5 |
| 35% H. Perox.; 2oz/gal | 25 | 10 | 10 | 10 | 10 | 5 |
| 35% H. Perox.; 4oz/gal | ≥100 | 50 | 25 | 25 | 25 | 10 |
| 35% H. Perox.; 6oz/gal | ≥100 | 50 | 25 | 25 | 10 | 10 |
| | | | | | | |
| HydroLine®; 1oz/gal | 2 | 2 | 0.5 | 0.5 | 0.5 | 0.5 |
| HydroLine®; 2oz/gal | 10 | 25 | 10 | 10 | 10 | 5 |
| HydroLine®; 4oz/gal | 25 | 25 | 25 | 10 | 10 | 5 |
| HydroLine®; 6oz/gal | ≥100 | 50 | 25 | 25 | 10 | 10 |
| | | | | | | |
| Proxy-Clean®; 1oz/gal | 25 | 10 | 10 | 5 | 5 | 2 |
| Proxy-Clean®; 2oz/gal | 25 | 25 | 25 | 10 | 10 | 10 |
| Proxy-Clean®; 4oz/gal | ≥100 | ≥100 | 50 | 25 | 25 | 10 |
| Proxy-Clean®; 6oz/gal | ≥100 | ≥100 | ≥100 | 50 | 25 | 25 |
| | | | | | | |
| Oxy Blast®; 1oz/gal | 10 | 10 | 10 | 10 | 10 | 5 |
| Oxy Blast®; 2oz/gal | 50 | 25 | 25 | 10 | 10 | 5 |
| Oxy Blast®; 4oz/gal | ≥100 | ≥100 | 50 | 25 | 10 | 10 |
| Oxy Blast®; 6oz/gal | ≥100 | ≥100 | 50 | 25 | 10 | 10 |

results suggest that hydrogen peroxide, Proxy-Clean® and Oxy Blast® at a 2 oz/gal stock solution concentration should be adequate for providing a 25-50 ppm residual for at least 24 hours.

The data shown in Figure 1 compare the average residual $H_2O_2$ activity for stabilized and unstabilized hydrogen peroxide products over all concentrations tested in this trial. While both product types began and were about the same concentration on days 3, 4 and 5 of the test, stabilized products maintained higher concentrations than unstabilized products on days 1 and 2. These data suggest that stabilized hydrogen peroxide products offer some additional residual $H_2O_2$ activity when compared to unstabilized products but, the additional residual activity is transient, lasting no more than one or perhaps two days.

**Summary**

Mixing hydrogen peroxide products to obtain a solution with a 25-50 ppm residual $H_2O_2$ in the drinking water required a stock solution of at least 2 oz/gal with most products. However, since hydrogen peroxide products can rapidly lose potency, it is recommended that fresh stock solutions be made every 2-3 days. Although stabilized hydrogen peroxide products offer some additional residual $H_2O_2$ activity over unstabilized products, this activity lasts no more than two days. Finally, it is important to note that not all the products are labeled as drinking water additives so please take this into consideration when choosing water sanitizer products and follow label direction.

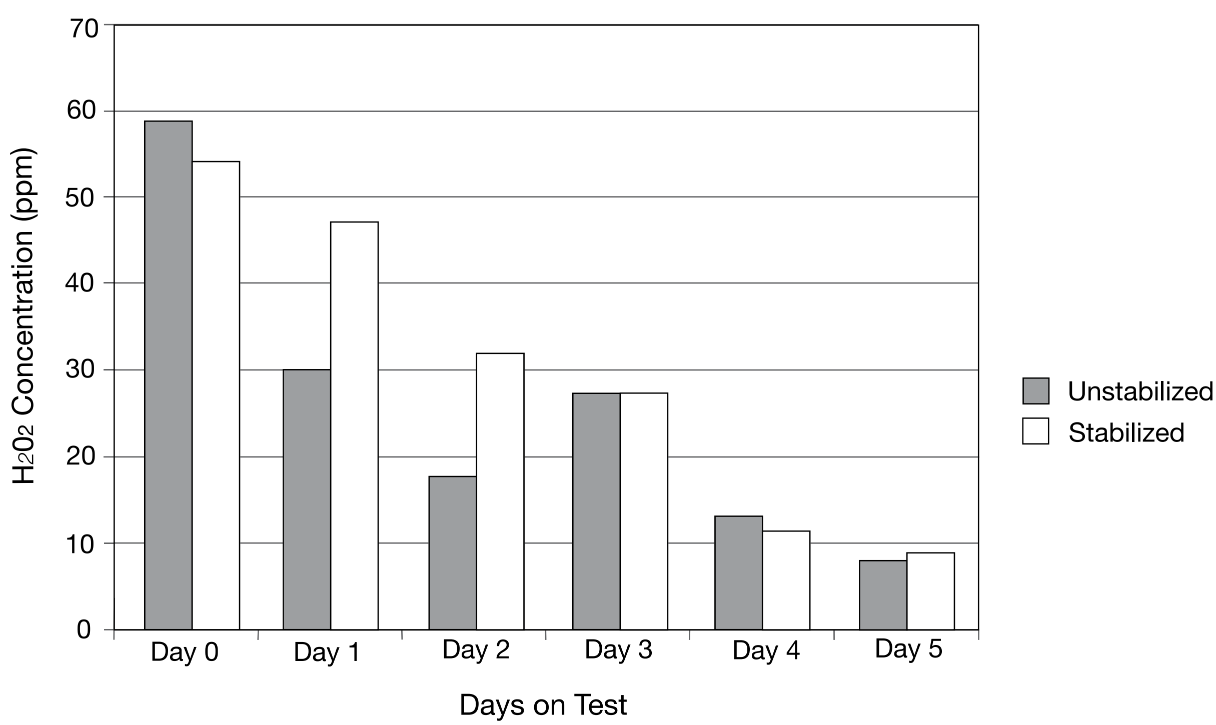
**References**

Carpentier, B. and O. Cefr, 1993. Biofilms and their consequences, with particular reference to hygiene in the food industry. J. Applied Bacteriol. 75:499-511.

Hancock, A., J. Hughes and S. Watkins, 2007. In search of the ideal water line cleaner. Avian Advice 9(1):1-4.

Schurman, J. J. 2001. Antibacterial activity of hydrogen peroxide against Escherichia coli O157:H7 and Salmonella spp in fruit juices, both alone and in combination with organic acids. Thesis submitted to Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of Master of Science.

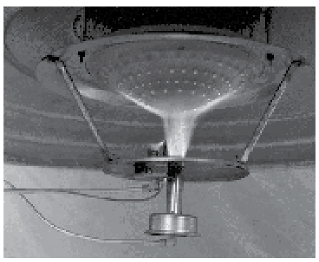
**Figure 1. Residual $H_2O_2$ Activity of Stabilized And Unstabilized Hydrogen Peroxide Products[1]**




[1] **The data represent the average concentrations obtained when 1, 2, 4 and 6 oz/gal solutions were diluted 1 to 128.**

Y. Liang[1] and G.T. Tabler[2]
[1]Department of Biological and Agricultural Engineering and
[2]Department of Poultry Science, University of Arkansas Division of Agriculture

# How Much Moisture Do Brooders Add to Poultry Houses?



**Introduction**

The vast majority of poultry growers use unvented heating units, i.e. brooders or space furnaces, to heat their poultry houses, using propane or natural gas as fuel sources. Record high propane/natural gas prices over the last two years have led a number of producers to explore the possibility of using biomass furnaces to provide heat in their poultry houses. A number of alternative heating systems exist with a price range of less than $10,000 to over $60,000 (Czarick, et al., 2008). Generally alternative heating systems are considered profitable if they are able to replace approximately 85% of the propane use, but conventional brooder/space heating systems must still supply heat during peak demand (Wimberly, 2008).

While the main benefit of biomass furnaces lies in its potential fuel saving, an overall improvement in air quality in the house as a result of introducing "dry heat" is an additional benefit reported by furnace vendors and some growers. This claim is based on the fact that unvented heating units such as brooders or space heaters release water vapor as they generate heat, while vented systems leave the combustion byproducts outside and introduce heat into the houses by heat exchangers. Unvented propane heaters are estimated to add 0.000078 pounds of water vapor for each BTU heat generated (ASHRAE, 1985). Natural gas releases slightly more water vapor than propane per unit of heat generated. If "dry heat" releases less water vapor into the poultry house, this is likely to lower in-house ammonia and ventilation requirements because of drier litter conditions. However, water vapor from unvented conventional heaters is only a portion of the moisture load added to the house, and this portion varies both within a flock and among flocks in a year. It may represent a high proportion of the moisture load during the brooding stage in cold weather when feed and water consumption are low, but much less of the load as birds get older. We decided to study the relative contribution of moisture to housing environment and potential significance of the "dry heat" benefit based on available scientific data so that growers are equipped to make wise investment decisions with respect to the relative importance of "dry heat."

**Materials and Methods**

This analysis was conducted based on weekly propane usage, feed consumption and water intake data collected from 18 winter flocks (flocks placed in November, December and January) raised at the Applied Broiler Research Farm (ABRF). When we did this study we assumed that, when relatively low levels of heating were required during mild weather, because of convenience and system efficiency, propane heating systems would be favored over biomass furnaces.

Moisture loads in poultry houses consist of moisture generated by birds and water vapor generated by propane heaters. Moisture generation by birds included water intake from drinkers, water in the feed (assume feed moisture content of 13%) and metabolic water generated through the digestion of feed. Yet some of the water in poultry houses is retained in the bodies of the birds. Therefore, the amount of water retained by the birds (water retention) was calculated.

Several assumptions were made to conduct the analysis:

1. Each 40 by 400 house was assumed to have 20,000 birds at placement, even though the actual bird number of each flock varied by target market weight and season;
2. Water was assumed to make up 80% of live weight of birds. This assumption was used to calculate the proportion water in the house that was retained by the birds (water retention);
3. One BTU of propane generates 0.000078 ($7.80 \times 10^{-5}$) lbs of water vapor;
4. One gallon of propane generates 92,000 BTU.

Further analysis was made on daily propane use during the first two weeks of the most recent five winter flocks raised in 2006, 2007 and 2008, and compared to daily moisture loads added by birds.

**Results and Discussion**

On average, birds drank between 1.5 to 2.1 pounds of water for every pound of feed consumed. Water consumption from drinkers was found to represent a majority of water added to the house. An average of 19% of the water in the house was retained by the birds. This means that 81% (range of 75 to 85%) of the water that entered houses was released back into the house environment, by respiration and excretion (Figure 1).

If unvented propane heaters account for a large portion of the moisture added to poultry houses, it seems logical to assume that moisture addition problems would be worst in the winter months. Yet, analysis of propane consumption data from winter flocks revealed that unvented burning of propane generated an average of 23% of total moisture loads in the first week of brooding, 11% of the moisture in the second week, and 5% or less in the remaining weeks (Table 1, Figure 2). Still, a major portion of the fuel combusted over the life of the flock is expended maintaining house temperatures of 85 to 90°F during these early weeks. In addition, the overall growth rate and settlement status may well be determined during these early weeks (Tabler, 2000; Tabler, 2003). Therefore, daily propane usage data from the five most recent winter flocks was analyzed to get a better picture of moisture loads within the first two weeks of chick placement.

Figure 3 shows that moisture generated by propane burning represented 84 and 41% of the total load on days 1 and 2, respectively. The percentage of moisture from burning propane decreased as birds grew, and stabilized at around 11% during the second week of age. The dry heat from vented furnaces is clearly beneficial during the early days after bird placement when propane consumption is very high. Calculations show that on average the moisture load could be reduced by 20% during the first week. While this reduction in moisture load would translate to drier litter conditions, and may allow the grower to reduce ventilation rates, it is important to remember that total moisture loads increase dramatically as birds grow, and moisture generated by birds remains the main reason for ventilation. While the benefits of dry heat from biomass furnaces become smaller as birds grow, it is also important to recognize that energy efficiency is also related to litter preparation between flocks. Growers that skip or short cut may save time, but those who take the extra time to do the job right will likely find dividends in the settlement check (Tabler et al., 2008).

**Summary**

Several potential environmental and economic benefits have been reported for biomass furnace systems. While these benefits are often valid, it is important to see the whole picture. Vented furnaces produce dry heat that is reported to reduce in-house ammonia levels, decrease ventilation rates, improve litter quality and produce a healthier environment within the house (Wimberly, 2008). Moisture load calculations based on propane usage data collected at the Applied Broiler Research Farm indicate that when using vented biomass furnace, about 23% less moisture can be added to the indoor environment during the first week of brooding, when birds are very sensitive to house conditions and maintaining elevated temperatures requires the combustion of large amounts of propane. However, as birds grow bigger, more moisture is added by feeding and drinking, which represent more than 90% of in-house water inputs from second week on.

**Table 1. Weekly Moisture Loads Generated by Birds and Unvented Propane Heaters**

| Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Water generation from unvented burning (gal/wk) | 322 | 405 | 299 | 172 | 103 | 82 | 79 |
| Water from birds (gal/wk) | 1078 | 3206 | 5772 | 8443 | 10926 | 12964 | 14319 |
| Proportion from propane (%) | 23 | 11 | 5 | 2 | 1 | 1 | 1 |

MOISTURE — continued on pg. 6

MOISTURE — continued from p. 5

**References**

ASHRAE. 1985. ASHRAE Handbook, 1985 Fundamentals. American Society of Heating, Refrigerating and Air-Conditioning Engineers. Atlanta, GA.

Czarick, M. B. Fairchild, and D. Dartnell 2008. Alternative heating system … an overview. University of Georgia Corporative Extension Service, Poultry Housing Tips. December 2008.

Tabler, T. 2000. Brooding chicks in colder weather. Avian Advice 2(1):3-4.

Tabler, T. 2003. Early feed intake and bird performance. Avian Advice 5(1):13-15.

Tabler, T., S. E. Watkins and F. T. Jones. 2008. Litter preparation between flocks: management is the key. Avian Advice 10(4):4-7.

Wimberly, J. 2008. A review of biomass furnaces for heating poultry houses in the Northwest Arkansas region. Winrock International, Little Rock, AR.

**Figure 1. Weekly Water Released and Retained (reflected as weight gain) per 1000 Birds as a Result of Feed and Water Intake.**

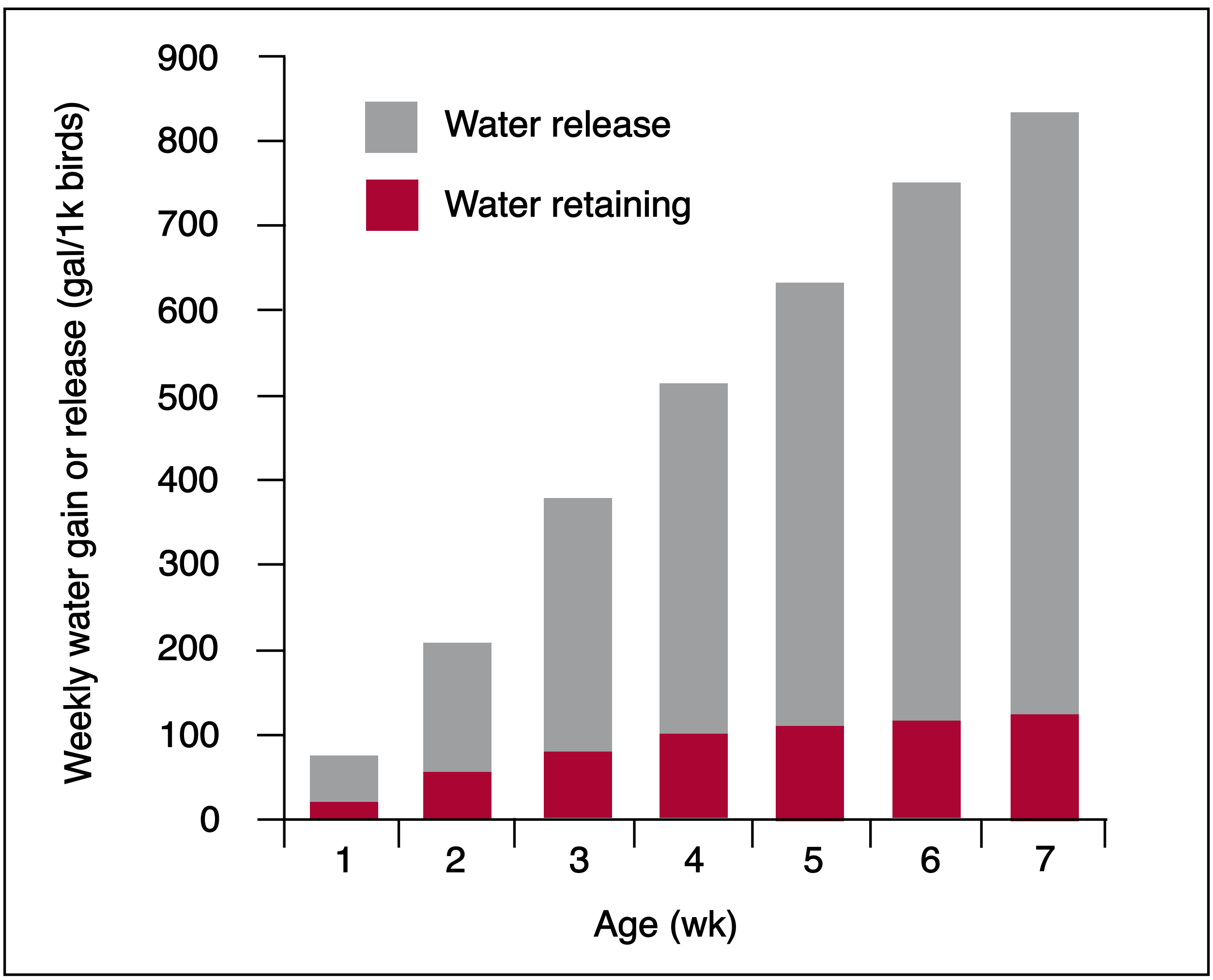


**Figure 2. Weekly Moisture Addition from Water Released by Birds and Generated by Propane Heaters (analyzed for 18 winter flocks, per house basis)**

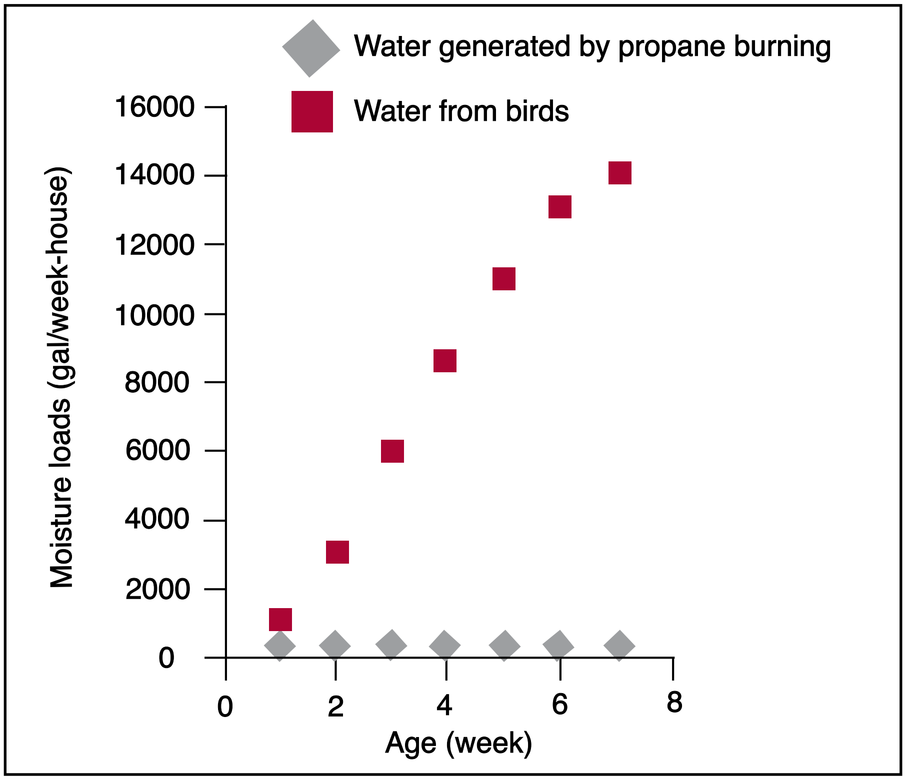
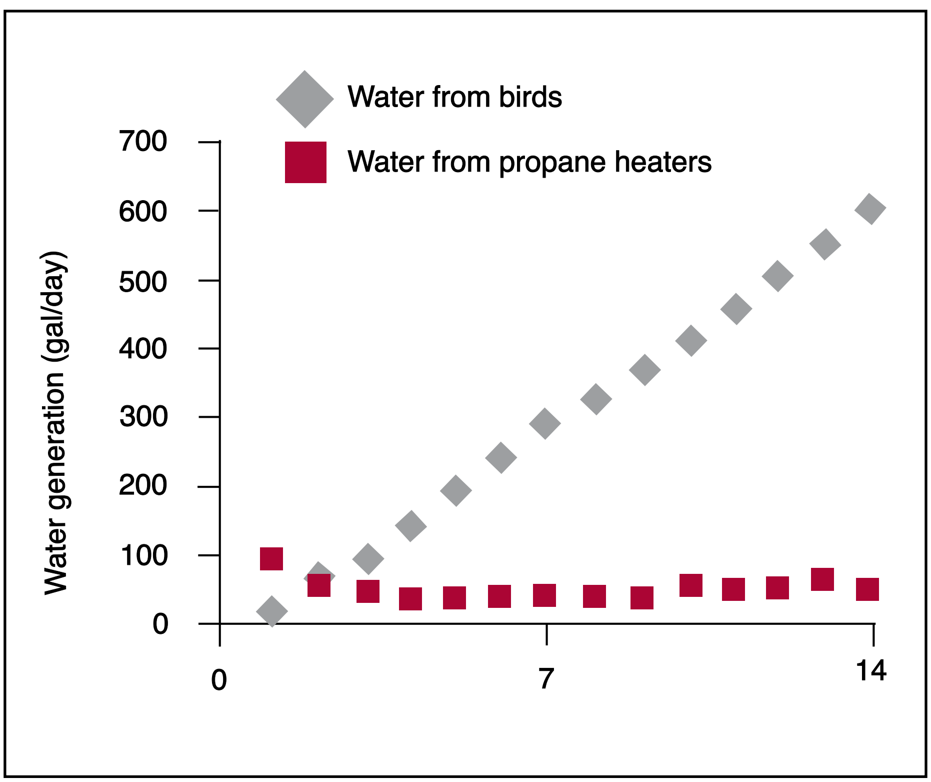



**Figure 3. Daily Moisture Addition from Water Released by Birds and Generated by Propane Heaters during the First Two Weeks after Chick Placement (analyzed on 5 winter flocks per house basis)**



F.T. Jones and S.E. Watkins
University of Arkansas, Division of Agriculture

# How Does Taste Influence Water Consumption in Broilers?

**Background**

Early studies suggest that birds are much more sensitive to flavors in water than in feed (Kare and Pick, 1960). This sensitivity to flavors in water may be due to the fact that birds consume almost twice as much water as feed. However, the issue of taste is much more complex than it may seem because humans perceive taste differently than many other animal species.

To illustrate this point one researcher compared the responses of different animals to a sucrose (sugar) solution, and its equivalent in saccharine. Most humans said that both solutions are sweet and pleasant tasting and laboratory rats had a similar reaction. Calves drank much more of the sucrose than humans did, but drank little of the saccharine. Chickens and dogs drank the sugar but found the saccharine very offensive. Cats did not respond to either of the solutions. The point of this illustration is we, as humans, cannot use our own sense of taste to predict how animals will respond (Kare, 1970).

Chickens, in fact, prefer water that is cold and slightly acid in taste rather than sweet (Kare, 1970). Although chicks have only a fraction of the number of taste buds found in other animals (Figure 1), birds have a well defined sense of taste and will reject certain flavors (Kare et al., 1957). In addition, the taste buds in chickens are in different locations as compared to other animals. In humans, and many other animal species, most taste buds are on the tongue; but in the chicken, taste buds are distributed primarily on the back part of the roof of the mouth, with only 2 to 4% being located on the tongue (Ganchrow and Ganchrow, 1985). In fact, the taste buds in chickens are so far back in the mouth that by the time the bird can taste something, it is almost too late to change its mind about swallowing it (Kare, 1970). Yet, the sense of taste is more than just how feed or water feels in the mouth of the bird. The sense of taste is all the sensation a bird experiences after consumption.

In general, the sense of taste guides an animal as to what it should eat. For example, chickens given a thiamin deficient diet and offered two solutions, one with and one without thiamin, will choose to drink a solution containing thiamin. While humans perceive xylose as about 70% as sweet as sucrose (sugar), chickens will drink little xylose, which has been found to cause cataracts in some bird species (Kare, 1970). These and similar choices suggest that taste is often the basis on which the bird seeks to meet its nutritional needs (Roura et al., 2008). However, the problem is still more complicated.

Water to humans is wet and tasteless, but to birds, water has a distinct taste. Therefore, water in itself is a strong stimulus for the bird and flavors tested in water solutions are actually perceived by the bird as mixtures of flavors (Beidler, 1961; Kare, 1970; Gentle, 1985). Although flavor perceptions in many animals also involve the perception of odors, in birds odors in their immediate environment have little apparent affect. Yet, temperature of water can be critical for birds. When presented with two choices of water, one at room temperature and the other a degree or two above their body temperature, birds will suffer from acute thirst rather than drink the warmer water. On the other hand, birds will readily consume water at temperatures close to freezing. This may be due to the fact that birds are well insulated with feathers, which protect them from the cold, but allow little or no means to dissipate excess body heat.

**Practical applications**

The data in Figure 2 were collected by Kare et al., (1957), who tested acceptance of water containing various flavors by placing two chick watering jars in each pen. One jar contained untreated water and the other contained flavored water. The researchers compared the amount of water consumed from the two jars to measure the acceptance or rejection of flavors by the birds. Some flavors (strawberry, alfalfa, nutmeg, honey, molasses, mushroom, and wild cherry) were rejected outright, while birds would drink certain flavors (butter pecan, butterscotch, raisin, coconut, grenadine, oil of patchouli, and colocynth pulp) sparingly at first, but gradually accept the flavor as illustrated by Figure 2. Other than the novelty of knowing how flavored water influences the taste of chickens, is there a practical application for this information? Absolutely. The taste of water due to either natural or added materials can dramatically influence consumption, particularly in young birds.

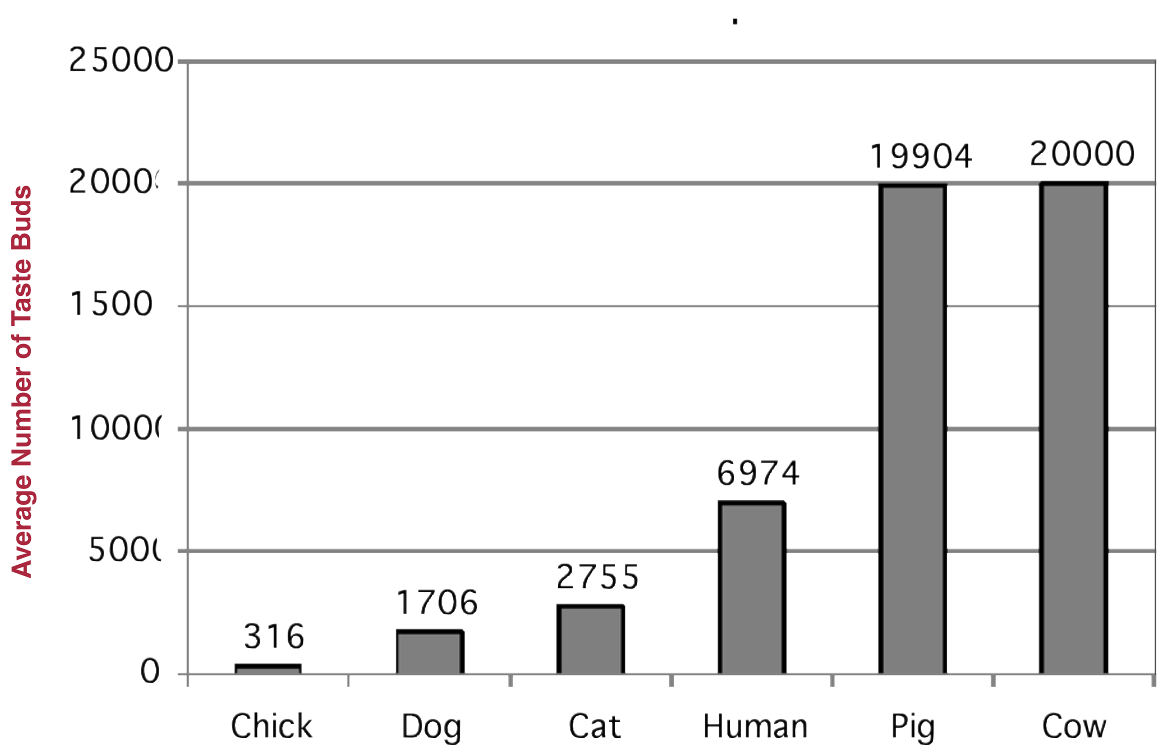
We witnessed firsthand the effects of differences in water consumption in young birds at the U of A Applied Broiler Research Farm when we tried a different water acidifier (Figure 3). The three flocks grown on product B were lighter at settlement than previous flocks grown on product A. Yet, overall water consumption data for these flocks showed no difference. However, data for the first week showed lower water consumption for flocks grown on product B as compared to product A and it took almost 21 days before the birds returned to consumption seen on product A. We were fortunate that we were raising a heavier bird and the additional time given to the birds to become acclimated to product B allowed us to make up some performance by the time they went to market. However, growers raising smaller weight birds would not have the luxury of making up for poor early water and feed consumption.

**How can growers identify water consumption challenges?**

If birds don't eat they don't gain weight. Since feed and water consumption are closely correlated (1 pound of feed consumed for approximately 1.67 pounds of water consumed) it is critical to pay attention to water consumption and head off problems before they start. As illustrated in Figures 2 and 3, when birds gradually accept water with certain flavors

TASTE — continued on page 10

**Figure 1. Number of Taste Buds in Various Animal Species[1]**




[1]Adapted from Roura et al, 2008

particularly early in the life of the flock, detection may be much more difficult, but the losses can be just as real (Tabler, 2003). In view of this situation, the following suggestions are offered:

1. Closely monitor water consumption, particularly early in the flock. Install meters in both the front and back of the house. Readings from these meters provide crucial information to determine if birds are properly spread through the house as well as determine if water lines are correctly adjusted. At about the same time each day, record water meter readings starting from day one of the flock. Identifying and solving water issues can more than pay for the cost of meters.
2. Develop water usage patterns. Since water consumption will likely vary from farm to farm, develop average water consumption charts for your farm. Compare each flock's consumption numbers to the average you have developed and pay particular attention early in the life of the flock.
3. Be aware that not all water supplies and water additives are compatible to the bird's taste. Pay close attention to water usage when trying new products to assure that there is no decrease in water usage. Make a note of products which the birds appear to like due to increased consumption which is not accompanied by flushing in the birds.

**Conclusion**

The factors influencing the sense of taste in birds are complex and not completely understood. However, it is clear that the taste of water can influence both feed and water consumption. By monitoring water usage and understanding what normal water usage patterns are for each day of age, producers can identify challenges and correct them before profits are lost.

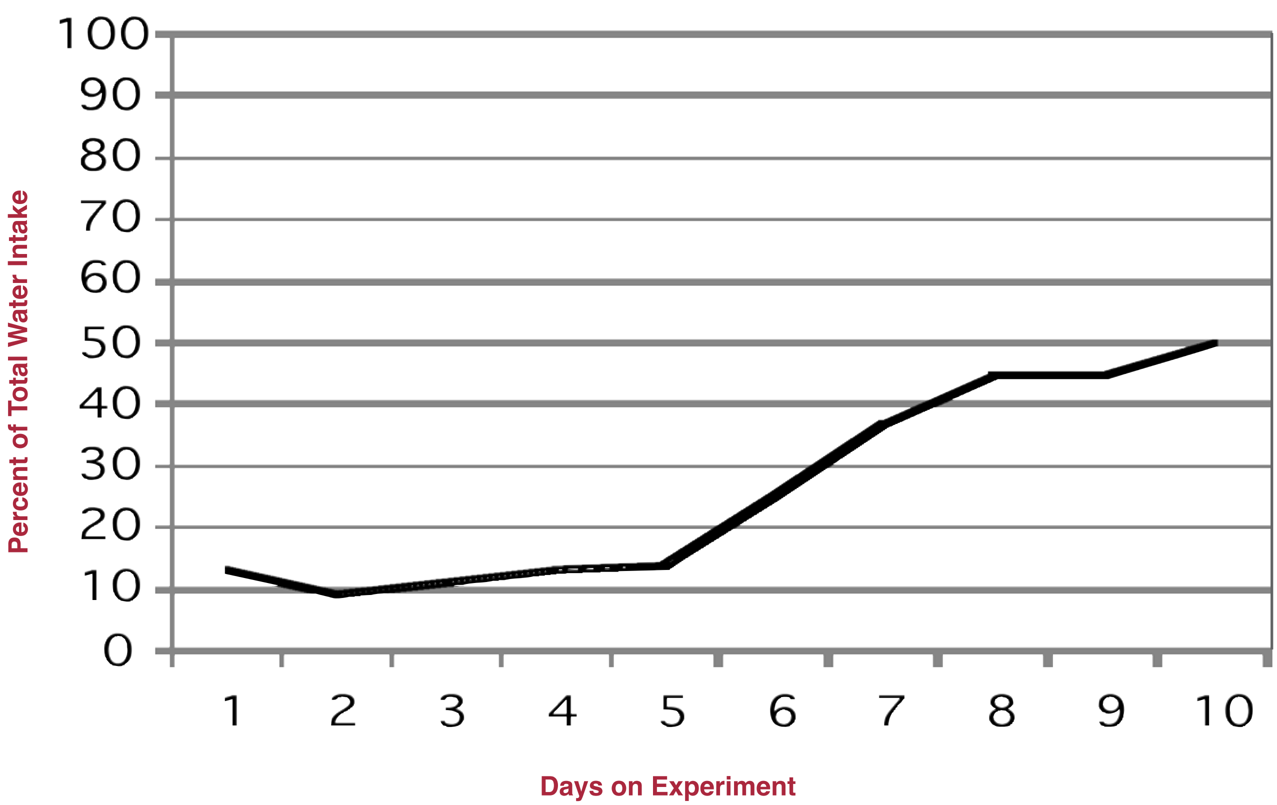
**References**


Beidler, L. M. 1961. The chemical senses. Ann. Rev. Psychol. 12:363-388.

Ganchrow, D. and J. R. Ganchrow. 1985. Number and distribution of taste buds in the oral cavity of hatchling chicks. Physiol. Behav. 34(6):889-894.

Gentle, M. J. 1985. Sensory involvement in the control of food intake in poultry. Proc. Nutr. Soc. 44:313-321.


**Figure 2. Daily Water Consumption in Chickens Provided Flavored Water[1,2]**




[1]Adapted from Kare et al. 1957 The Sense of Taste in the Fowl. Poultry Science 36:129-138
[2]Birds were given a choice of unflavored water or water containing 4 parts per thousand butter pecan flavor, these data represent the percentage of flavored water consumed.

Kare, M. R. 1970. The chemical senses of birds. Bird Control Seminars Proceedings http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1183&context=icwdmbirdcontrol Accessed 3/24/09

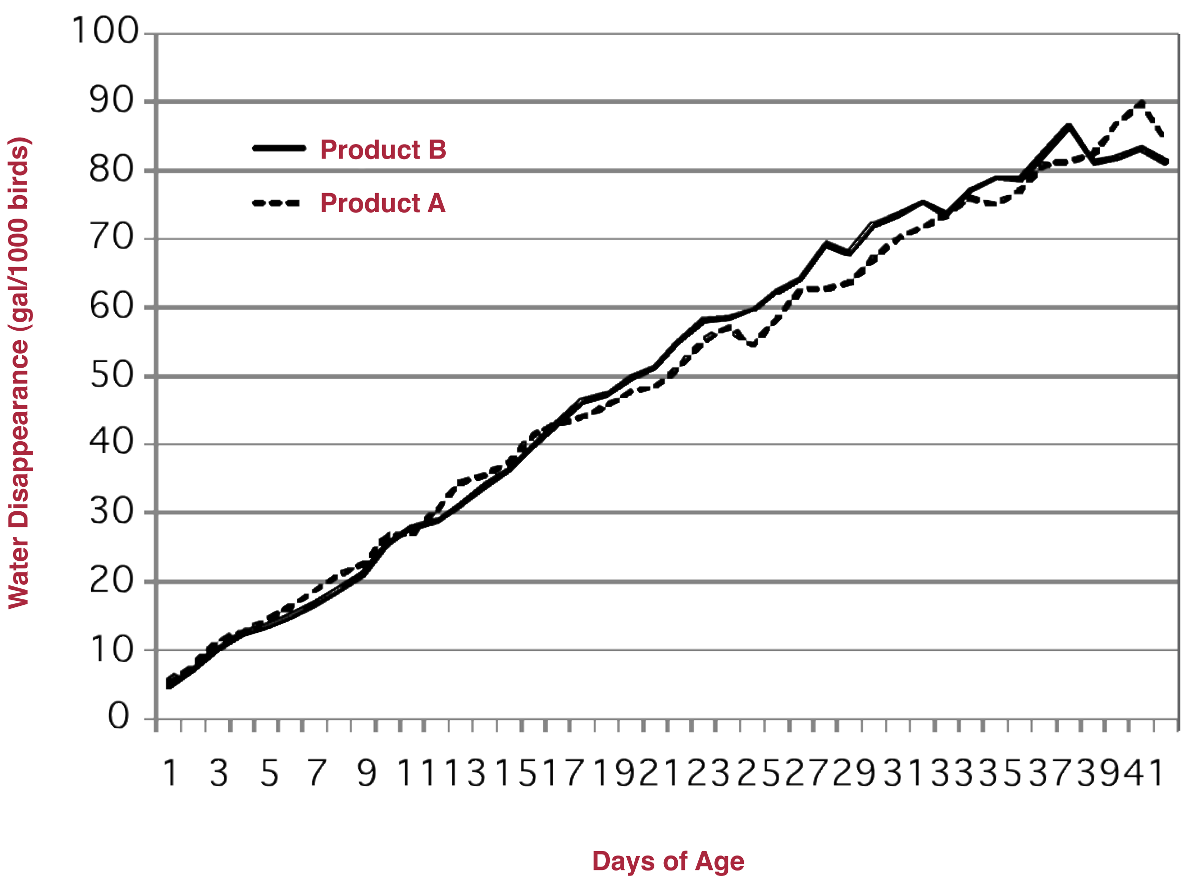
Kare, M. R., R. Black and E. G. Allison. 1957. The sense of taste in the fowl. Poultry Sci. 36:129-138.

Kare, M. R. and H. L. Pick. 1960. The influence of the sense of taste on feed and fluid consumption. Poultry Sci. 39:697-706.

Roura, E., B. Humphrey, G. Tedo and I. Ipharraguerre. 2008. Unfolding the codes of short-term feed appetence in farm and companion animals: A comparative oronasal nutrient sensing biology review. Can. J. Animal Sci. 88:535-558.

Tabler, G. T. 2003 Early feed intake and bird performance. Avian Advice 5:13-15

**Figure 3. Water Usage With Different Water Acidifier Products.**



*Write Extension Specialists,*
*except Jerry Wooley, at:*
*Center of Excellence*
*for Poultry Science*
*University of Arkansas*
*Fayetteville, AR 72701*

# UA Poultry Science Extension Faculty

**Dr. R. Keith Bramwell**, Extension Reproductive Physiologist, attended Brigham Young University where he received his B.S. in Animal Science in 1989. He then attended the University of Georgia from 1989 to 1995 where he received both his M.S. and Ph.D. in Poultry Science. As part of his graduate program, he developed the sperm penetration assay, which is still in use today, as both a research tool and as a practical troubleshooting instrument for the poultry industry. He then spent one year studying in the Animal Reproduction and Biotechnology Lab at Colorado State University. In 1996, Bramwell returned to the University of Georgia as an Assistant Professor and Extension Poultry Scientist. Dr. Bramwell joined the Center of Excellence for Poultry Science at the University of Arkansas as an Extension Poultry Specialist in the fall of 2000. His main areas of research and study are regarding the many factors (both management and physiological) that influence fertility and embryonic mortality in broiler breeders. Telephone: 479-575-7036, FAX: 479-575-8775, E-mail: bramwell@uark.edu

**Dr. Dustan Clark**, Extension Poultry Health Veterinarian, earned his D.V.M. from Texas A&M University. He then practiced in Texas before entering a residency program in avian medicine at the University of California Veterinary School at Davis. After his residency, he returned to Texas A&M University and received his M.S. and Ph.D. Dr. Clark was director of the Utah State University Provo Branch Veterinary Diagnostic Laboratory prior to joining the Poultry Science faculty at the University of Arkansas in 1994. Dr. Clark's research interests include reoviruses, rotaviruses and avian diagnostics. He is also responsible for working with the poultry industry on biosecurity, disease diagnosis, treatment and prevention.
Telephone: 479-575-4375, FAX: 479-575-8775, E-mail: fdclark@uark.edu

**Dr. Frank Jones**, Extension Section Leader, received his B.S. from the University of Florida and earned his M.S. and Ph.D. degrees from the University of Kentucky. Following completion of his degrees Dr. Jones developed a feed quality assurance extension program which assisted poultry companies with the economical production of high quality feeds at North Carolina State University. His research interests include pre-harvest food safety, poultry feed production, prevention of mycotoxin contamination in poultry feeds and the efficient processing and cooling of commercial eggs. Dr. Jones joined the Center of Excellence in Poultry Science as Extension Section Leader in 1997. Telephone: 479-575-5443, FAX: 479-575-8775, E-mail: ftjones@uark.edu

**Dr. John Marcy**, Extension Food Scientist, received his B.S. from the University of Tennessee and his M.S. and Ph.D. from Iowa State University. After graduation, he worked in the poultry industry in production management and quality assurance for Swift & Co. and Jerome Foods and later became Director of Quality Control of Portion-Trol Foods. He was an Assistant Professor/Extension Food Scientist at Virginia Tech prior to joining the Center of Excellence for Poultry Science at the University of Arkansas in 1993. His research interests are poultry processing, meat microbiology and food safety. Dr. Marcy does educational programming with Hazard Analysis and Critical Control Points (HACCP), sanitation and microbiology for processing personnel. Telephone: 479-575-2211, FAX: 479-575-8775, E-mail: jmarcy@uark.edu

**Dr. Susan Watkins**, Extension Poultry Specialist, received her B.S., M.S. and Ph.D. from the University of Arkansas. She served as a quality control supervisor and field service person for Mahard Egg Farm in Prosper, Texas, and became an Extension Poultry Specialist in 1996. Dr. Watkins has focused on bird nutrition and management issues. She has worked to identify economical alternative sources of bedding material for the poultry industry and has evaluated litter treatments for improving the environment of the bird. Research areas also include evaluation of feed additives and feed ingredients on the performance of birds. She also is the departmental coordinator of the internship program.
Telephone: 479-575-7902, FAX: 479-575-8775, E-mail: swatkin@uark.edu

**Mr. Jerry Wooley**, Extension Poultry Specialist, served as a county 4-H agent for Conway County and County Extension Agent Agriculture Community Development Leader in Crawford County before assuming his present position. He has major responsibility in the Arkansas Youth Poultry Program and helps young people, parents, 4-H leaders and teachers to become aware of the opportunities in poultry science at the U of A and the integrated poultry industry. He helps compile annual figures of the state's poultry production by counties and serves as the superintendent of poultry at the Arkansas State Fair. Mr. Wooley is chairman of the 4-H Broiler show and the BBQ activity at the annual Arkansas Poultry Festival.
Address: Cooperative Extension Service, 2301 S. University Ave., P.O. Box 391, Little Rock, AR 72203
Telephone: 501-671-2189, FAX: 501-671-2185, E-mail: jwooley@uaex.edu