Discovery, The Student Journal of Dale Bumpers College of Agricultural, Food and Life Sciences

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# Discovery: The Student Journal of Dale Bumpers College of Agricultural, Food and Life Sciences - Volume 16 2015

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# DISCOVERY

The Student Journal of Dale Bumpers College of Agricultural, Food and Life Sciences

Vol. 16 Fall 2015


UofA
DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

UNIVERSITY OF ARKANSAS
DALE BUMPERS COLLEGE
OF AGRICULTURAL, FOOD
& LIFE SCIENCES

# DISCOVERY

The Student Journal of Dale Bumpers College of Agricultural, Food and Life Sciences

Vol. 16 Fall 2015

# Contents

## Undergraduate Research Articles



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*Cover: Megan Lankford* works with her faculty mentor, Catherine Shoulders collecting data for her project, Maintaining a way of life: trials and tribulations of farmers' market families. Photo by Fred Miller.

# DISCOVERY

**The Student Journal of Dale Bumpers College of Agricultural, Food and Life Sciences**

**Vol. 16** **Fall 2015**

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## Undergraduate Research Articles *continued*

# Letter from the Dean

***Michael Vayda***

## Publishing Research in *Discovery* Helps Students Become Leaders, Innovators, Entrepreneurs

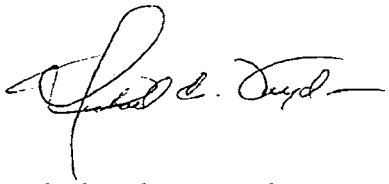
We in the Bumpers College are proud of our students and their accomplishments. The *Discovery* undergraduate journal highlights the work of our students conducting research projects under the mentorship of outstanding faculty. This is one example of the value-added educational experiences provided by our dedicated faculty to prepare our students for professional careers in the businesses associated with foods, agriculture, the environment, and human quality of life.

We are proud to showcase their work in the *Discovery* journal and promote their abilities as leaders, innovators, policy makers, and entrepreneurs, making them first-choice candidates of prospective employers.

The journal encourages students to engage beyond the classroom, offers an outlet to share results and findings in a citable publication, and provides a service to the college, the university, our friends and supporters, and society as a whole.

We encourage student research by awarding undergraduate research grants. Our students have been competitive for research and travel grants awarded by the Honors College, the Bumpers College, extramural benefactors, and the Arkansas Department of Higher Education. Many projects are designed to meet the requirements for an honors thesis in the Bumpers College Honors Program and some have been funded by our Undergraduate Creative Projects/Research Grants Program.

We are pleased to present the exceptional work of our students, which is a testament to them, our faculty mentors, and their research. Congratulations to the student authors, and thank you to the faculty mentors and editors of this year's journal.



Michael Vayda, Dean and
Associate Vice President–Academic Programs

# A Message from the Editorial Board

This is the 16th issue of *Discovery*, highlighting another year of undergraduate research accomplishments. This might be our most exciting issue ever!

*Discovery* was first published in the fall, 2000. I had the honor of serving as faculty editor for seven years. The first issue contained eight articles from six academic departments, and totaled forty-six pages. Our goal was to open an avenue for undergraduates to participate in the entire research experience: develop a relationship with a mentor, then plan, execute and conclude a research study. *Discovery* provided the last step, publication, the true measure of follow through. Seeing your name in print! This is always exciting to a young researcher and writer.

*Discovery* has come a long way. One could likely write pages of stories about students who had the opportunity to conduct research and publish in *Discovery* in the last 15 years, who then went on to pursue great professional achievements, many attending graduate school, and are now making major impacts in the world. This issue shares results of findings from our newest array of outstanding scholars. And, it is substantially larger, with a total of 112 pages of articles. That is quite the record of growth.

Very exciting is the inclusion of five articles from students and mentors in the School of Human Environmental Sciences. The topics reported in the current issue from HESC students include articles on food policy, breakfast nutrition, destination marketing, childhood obesity, and apparel packaging. This reflects a strong commitment in the School towards research.

Further, there are articles across a range of other topics including those in Environmental Sciences and sustainability reporting research on ecological restoration and habitat assessment, as well as compost processing and quality. Other studies in this area include aquatic nutrient competition and earthworm impacts in wheat and soybean production. Unique reports are also found on experiences of farmer's market families and hunger relief/food donation program missions. Two studies in Animal Science include a report on tall fescue intake and digestibility and one evaluating bull sperm motility responses. Finally, a report from Food Science shares results on chocolate paste production and characterization.

*Discovery* provides the final step in the research adventure, sharing results with others. Some might say "it is not finished until it is shared and reported," and they would be right. These articles reflect this noble final goal. This group of student authors will be tomorrow's leaders. I hope you rejoice with me in their accomplishments!

John R. Clark, *Discovery* Editorial Board Member
University Professor of Horticulture
University of Arkansas

## Undergraduate Research Articles

# Habitat assessment and ecological restoration design for an unnamed tributary of Stone Dam Creek, Conway, Arkansas

*Paige E. Boyle*[*], *Mary C. Savin*[†], *James A. McCarty*[§], *and Marty D. Matlock*[‡]

### ABSTRACT

Urbanization can lead to increased sedimentation, erosion, pollution, and runoff into streams. The United States Environmental Protection Agency's (USEPA) Rapid Bioassessment Protocols (RBPs) are sets of guidelines that can be used to assess a habitat's sedimentology, hydrology, vegetation, and geomorphology to determine impairment. An unnamed tributary of Stone Dam Creek on the University of Central Arkansas (UCA) campus in Conway, Arkansas runs partially underground and through the urbanized UCA campus watershed. The stream was assessed using the USEPA's RBPs to determine impairment of the stream, and received a RBP score of 71.2 out of 200 compared to 153.5 in a reference stream. An ecological restoration design was then prepared for a 2-year, 1-hour rainfall event to address areas of impairment. The goal was to increase the RBP score by increasing cross-sectional area of the stream as well as by improving stream morphology where possible. With the proposed design, modeled stream velocity was reduced throughout the stream by an average of 19.6%. It was assessed that as a result of the reduction in velocity and changes to morphology, RPB scores would increase throughout the stream reach.

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† Mary C. Savin, a faculty mentor, is a professor in the Department of Crop, Soil, and Environmental Sciences.
§ James A. McCarty is a program associate in the Office for Sustainability.
‡ Marty D. Matlock, a faculty mentor, is the Executive Director for the Office for Sustainability and a professor in the Department of Biological and Agricultural Engineering.

## MEET THE STUDENT-AUTHOR

***Paige Boyle***

I grew up in Bentonville, Arkansas and graduated with honors from Bentonville High School in 2011. I graduated from the University of Arkansas in May 2015 with a B.S. in Environmental, Soil and Water Science, and minors in Horticulture and Wildlife Habitat. During my undergraduate time at the University of Arkansas, I served as a student ambassador for the Dale Bumpers College of Agricultural, Food and Life Sciences; president of the Crop, Soil and Environmental Sciences Undergraduate Club; two-time intern for Boston Mountain Solid Waste District; and summer intern for the University of Arkansas Ecosystem Research Experience for Undergraduates (REU). I would like to thank Dr. Mary Savin for all her guidance as my academic and club advisor, research mentor, and professor. I would also like to thank Dr. Marty Matlock and the entire Arkansas Ecosystem REU program for providing the opportunity to conduct this research, and James McCarty for his patient supervision and instruction. I will be pursuing a graduate degree at the University of Arkansas starting in the fall of 2015.

## INTRODUCTION

Streams in densely populated areas can often exhibit "urban stream syndrome" which describes a series of changes in urban stream channels. These changes can include increased stream discharge, sediment, nutrients, pollutants, and temperature, and decreased biodiversity (Shoredits and Clayton, 2013; Walsh et al., 2005). Many restoration efforts focus on aesthetics (Charbonneau and Resh, 1992; Palmer et al., 2005; Shoredits and Clayton, 2013), yet do not specifically address ecological restorative needs. Ecological restoration focuses on restoring the stream to a natural, dynamic, and self-sustaining system, with increased ecological services (Palmer et al., 2005) such as habitat availability, nutrient and sediment cycling, and disturbance regulation (Costanza et al., 1997).

Several researchers have developed potential ecological restoration plans for on-campus streams on the Ohio State University at Marion (Huang et al., 2009), University of California at Berkeley (Charbonneau and Resh, 1992), and the University of Arkansas at Fayetteville (pers. comm., Matthew A. Van Eps, Watershed Conservation Resource Center) campuses. Implementation of the Strawberry Creek restoration at University of California at Berkeley successfully resulted in reintroduction and spawning of native fish, increased family richness of macroinvertebrates, increased water quality, and decreased erosion in the restored reach of the stream (Charbonneau and Resh, 1992). The Mullins Creek restoration on the University of Arkansas campus included in-stream features to divert flow away from the banks, along with bioengineering materials and re-vegetation using native species to reduce erosion along the banks (pers. comm., Matthew A. Van Eps, Watershed Conservation Resource Center).

The U.S. Environmental Protection Agency (USEPA) Rapid Bioassessment Protocols (RBP) provide guidelines for habitat assessment based on various parameters related to sedimentology, hydrology, vegetation, and geomorphology (Barbour et al., 1999). The RBP are useful for determining whether a stream is impaired (Stephens et al., 2008; Winger et al., 2005). The RBP can also be used in conjunction with other metrics to determine the cause of impairment (Mažeika et al., 2004; Stephens et al., 2008; Winger et al., 2005) or to monitor and compare restored sites (Price and Birge, 2005).

The purpose of this project was to measure the geomorphology of a 138-meter section of an unnamed tributary of Stone Dam Creek on the University of Central Arkansas (UCA) campus, Conway, Ark. This was done through surveying the stream thalweg (the line of lowest elevation within a valley or watercourse) to create a stream profile. Measuring the profile along the deepest point, the thalweg, allows the survey to capture changes in morphology, and also allows comparison between

current stream condition and future changes in stream channel aggradation patterns (Madej, 1999). Six stream reach cross sections were also surveyed to determine current water holding capacity of the tributary. Additionally, the USEPA's RBP habitat assessment methodology was conducted to determine ecological impairment of the stream. An ecological restoration design was then developed for the tributary based off the stream profile and cross-section data, with the goal of increasing the storage capacity of the tributary and improving the habitat assessment RBP score.

## MATERIALS AND METHODS

*Study Area*. The unnamed tributary leads into Stone Dam Creek on the UCA campus in Conway, Ark. It is part of the 109.04 km² Little Creek–Palarm Creek watershed, which is 35.5% urban cover and home to three major universities (ANRC, 2006). The tributary is highly channelized, and runs underground until it surfaces between a large parking lot and the UCA's Health, Physical Education, and Recreation (HPER) building (Fig. 1), which is currently undergoing construction. The area under study begins where the tributary exits the culvert south of Robins Street and ends at the far end of the HPER building, a total length of 138 m. The area was further broken up into three sections, with breaks between sections 1 and 2 at the dam and between sections 2 and 3 at the point of change in canopy cover (Fig. 2).

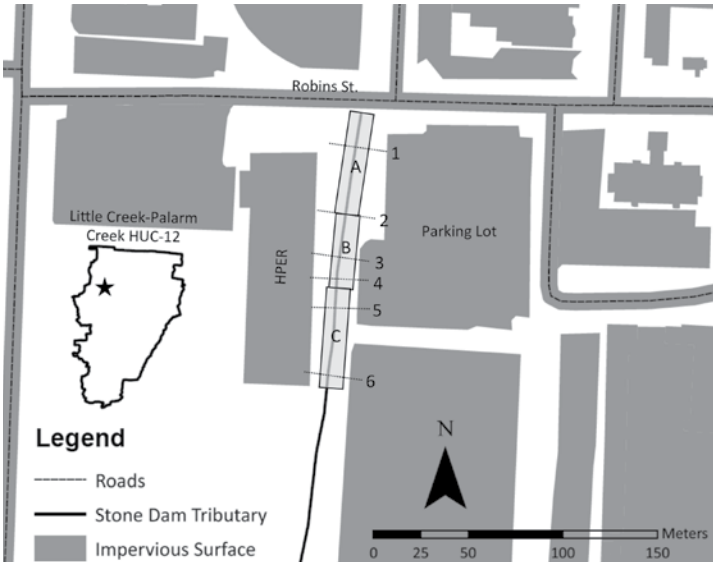


**Fig. 2.** Map of the study area within the Little Creek-Palarm Creek HUC-12 watershed. Study sections where Rapid Bioassessment Protocol assessment was performed are labeled A, B, and C. Surveyed cross sections are labeled 1-6.

**Fig. 1.** Downstream view of the unnamed tributary of Stone Dam Creek on the University of Central Arkansas campus, Conway, Ark. University of Central Arkansas Health, Physical Education, and Recreation building shown on the right, with a large parking lot to the left.

*Reference Area*. A similar restoration effort was conducted on Mullins Creek on the University of Arkansas campus in Fayetteville, Ark. between July and October, 2014 (pers. comm., Matthew A. Van Eps, Watershed Conservation Resource Center). The study area and reference stream share similar flow characteristics, low density urban/forest land use, and position in the larger watershed as a headwater stream. Additionally, both streams surface from underground drainage in similar manners after spending a considerable distance underneath their respective campuses. Mullins Creek and the study area suffer loss of riparian zones due to development, severe bank erosion, poor habitat, and sedimentation, which make the two streams well suited for comparison.

The Mullins Creek restoration utilized in-stream features to divert flow away from the banks, as well as revegetation efforts with native flora (Fig. 3) to increase habitat diversity and stabilize stream banks (pers. comm., Matthew A. Van Eps, Watershed Conservation Resource Center). Based on their similarities, a habitat assessment RBP was conducted on a 50-m reach of Mullins Creek to determine an estimate of what the unnamed Conway tributary habitat assessment goal could be after restoration. An average of four assessors' scores was taken.

**Fig. 3.** Upstream view of Mullins Creek on the University of Arkansas campus, Fayetteville, Ark.

*Habitat Assessment Parameters*. A visual habitat assessment was conducted in early July, 2014 for each of the three sections of the unnamed tributary, using the USEPA RBP habitat assessment for high gradient streams (Barbour et al., 1999). The high gradient approach was used because the study site consisted of the riffle-run morphology consistent with high gradient streams (Barbour et al., 1999). Parameters covered include: Epifaunal Substrate/Available Cover, Embeddedness, Velocity/Depth Regime, Sediment Deposition, Channel Flow Status, Channel Alteration, and Frequency of Riffles. Each of these parameters was graded on a 0-20 score, with 0-5 indicating Poor condition, 6-10 Marginal, 11-15 Suboptimal, and 16-20 Optimal. Bank Stability, Vegetative Protection, and Riparian Vegetative Zone Width were measured by individual bank, looking downstream, with each bank receiving a separate score of up to 10 points with 0-2, 3-5, 6-8, and 9-10 indicating Poor, Marginal, Suboptimal, and Optimal conditions, respectively. Each parameter has a description and criteria to follow when assigning a score (Barbour et al., 1999).

Each section received an average of three assessors' scores, with an overall average score for the entire study area calculated from the three average scores. An average of three assessors' scores was used due to inexperience with RBP habitat assessment scoring. This score was compared to the Mullins Creek score to determine whether the unnamed tributary was impaired when compared to a successfully restored creek.

*Physiochemical Assessment*. Other measurements were conducted for the purpose of determining water quality and for mapping the current geomorphology of the tributary bed. Rapid Bioassessment Protocol physiochemical parameters including water temperature and dissolved oxygen were recorded (Barbour et al., 1999). Percent riffle, run, and pool was estimated for the entire study site and stream width was measured at bankfull height. *In situ* water measurements were conducted using a YSI 550A dissolved oxygen meter (YSI Inc., Yellow Springs, Ohio) to determine dissolved oxygen concentration and temperature.

*Stream Profile and Cross Sections*. The thalweg was surveyed to produce a stream profile. Cross sections were surveyed along six transects across the study area to measure among different morphology types. Surveying was conducted using a Leica TCP1201 total station (Leica Geosystems, Inc., Norcross, Ga.) and Carlson Explorer data collector (Carlson Software, Maysville, Ky.). The data were downloaded onto ArcGIS (Esri, Redlands, Calif.), and Jag3D was used to correct the data points for georeferencing. Survey measurements provided reference points which were utilized when preparing the restoration design for the tributary. The measured stream profile was then used to determine potential sites for morphology alteration, while the cross-sectional areas helped determine points with potential for widening the stream cross-sectional area. Increasing the cross-sectional area will decrease the velocity and reduce erosion hazard within the stream.

*Rational Method*. ArcGIS was used to delineate the drainage area for the tributary. This information was then used as the area factor in the Rational Method (Eq. 1),

$$Q = CiA \qquad \text{Eq. (1)}$$

where $Q$ = maximum rate of runoff, $C$ = runoff coefficient, $i$ = average intensity, $A$ = drainage area (Marek, 2014; Bledsoe and Watson, 2001). Rational Method was used to determine peak rate of runoff for a 2-year, 1-hour storm event for the area (Marek, 2014; U.S. Department of Commerce, 1955). Using this calculated input, we could then plan the restoration design to decrease velocity of the stream by increasing cross-sectional areas of the measured transects.

*Restoration Design*. A stream restoration design was conducted based on the above measurements and with the following goals: 1) design for a 2-year, 1-hour rainfall event; 2) decrease velocity within the stream; and 3) create a profile with <7:1 distance between riffles to width of stream ratio (Barbour et al., 1999).

**Table 1. Average scores (n = 5) and category description based on Rapid Bioassessment Protocols (Barbour et al., 1999) for Mullins Creek reference reach on the University of Arkansas campus, Fayetteville, Ark.**

| Habitat Parameter | Average Score | Category Description |
|---|---|---|
| Epifaunal Substrate/Available Cover | 13.5 | Suboptimal – 40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale). |
| Embeddedness | 13.75 | Suboptimal – Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment. |
| Velocity/Depth Regime | 18 | Optimal – All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). |
| Sediment Deposition | 18.25 | Optimal – Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition. |
| Channel Flow Status | 16 | Optimal – Water reaches base of both lower banks, and minimal amount of channel substrate is exposed. |
| Channel Alteration | 9.25 | Marginal – channelization may be extensive; embankments or shoring structures present on both banks; and 40-80% of stream reach channelized and disrupted. |
| Frequency of Riffles (or bends) | 19 | Optimal – Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstructions is important. |
| Bank Stability (Score each bank) | Left bank – 9<br>Right bank – 8.5 | LB – Optimal – Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. Less than 5% of bank affected.<br>RB – Suboptimal – Moderately stable; infrequent, small areas of erosion mostly healed over. Five percent to thirty percent of bank in reach has areas of erosion. |
| Vegetative Protection (Score each bank) | Left bank – 9.25<br>Right bank – 8.5 | LB – Optimal – More than 90% of the stream bank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.<br>RB – Suboptimal – 70-90% of the stream bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than 50% of the potential plant stubble height remaining. |
| Riparian Vegetative Zone Width (Score each bank) | Left bank – 6<br>Right bank – 4.5 | LB - Suboptimal – Width or riparian zone 12-18 meters; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.<br>RB – Marginal – Width of riparian zone 6-12 meters; human activities have impacted zone only minimally. |

## RESULTS AND DISCUSSION

The reference stream's mean habitat assessment score was determined to be 153.5 out of a possible 200 points. Average scores by parameter and a description of the category class that each score falls under are provided in Table 1. The Mullins Creek site demonstrates a successful ecological restoration on a college campus, and provides a reference goal for the restoration of the tributary in Conway.

The study area morphology consisted of approximately 15% riffle, 85% run, and 0% pool. The deepest point of the stream, measured 2.03 m downstream from the culvert, was 0.40 m deep. High water mark was estimated to be at 1 m. The three sections were measured to be 51.8 m, 38.7 m, and 47.5 m each in length. With a stream bankfull width of 9.4 m, the section areas were calculated to be 0.49 $km^2$, 0.36 $km^2$, and 0.45 $km^2$, respectively. Water temperature of the stream was 26.1 °C and dissolved oxygen was measured to be 6.68 mg/L, both of which comply with the primary criteria of 31 °C or less and greater than 5 mg/L, respectively, for streams in the Arkansas River Valley (ADEQ, 2014).

Overall average habitat assessment score equaled 71.2 out of a possible 200. Average scores by parameter and a description of the category class that each score falls under are provided in Table 2. Figure 4 shows the stream profile, measured at the thalweg, as well as the measured water level. The profile shows the measured morphology of the tributary, indicating where riffles and runs are currently located along the study area. Figure 4 also shows the proposed restoration plan's profile.

The poor scores for epifaunal substrate/available cover and frequency of riffles (Table 2) indicate that habitat diversity is lacking in the stream system, which reduces the number of niches available to insects, fish, and macroin-

**Table 2. Average scores (n = 3) and category description based on Rapid Bioassessment Protocols (Barbour et al., 1999) for an unnamed tributary of Stone Dam Creek, Conway, Ark.**

| Habitat Parameter | Average Score | Category Description |
|---|---|---|
| Epifaunal Substrate/Available Cover | 2.2 | Poor - Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking. |
| Embeddedness | 4 | Poor – Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment. |
| Velocity/Depth Regime | 6.4 | Marginal – Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low). |
| Sediment Deposition | 10.3 | Marginal – Moderate deposition of new gravel, sand of fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent. |
| Channel Flow Status | 10.1 | Marginal – Water fills 25-75% of the available channel and/or riffle substrates are mostly exposed. |
| Channel Alteration | 6.7 | Marginal – Channelization may be extensive; embankments or shoring structures present on both banks; and 40-80% of stream reach channelized and disrupted. |
| Frequency of Riffles (or bends) | 4.7 | Poor – Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. |
| Bank Stability (Score each bank) | Left bank – 4.4<br>Right bank – 4.8 | Marginal – Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods. |
| Vegetative Protection (Score each bank) | Left bank – 6.3<br>Right bank – 7.3 | Suboptimal – 70-90% of the stream bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining. |
| Riparian Vegetative Zone Width (Score each bank) | Left bank – 1.7<br>Right bank – 2.3 | Poor – Width of riparian zone <6 meters: little or no riparian vegetation due to human activities. |

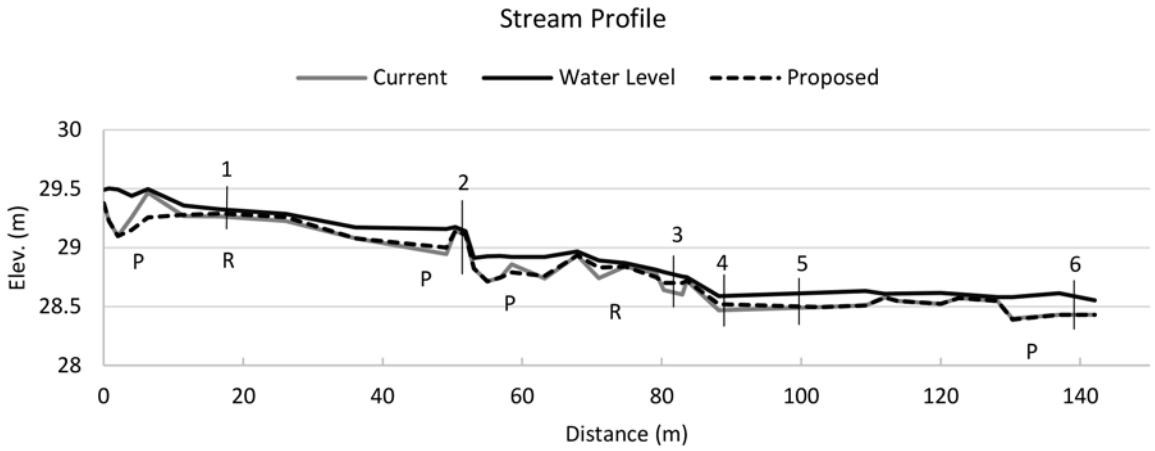


**Fig. 4.** Current and proposed stream profiles and measured water level of an unnamed tributary of Stone Dam Creek, Conway, Ark. Surveyed cross sections are labeled as 1-6. Areas of pools (P) and riffles (R) are labeled along the profile.

vertebrates (Barbour et al., 1999). The proposed profile improves existing geomorphology in the stream with the purpose of restoring a more natural channel structure. The main limiting factor in this design is the dam structure and the position of bedrock within the channel. The new profile elongates and deepens existing pools and increases the frequency of riffles from >25:1 to 4.5:1 ratio of distance between riffles divided by width of the stream. A change in riffle frequency would raise the RBP score for that parameter from poor to optimal. Creation of more diverse morphology, including deep pool areas, also increases the velocity/depth regimes present from two to three, which would increase the parameter score from marginal to suboptimal/optimal.

The low score for riparian width indicates that the riparian zone is less than 6 m wide (Barbour et al., 1999). Mayer et al. (2005) claimed that grass buffers needed to be over 5 m wide to be effective at reducing nitrogen from runoff before it enters the stream, which suggests that the current riparian zone is too narrow. In addition, riparian buffers provide bank stability and important habitat for biota. Riparian width is limited at this site due to the presence of the HPER building and the parking lot which border the site. This is a potential problem because the surrounding construction and parking lot can contribute pollutants such as oils, inorganics (including heavy metals), and sediment to runoff entering the stream (Davis et al., 2010; McQueen et al., 2010). Currently, the riparian zone consists largely of blackberry shrubs and herbaceous materials. Re-vegetating with a more diverse mixture of classes of native plants could help increase the habitat assessment score (Barbour et al., 1999).

Low habitat assessment scores for bank stability indicate a possible erosion hazard. Using the rational method (Eq. 1), peak flow ($Q$) was calculated to be 1.33 $m^3/s$. To address the risk of erosion, cross sections were designed to increase area, which would reduce stream velocity and reduce the erosion hazard. The bedrock that was predominant along the streambed, as well as the presence of the HPER building and the sidewalk bordering the parking lot restricted the amount of alteration possible for the cross sections; however, cross-sectional area was increased on all 6 transects by creating a step cross-sectional profile (Fig. 5). This allows a higher channel during high flow conditions. Velocities for the cross sections 1-6 were reduced by 18.6%, 11.9%, 10%, 13.9%, 36%, and 27%, respectively, with the proposed designs. The reduction in erosion would also reduce the amount of fine sediment and reduce embeddedness, which would further increase the habitat assessment score.

In summary, if implemented, this restoration design would increase habitat diversity and availability, decrease velocity and erosion hazard, and increase ecosystem services in a highly degraded stream channel. Improving pools in the stream profile and further defining riffles will increase the diversity of niches available to in-stream organisms. Increasing the stream cross-sectional area will reduce velocity and reduce risk of erosion along the stream banks. Further study to determine a suitable riparian zone width and plant composition, with a focus on diversity and the use of native plants, would further increase the ecological services provided by the stream system.

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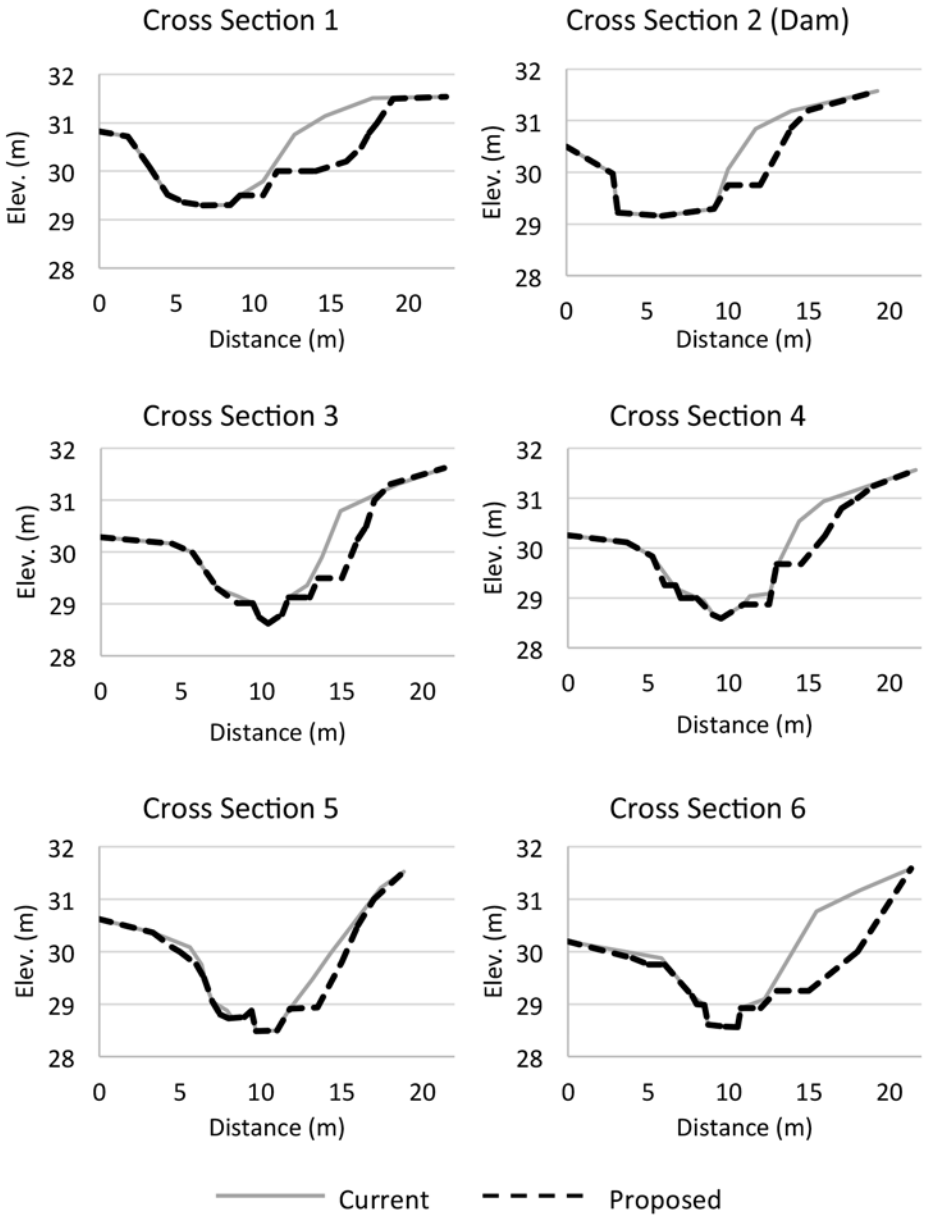


**Fig. 5.** Cross-sectional view of the six cross sections, measured and proposed, at an unnamed tributary of Stone Dam Creek, Conway, Ark. See Fig. 2 for location of cross sections.

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# The effect of turning frequency on in-vessel compost processing and quality

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## ABSTRACT

Composting can contribute to the zero waste initiative on the University of Arkansas (UA) campus. In-vessel systems like Earth Tubs™ are purported to provide better control of temperature and moisture during the composting process. Turning materials helps facilitate microbial activity and thermophilic composting. The goal of this research was to determine if turning frequency affects processing or final quality of compost made with pre- and post-consumer food waste feedstock and a wood chip bulking agent. Turning frequencies (treatment) of 3 days/week and 7 days/week were evaluated simultaneously throughout three sequential runs. Temperature, pH, electrical conductivity (EC), and moisture content (MC) were measured weekly during vessel filling. When the vessels reached one-half to two-thirds volumetric capacity, the compost entered a 30-day composting period during which no food waste or wood chips were added to the vessels, but turning continued. Total C, N, C:N ratio, and hot water extractable C (HWEC) and N (HWEN) were also measured at the conclusion of composting. Recommended values for temperature, pH, MC, and total C:N ratio are all possible to reach when composting with Earth Tubs™, but there is little to no effect of 3 days/week versus 7days/week treatment on final quality of compost, and quality is not consistent over time between runs. Further research would need to be done to assess whether Earth Tubs™ are a viable option for large-scale food waste composting at UA, and whether the logistics of having the vessels off-site lend themselves to a sustainable campus-wide composting program.

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## MEET THE STUDENT-AUTHOR

***Paige Boyle***

I grew up in Bentonville, Arkansas and graduated with honors from Bentonville High School in 2011. I graduated from the University of Arkansas in May 2015 with a B.S. in Environmental, Soil and Water Science, and minors in Horticulture and Wildlife Habitat. During my undergraduate time at the University of Arkansas, I served as a student ambassador for the Dale Bumpers College of Agricultural, Food and Life Sciences; president of the Crop, Soil and Environmental Sciences Undergraduate Club; two-time intern for Boston Mountain Solid Waste District; and summer intern for the University of Arkansas Ecosystem Research Experience for Undergraduates. I would like to thank Dr. Mary Savin for all her guidance as my academic and club advisor, research mentor, and professor. I would also like to thank Dr. Lisa Wood for all her assistance with the day-to-day composting operation and her guidance and patience as my instructor and club advisor. I will be pursuing a graduate degree at the University of Arkansas starting in the fall of 2015.

## INTRODUCTION

The University of Arkansas (UA) dining halls, run by Chartwell's Food Service, produce approximately 110 metric tons of food waste annually (pers. comm., Kim Johnson, Chartwell's Food Service). With an estimated cost to landfill at $132.30 per metric ton (pers. comm., Gary Enzor, UA Facilities Management), this amounts to $14,553 to landfill campus dining hall food waste each year.

In 2007, UA signed the American College and University Presidents' Climate Commitment Plan, which launched the university's zero-waste initiative (pers. comm., Carlos Ochoa, UA Office for Sustainability). The UA now has a goal of being zero waste by 2021, which entails 90% diversion (UAOSAP, 2014). This is achieved by keeping 90% of campus-produced waste out of the landfill through preventative planning, recycling, and composting (UAOSAP, 2014). The UA Office for Sustainability claims to be at 16% diversion as of December, 2014 (UAOSAP, 2014). In August, 2013, the UA Crop, Soil and Environmental Sciences Club (CSES) Club, in collaboration with the Office for Sustainability, began composting food waste provided by Chartwell's Food Service as a method of diverting food waste from Fulbright Dining center on campus. Composting food waste is one method of increasing the UA diversion rate and reducing waste on campus.

Composting refers to the decomposition of piled, moist organic material under aerobic conditions (Brady and Weil, 2002). For composting to occur, temperatures must progress through a mesophilic range, to a thermophilic stage, followed by a mesophilic curing stage where temperatures reduce to ambient levels (Pepper et al., 2006). Mesophilic temperatures are considered moderate, ranging from 15 °C to 40 °C (Brady and Weil, 2002). Thermophilic temperatures range from 45 °C to 90°C (Brady and Weil, 2002).

Nutrient cycling processes are impacted by aeration. To ensure decomposition of the organic material in compost, proper nutrient ratios, suggested to be between 20:1 and 40:1 for C:N (Kumar et al., 2010; Monson and Murugappan, 2009; Chang and Chen, 2010), are required for input materials (feedstock and bulking agents). Activity of the microbial community is affected by moisture and proper aeration, which are necessary to ensure optimal temperatures are reached during the composting process. Too little aeration can result in non-uniform moisture and temperature, anaerobic conditions, buildup of harmful gases, odor, and limited decomposition. Excessive aeration can lead to loss of heat needed for thermophilic stage microorganisms and moisture reduction, which in turn, increases composting time (Brady and Weil, 2002; Xu et al., 2012; Guo et al., 2012).

Closed, in-vessel systems such as Earth Tubs™ are purported to provide greater degree of control of the composting atmosphere, reducing composting time to only three weeks (Kalamdhad and Kazmi, 2009 a,b; Monson and Murugappan, 2009). Through a 2008 pilot study, UA

received two Earth Tub™ composting vessels (Teague, 2011), and in 2013, the composting operation was taken over by the CSES Club. As composting relied on volunteers, determining if reduced effort in turning (aerating) materials in the vessel could achieve compost of similar quality in the same time frame as daily turning became an important objective. Thus, the objective of this study was to determine if turning (aeration) frequency (3 days/week versus 7 days/week) for an in-vessel composting system impacts compost processing or final quality of compost to be used for food production.

## MATERIALS AND METHODS

The in-vessel composting was completed in two Earth Tubs™ (Green Mountain Technologies, Bainbridge Island, Wash.), located at the Division of Agriculture Agricultural Research and Extension Center, Fayetteville, Ark. Each Earth Tub™ was capable of holding up to 2.3 $m^3$ of waste and contains a 30-cm diameter stainless steel mechanized auger, which can move the radius of the vessel. Each Earth Tub™ lid is equipped with handles, which were used to manually turn the rotating auger around the vessel to mix and aerate the composting materials within the stationary vessel.

The food waste feedstock was provided primarily by Chartwell's Dining Services and delivered by Facilities Management. Additional food waste was provided by the School of Human and Environmental Sciences and the Jean Tyson Child Development Center to supplement the dining hall food waste to help fill the vessels during the first run. Food waste was split by volume between the two vessels. Wood chips, supplied by the Division of Agriculture, were added at a 1:1 (vol:vol) ratio to food waste as the bulking agent to increase the C:N ratio and reduce the high moisture content (MC) of the food waste. Wood chips were heterogeneous in size and of unknown source.

Treatments of rotation 3 days/week (MWF) or 7 days/week were randomly assigned to a vessel and replicated over time in three separate, consecutive composting runs from January 2014–April 2015. Each run consisted of a period of vessel-filling until the vessels were approximately one-half to two-thirds full, followed by a 30-day composting period, the solids retention time used by Kim et al. (2008).

Temperatures were measured on a weekly schedule during both the filling and maturation stages, and at the time of final compost sampling. Weekly samples of compost were collected throughout the composting process until vessels were emptied to measure pH, electrical conductivity (EC), and MC, as indicators of compost maturation. Samples were collected with a 6.4-cm diameter soil auger. Five auger samples were composited per sample, and two samples were collected per vessel per week. The pH and EC were measured for each sample at a 1:2 compost:water (wt:vol) ratio (10 g compost:20 mL deionized water) by pH and EC electrodes and meter. Gravimetric moisture content was calculated on a wet weight basis after oven-drying compost at 55 °C for 5 days.

Once the vessels reached approximately one-half to two-thirds volumetric capacity, the compost was allowed to stabilize for 30 days. Aeration through turning continued during this stage, but no food waste or wood chips were added. Vessels were emptied at the end of the 30-day period. Two composite samples per vessel per run were collected at emptying and split into three subsamples each per vessel to measure hot water extractable carbon (HWEC) and nitrogen (HWEN), total C and N, and associated C:N ratios to assess final compost quality. The total C and N in wood chips (n = 6) and final compost was measured by combustion at 950 °C (Leco Corp., St. Joseph, Mich.). Hot water extractable C and N were measured in 1:10 (wt:vol) extracts after 16 h incubation at 80 °C using a procedure modified from Ghani et al. (2003). Carbon and N in diluted extracts were measured on a Shimadzu TOC-V PC-controlled total organic C with attached total-N analyzer (Shimadzu, Columbia, Md.).

Temporal changes in compost were observed separately for the first run due to the time difference between run 1 and runs 2 and 3. Temporal trends for temperature, moisture, pH and EC were assessed qualitatively for the final two runs. The C and N concentrations were evaluated by analysis of variance (ANOVA) in SAS v. 9.4 (SAS Institute, Inc., Cary, N.C.) as a randomized complete block (RCB) with subsampling, with run as the block and vessel as the treatment. Contribution of both the block-by-treatment and subsample variance to the total error was assessed. Least square means were compared using a protected least significant difference procedure where appropriate ($P < 0.10$).

## RESULTS AND DISCUSSION

**Compost Processing**

Run 1 ran from 18 January 2014 to 30 August 2014, lasting 32 weeks, due to lack of food waste delivery. Run 2 lasted 12 weeks from 31 August 2014 to 21 November 2014; and run 3 lasted 10 weeks and ran from 28 January 2015 to 6 April 2015.

Run 1 temperatures followed the normal composting stages outlined by Brady and Weil (2002) during vessel filling. Temperatures began below mesophilic ranges, but warmed to mesophilic ranges by 19 February (week 4). Mesophilic range temperatures were maintained until temperatures increased to a thermophilic range in early May (week 15). Temperatures dropped back down to

mesophilic temperatures in mid-June (week 20; Fig. 1). Between 5 May and 7 May 2014, 55 °C was reached and maintained in both treatments. There was very little overall difference in temperatures between treatments; and during the final 30-day composting period, the temperatures in the 3 days/week and 7 days/week treatments were essentially the same. The point of temperature increase to thermophilic ranges coincides with the increase in EC (Fig. 2) and decrease in MC (Fig. 3) that occurred between week 14 and 15. The increased EC and decreased MC occurred about the time of the switch to post-consumer food waste. Run 1 confirmed that thermophilic temperatures were possible to reach within the Earth Tub™ vessels.

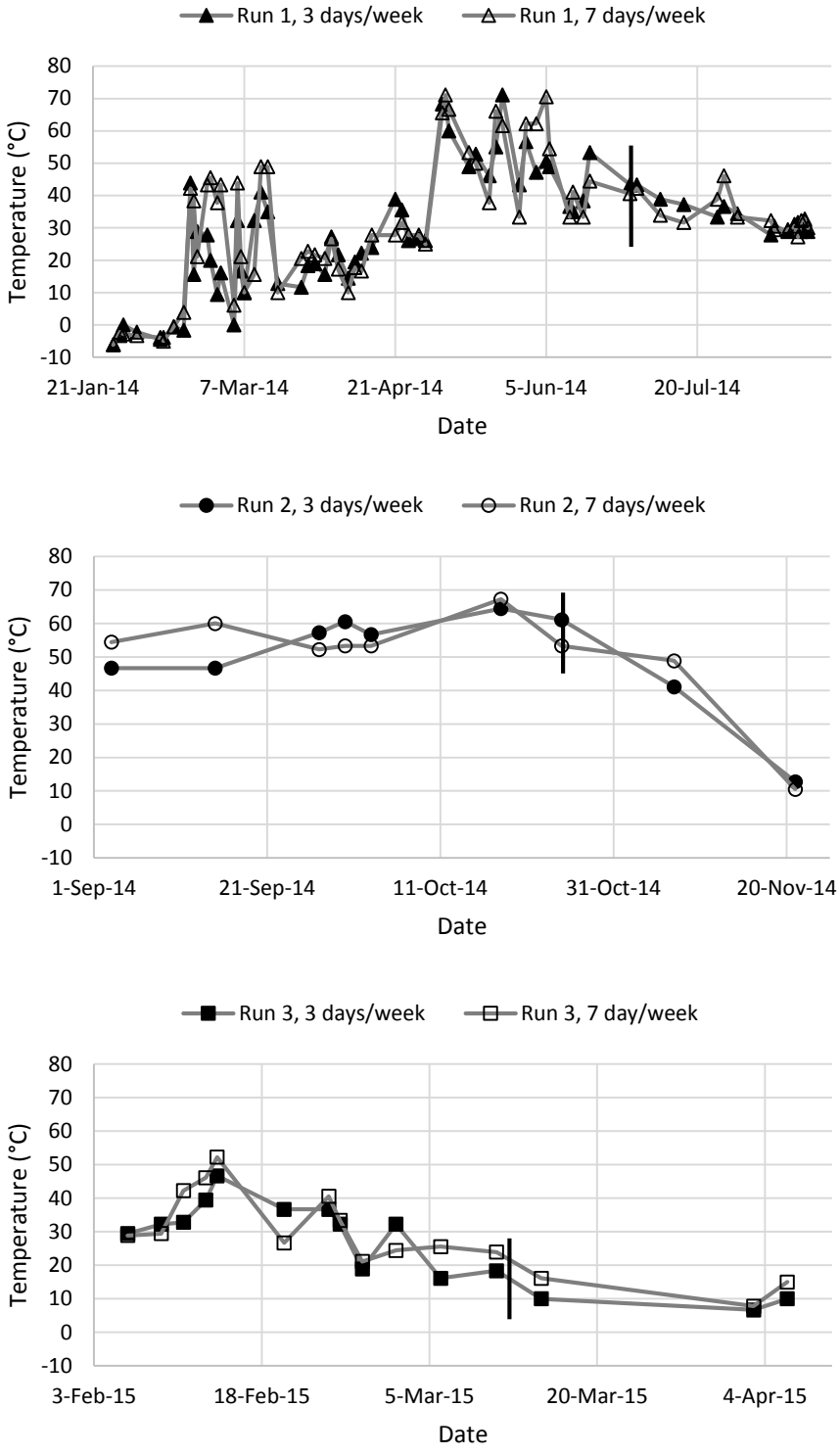


**Fig. 1.** Temperatures for runs 1, 2, and 3. Solid lines indicate the beginning of the 30-day composting period for each run.

Both treatments in run 2 reached and maintained temperatures in the thermophilic range during vessel filling (Fig. 1). The 3 days/week treatment reached and exceeded the 55 °C between 27 September and 25 October 2014 (weeks 4–8). The 7 days/week treatment reached a maximum temperature of 67 °C on 18 October, but did not maintain above 55 °C for three days. In contrast, both treatments in run 3 remained within the mesophilic range with the exception of one sampling point in the 3 days/week treatment and two sampling points in the 7 days/week treatment, all in mid-February (week 3; Fig. 1). Neither treatment reached 55 °C.

Measurements for run 1 MC, pH, and EC began in week 8. Moisture content for both treatments in run 1 began and was maintained in the 50-70% range recommended by Chang and Chen (2010), Guo et al. (2012), and Monson and Murugappan (2009) until week 14 when moisture content declined in both treatments (Fig. 4). Moisture content remained variable between treatments, with the 3 days/week treatment having overall lower moisture content (Fig. 3). At week 24, moisture content in the 7 days/week treatment returned to the 50-70% range, and remained in this range through the 30-day composting period (Fig. 3). Moisture

content for the 3 days/week treatment only reached the recommended range at weeks 7 and 30, but final moisture content at 43.8% was below the recommended range (Fig. 3).

Moisture content for both treatments in run 2 generally decreased throughout vessel filling. Both treatment values were similar except at week 4, when there was a 16% difference between treatments (Fig. 3). Moisture content for both treatments in run 2 was initially within the 50-70%, but by the end of the composting period, MC had decreased below the recommended range (Fig. 3). There was a final difference of 2% in MC between the two treatments in run 2 (Fig. 3). Moisture content for run 3 remained within the 50-70% range recommended throughout the filling and final 30-day composting periods (Fig. 3). Moisture was also similar between treatments throughout the process, with the largest difference of 3% at week 5 (Fig. 3).

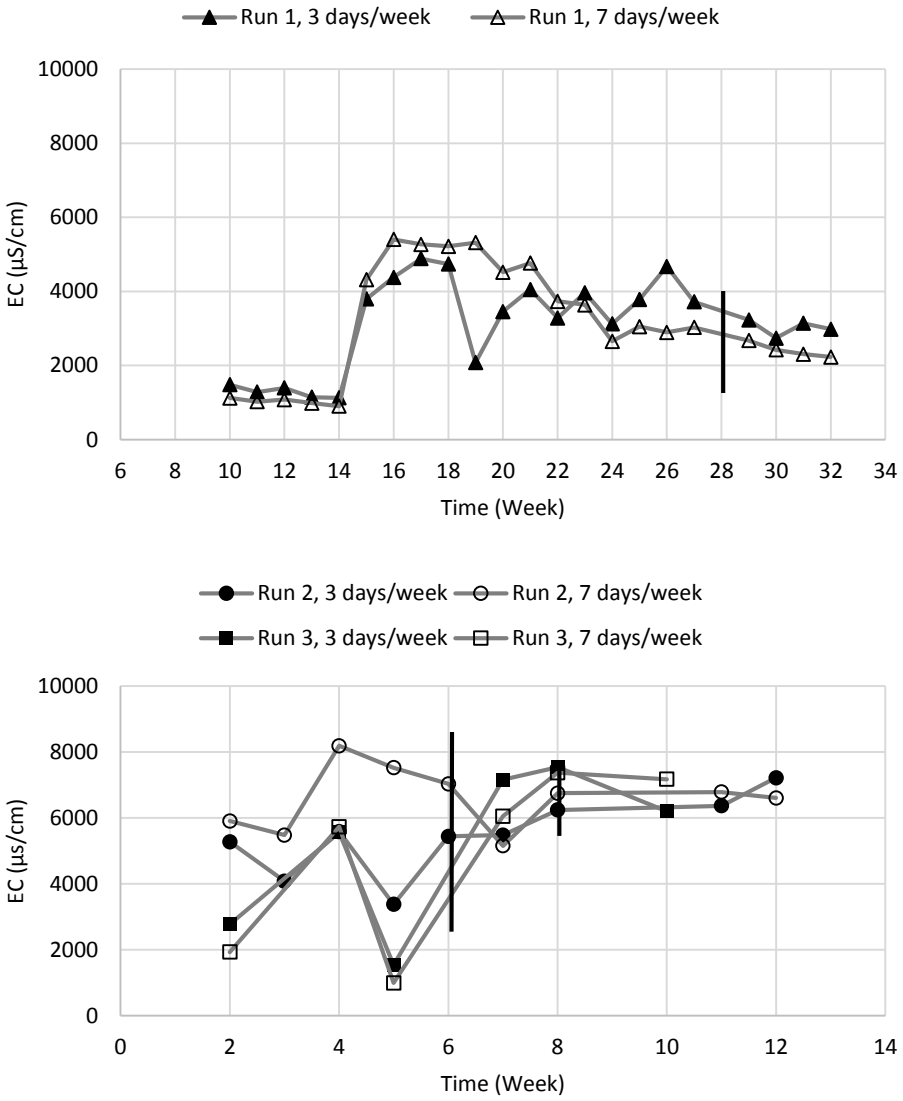


**Fig. 2.** Average electrical conductivity for runs 1, 2, and 3. Solid lines at weeks 28, 8, and 6 indicate the beginning of the 30-day composting period for runs 1, 2, and 3, respectively.

Average pH for run 1 was similar between treatments with values of 7.2–8.8, until week 19 when the 3 days/week treatment decreased to a low of 6.1 by week 25 (Fig. 4). The pH for the 7 days/week treatment remained within the recommended values of 7–8 (Kalamdhad and Kazmi, 2009b; Antil and Raj, 2012), with the exception of week 29, when the pH rose to 8.1 (Fig. 4). Both treatments followed the expected initial increase followed by a decrease in pH as organic material was broken down, resulting in the production of organic acids, as discussed by Wu et al. (2000). Final pH for the 3 days/week and 7 days/week treatments remained steady between 6.1–6.3 and 7.6–8.1, respectively, indicating that 7 days/week aeration results in a higher pH that better fit the recommended 7–8 range of values, while 3 days/week aeration results in lower pH.

The pH for runs 2 and 3 was highly variable throughout time in both treatments, although it differed between runs (Fig. 4). The pH in run 2 for both treatments generally increased from around pH 6 and stabilized after week 8 to around pH 8 during the final 30-day composting period (Fig. 4). Run 3 had variable pH throughout the vessel filling, but stabilized at around pH 5 at week 7 which was during the final 30-day composting period (Fig. 4). The decrease in pH at the 7 week mark for run 3 coincided with the observed presence of standing water in both Earth Tub™ vessels (affecting both treatments), which suggests that the drop in pH was potentially the result of the shift to pockets of anaerobic activity, during which decomposition would be expected to slow down and acids would be produced (Brady and Weil, 2002).

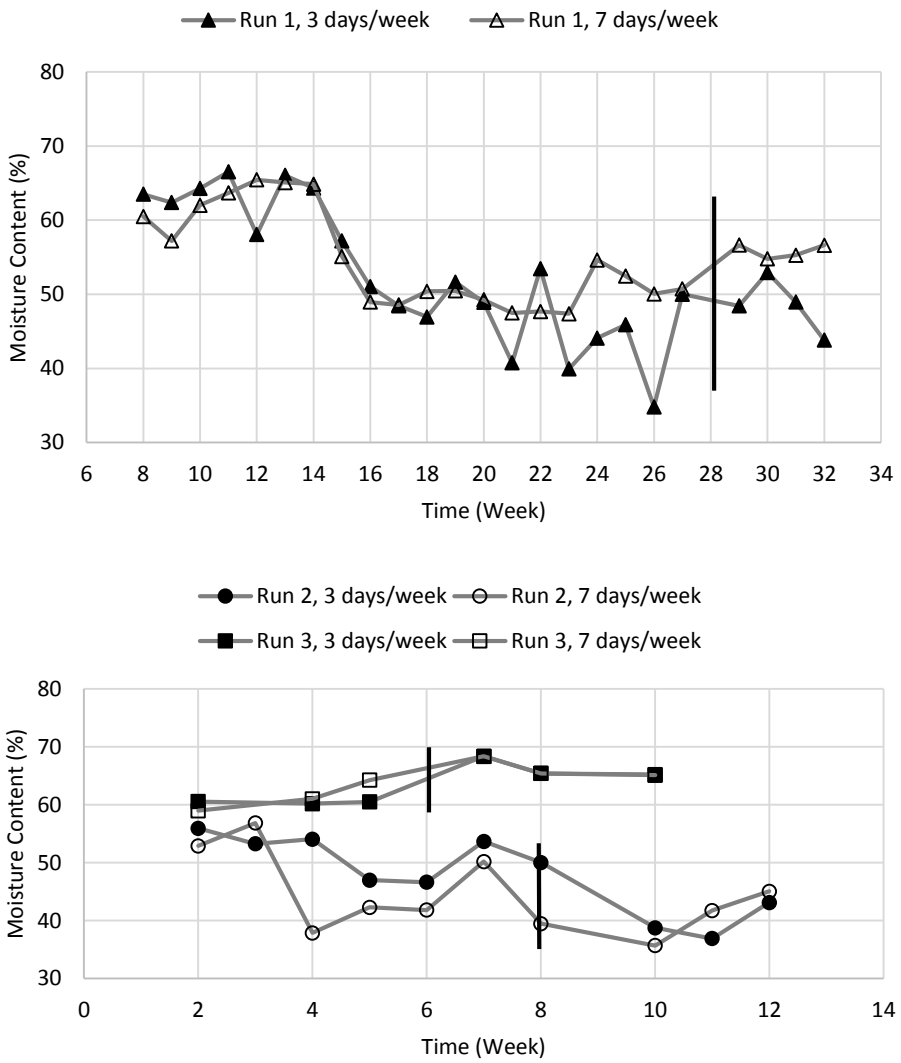


**Fig. 3.** Average gravimetric moisture content for runs 1, 2, and 3. Solid lines at weeks 28, 8, and 6 indicate the beginning of the 30-day composting period for runs 1, 2, and 3, respectively.

Electrical conductivity in run 1 started relatively low, compared to runs 2 and 3 (Fig. 2). This is potentially related to the food waste feedstock type. Initially, feedstock consisted of pre-consumer food waste, to include coffee grounds, egg shells, and vegetable scraps. At week 15, there was a noticeable increase of EC that coincided with the switch to include post-consumer food waste in the feedstock. This change was made to increase the amount of food waste received in an effort to fill the vessels more quickly. Post-consumer food waste included processed foods, sauces, occasional meats, and other cooked foods. The change in food waste composition resulted in increased EC throughout the rest of the project. Weeks 19 and 26 show noticeable differences in EC between treatments; but overall, EC during vessel filling remained fairly similar (Fig. 2).

Electrical conductivity was variable throughout both treatments for both runs 2 and 3 (Fig. 2). In run 2, EC varied by as much as 1400 and 2600 µS/cm between treatments at weeks 4 and 5, respectively. However at week 6 (the beginning of the final 30-day composting period), the difference diminished, and at the end of the composting period, the two treatment values varied by about 600 µS/cm (Fig. 2). The EC in run 3 was initially lower than that of run 2 (Fig. 2). There was a noticeable peak at week 4 before the EC decreased to the lowest point at week 5; however, values rose again and remained similar to run 2 values, regardless of treatment, for the remainder of the composting period (Fig. 2).

**Final Compost Quality**

Compost quality can be determined by measuring various parameters. Temperature indicates whether compost reached the U.S. Environmental Protection Agency (USEPA) standard of 55 °C maintained for 3 days, which is necessary to kill weed seed and pathogens (USEPA, 2002; Kalamdhad and Kazmi, 2009a; Monson and Murugappan, 2009), and whether the compost has progressed through the mesophilic, thermophilic, and curing stages (Brady and Weil, 2002; Pepper et al., 2006). Temperature in all three runs reached thermophilic stages, then decreased to temperatures at or below mesophilic ranges by the end of the 30-day composting period (Fig. 1). This suggests that the vessels are able to process the temperature stages of compost. Final temperature never varied between treatments more than 5 °C (run 3), which suggests there is little or no effect of turning frequency in final temperature of compost.

Neither the 7 days/week treatment in run 2 nor either treatment in run 3 reached the 55 °C threshold, and as

such, would have restricted use due to the risk of weed seed germination and potential pathogenic effects if used for food crop production. Both treatments in run 1, as well as the 3 days/week treatment in run 2 were able to reach the 55 °C threshold to kill pathogens and weed seed.

Moisture must be maintained between 50-70% gravimetric moisture content (MC) on a wet-weight basis (Chang and Chen, 2010; Guo et al., 2012; Monson and Murugappan, 2009) to facilitate transport of dissolved nutrients and waste removal without development of anaerobic conditions (Kumar et al., 2010; Guo et al., 2012). Moisture content for all treatments and runs was maintained at or below the recommended moisture content. This could be amended by altering the bulking agent content or ratio, to better control moisture throughout the process. Standing water was observed during the final 30-day composting period in both treatments of run 3. This resulted in moisture contents higher than those in runs 1 and 2 but did not result in moisture content percentages outside of the recommended values. Though end MC was different between runs 2 and 3, the final MC in each run was similar between treatments (Fig. 4). The results suggest that there was no effect of aeration treatment on final MC of compost produced in Earth Tub™ vessels.

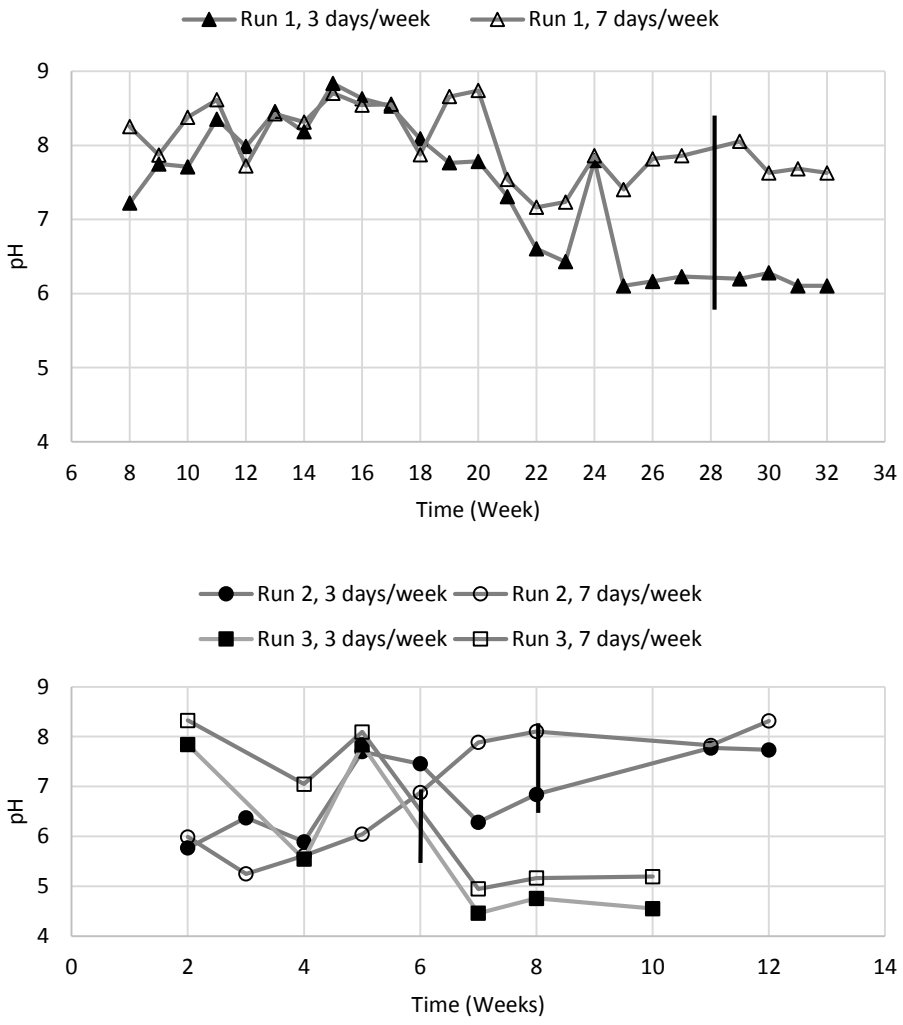


**Fig. 4.** Average pH for runs 1, 2, and 3. Solid lines at weeks 28, 8, and 6 indicate the beginning of the 30-day composting period for runs 1, 2, and 3, respectively.

Other parameters, including pH and electrical conductivity (EC), affect microbial development and activity (Kim et al., 2008). The pH value can be used as an indicator of maturation of compost, with an ideal pH around 7–8 (Kalamdhad and Kazmi, 2009b; Antil and Raj, 2012). End pH was different between runs, but the final pH values in each run were similar between treatments (Fig. 2). The results suggest that there was no effect of turning frequency on final pH of compost, though there was a noticeable difference in pH values between runs. The 7 days/week treatment of run 1 and both treatments in run 2 resulted in pH between 7 and 8, as recommended by Kalamdhad and Kazmi (2009b) and Antil and Raj (2012). This suggests that the in-vessel systems are capable of producing compost with a desirable final pH, but results were not consistent through time. This inconsistency could be related to possible pockets of anaerobic activity that would be expected to result in the production of strong acids, as may have been the case in run 3.

Final EC was highest in the 3 days/week treatment for all 3 runs, with the largest treatment difference of 920 µS/cm in run 3 (Fig. 2). This suggests that aeration potentially could have an effect on the final EC of compost produced in an in-vessel system, as turning helps distribute nutrients and thus helps facilitate breakdown of material by microbes in the compost. Final EC of run 1 ranged from 2230–2980 µS/cm, which is lower than the final

**Table 1. Final mean total C, total N, and hot water extractable C after composting food waste and wood chips in Earth Tub™ vessels during three separate consecutive runs.**

| Run # | Total C (%) | Total N (%) | Hot Water Extractable C (mg/g) |
|---|---|---|---|
| 1 | 40.97a† | 3.29a | 15.01b |
| 2 | 26.73c | 2.19c | 24.24a |
| 3 | 35.08b | 2.81b | 28.64a |
| *P* value | 0.0299 | 0.0099 | 0.0935 |

† Means followed by a similar letter are not significantly different.

EC value of 4840 µS/cm found for food waste compost by Kalamdhad and Kazmi (2009b). Final EC for runs 2 and 3 ranged from 6195–7215 µS/cm (Fig. 2), which was higher than that found by Kalamdhad and Kazmi (2009b). These differences could be due to differences in food waste composition. All final EC values were above the 1500 µS/cm value recommended by the University of Missouri Extension (2015); however, this recommendation is based on compost used as a growing medium, and does not factor in the dilution effect that occurs when compost is mixed with other media, such as soil.

Total C differed significantly ($P = 0.0299$) by run but not treatment ($P = 0.2859$; Table 1). The lack of significant difference in mean total C between treatments suggests that there is no consistent effect of turning frequency on total C of compost produced in an in-vessel system. Differences among runs may be due to differences in feedstock composition, differences in initial wood chip C content, and the possible anaerobic pockets which would prevent C breakdown by microbes. Final total C for run 1 is higher than those found by Kim et al. (2008) and Kalamdhad and Kazmi (2009b), where final total organic C of compost made with food waste feedstock was 34% and 24.82%, respectively. Total C could be reduced by adjusting the amount of wood chip bulking agent added in with the feedstock. It would be beneficial to measure initial total C of inputs and total C throughout composting, so adjustments could be made as necessary to ensure conditions suitable for microbial metabolism.

Total N consists of inorganic and organic forms of N. Total N differed by the run ($P = 0.0099$) but not treatment ($P = 0.1599$; Table 1). Mean total N for all three runs were higher than the 1.2–1.7% final N reported by Antil and Raj (2012). Differences in total N could be related to differences in the feedstock used as Antil and Raj (2012) composted farm and agro-industrial wastes of different compositions.

Total C:N ratio is an indicator of compost maturity, with an ideal initial C:N ratio of 20:1 and 40:1 for C:N (Kumar et al., 2010; Monson and Murugappan, 2009; Chang and Chen, 2010) and an ideal final C:N ratio under 15–20 (Antil and Raj, 2012; Kim et al., 2008). The average initial C:N ratio of the wood chips was 24:1, which was within the recommended range. Total final C:N was 12.4:1, and was not significantly affected by run ($P = 0.6382$) or treatment ($P = 0.6021$). This ratio complies with the recommendations of Antil and Raj (2012) and Kim et al. (2008) of 15 or less for mature compost, and is an indication that the compost was mature; however, Antil and Raj (2012) do state that C:N ratio cannot be used exclusively to determine maturity of compost. Subsamples accounted for 42%, 89%, and 95% of total variance for total C, N, and C:N, respectively (data not shown). The high variability in amount of C and N in the material within a vessel may indicate that the composting process was incomplete.

Dissolved C represents the easily accessed and biodegradable sugars and acids in the composting material (Antil and Raj, 2012). The recommended level of dissolved C is <10 mg C/g on a water extractable basis (Antil and Raj, 2012). There was a significant effect of HWEC on run ($P = 0.0935$; Table 1) but not treatment ($P = 0.7943$; data not shown). All HWEC values were above the recommended 10 mg C/g, likely due to the fact that the dissolved C of a hot water extractable sample would naturally be higher than that of a water soluble test due to the heat involved. This measure of dissolved C also suggests that there was still easily biodegradable C within the compost, and that the compost was not yet mature.

Neither run nor treatment was significant for HWEN ($P = 0.8241$ and 0.5213, respectively) or the HWEC:HWEN ratio ($P = 0.1051$ and 0.3466, respectively; data not shown). Subsamples accounted for 44%, 44%, and 47% of total variance for HWEC, HWEN, and HWEC:HWEN, respectively (data not shown). The large contribution to the total variability for hot water extractable C and N in the material within a vessel may also be indicating that the composting process was incomplete.

**Lesson Learned and Recommendations for UA Earth Tub™ Composting**

Use of in-vessel composting can come with multiple challenges in a university campus setting, including establishing coordination and cooperation among multiple groups of participants (dining hall, food waste transportation, compost volunteers, maintenance workers, etc.). Utilization of the vessels is labor intensive, as they need manual rotation of the vessel lid to aerate and turnover the food waste, and the vessels are subject to mechanical break down and failures when housed outside. It was difficult to maintain volunteer interest over the course of a year time period.

The location of the vessels was established prior to this study, as they had been installed during a previous pilot

study (Teague, 2011). This caused logistical problems, as the food waste had to be transported from the UA campus to the UA farm. I would suggest that the Earth Tub™ vessels only be used on-site, so as to avoid transportation issues.

## CONCLUSIONS

Turning (aeration) frequency (3 days/week versus 7 days/week) for an in-vessel composting system was investigated using two Earth Tubs™ located at the UA Agricultural Research and Extension Center, Fayetteville, Ark. during three separate, consecutive composting runs from January 2014–April, 2015. Overall, there was little to no effect of turning frequency on compost processing or quality, and the Earth Tub™ vessels produced compost with inconsistent quality. Additionally, the in-vessel systems were not equipped to compost food waste in as short a time as 2–3 weeks, as projected by Kalamdhad and Kazmi (2009a, 2009b) and Monson and Murugappan (2009). It should also be noted that this project only utilized food waste from one of the three dining halls on campus. If the UA were to expand the composting operation to include all dining halls and other food service providers, as would be necessary to achieve its zero waste initiative, there would need to be further research conducted to assess if the Earth Tubs™ were a viable option for handling an increased food-waste stream. Location and logistics would also need to be reassessed, and the potential for either on-site composting or a change in transportation and labor would need to be made to make UA composting sustainable.

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# Leadership in food policy: raising a foodie part II

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## ABSTRACT

Obesity is experiencing a problematic rise in America. Children develop habits that potentially last a lifetime, which also dictate their medical fate. The focus of this study was to identify and decrease the factors of childhood obesity through education, healthy eating, and changes in food choices through surveys administered by the researchers. Previous research has linked obesity to the diagnosis of type 2 diabetes and chronic diseases in children through decreased physical activity and poor diet due to the lack of essential nutrition knowledge. Other factors contributing to childhood obesity include poor food preparation/creation, deceptive advertising, cultural habits, and an increased demand for fast and convenience foods; leaving children's recognition and desire for healthy food choices clouded. The purpose of this study was to discover the factors contributing to childhood obesity in the Hispanic culture. Therefore, childhood obesity factors were explored that related to and specifically linked food purchases, childhood activities, and eating patterns. The study took place with a prevalently Hispanic population within Springdale, Arkansas. The findings indicated that price, as well as nutrition and taste, were major factors when purchasing food. In addition, what a child ate, the amount of food the child ate, what the child weighed, and if the child participated in some form of exercise were determined to be factors contributing to childhood obesity.

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## MEET THE STUDENT-AUTHORS

***Ashlyn Cook***

I was born and raised in Jefferson City, Missouri, but now call Northwest Arkansas home. I graduated in May 2015 from the University of Arkansas with a B.S. in Human Environmental Sciences, majoring in Human Nutrition and Hospitality Innovation, with a concentration in Hospitality Innovation and a minor in Spanish. To broaden my knowledge, I participated in a one-month intensive language-study program in Spanish composition and culture in Madrid, Spain during the summer of 2013. I have been a member of the Hospitality Club, as well as the AFLS Honor's Program, Mortar Board National Honor Society and the Order of Omega Honor Society. During my senior year, I interned at the Razorback Foundation and was an active member of Kappa Kappa Gamma sorority, where I served as Vice President of Academic Excellence. I have enjoyed being involved in multiple organizations on campus, as well as volunteering throughout the community. Faith, family and friends are the three most important parts of my life. I enjoy music, writing, the outdoors and investing time in others.

I would like to thank Dr. Kelly Way who has given an immense amount of time to guide, teach and mentor Amy and me this past year. She gave both Amy and I the motivation and confidence to complete our thesis with enthusiasm and positivity.

I was born and raised in Little Rock, Arkansas where I grew up spending most of my time outdoors, traveling and playing soccer. I have always been a big Razorback fan, and when I visited the school, it was like fitting the final pieces of my puzzle together. I was drawn to the Hospitality program and what the University had to offer. I immediately began taking classes and diving into this incredible experience freshmen year.After getting the opportunity to study abroad in Spain the summer before my junior year, I knew I needed to tackle Spanish as my second major, and I truly fell in love with the language. I also began my experience during my junior year working for the catering and events company on campus known as Chartwell's where I have learned many fundamental skills and traits that I plan to take into my coming endeavors.

I would like to thank my advisor and mentor, Dr. Kelly Way, for her unending support and guidance she has shown to me along the way. She is a constant encouragement and a source of laughter that I incredibly appreciate.

***Amy Moorehead***

## INTRODUCTION

During the past 30 years, childhood obesity has more than doubled in the United States alone (Centers for Disease Control, 2015). Obese children have been found to have risk factors for cardiovascular disease, high cholesterol levels, high blood pressure, and abnormal glucose tolerance (National Collaborative on Childhood Obesity Research, n.d.). Nearly $150 billion per year has been spent to treat obesity-related medical conditions (Solving the Problem of Childhood Obesity within a Generation, 2010). Childhood obesity has become the number one health concern among parents in the United States surpassing drug abuse and smoking (American Heart Association, 2014).

In relation to different childhood ethnic groups, Hispanic children suffer more from increased obesity rates. Due to the lack of available healthy foods and the low income associated with Hispanic parents, there has been a rise in poor eating habits among Hispanic children (Cummins et al., 2014). Hispanic children traditionally have had a greater risk for obesity than their Caucasian or African-American peers (Leadership for Healthy Communities, 2010). According to Rodriguez (2011), 38.2% of Hispanic children ages 2 to 19 were overweight or obese, compared with 31.7% of other ethnic children. This percentage is particularly alarming given that Hispanic children comprise 22% of the United States youth and represent the largest and fastest-growing minority group in the nation (Salud America!, n.d.).

The purpose of this study was to discover the factors contributing to childhood obesity in the Hispanic culture. The two research questions this study explored were: 1) What factors do Hispanic families feel are most important when purchasing food for their children? 2) What do Hispanic parents think are the common factors contributing to childhood obesity and their child's present and future health?

## MATERIALS AND METHODS

The selected target population consisted of Hispanic parents of elementary school students from Springdale, Ark., who had presumed means and ability to participate. It was deemed impossible to survey every Hispanic parent with a child in elementary school; therefore, a convenience sample of parents from the Worker's Justice Center, the Arkansas United Community Coalition and Catholic Charities and the Jones Center's S.O.A.R. afterschool programs were utilized to collect data.

The instrument design consisted of a descriptive, paper survey containing multiple choice questions and Likert scales related to questions regarding childhood obesity. A self-administered questionnaire was developed for this study based on the review of literature and a previous study completed by University of Arkansas' Honors Students, who researched childhood obesity (Altimont et al., 2014). The survey was translated into Spanish and participants were given their choice of a survey in English or Spanish. The majority of the respondents requested a Spanish survey, which was distributed by the researchers. The surveys were collected during the months of February and March, 2015 at the Arkansas United Community Coalition and Catholic Charities and at the Jones Center.

The planned method of data collection consisted of university students handing out the survey to parents as they picked up their children at the after-school care programs. The parents were asked to fill out the surveys when they entered the center. All parents were informed that participation was voluntary and information gathered as a result of the survey would remain confidential. There was an incentive offered for participation: a drawing for four $50 gift certificates to Wal-Mart. The data collected were analyzed using descriptive statistics, percentages, and frequencies.

## RESULTS AND DISCUSSION

The demographic characteristics of the respondents were described for male and female parents of the preschool aged children. The breakdown of the respondents was: 40% male and 60% female. The majority of male respondents were between the ages of 26 and 35 (20%), while the majority of female respondents ranged between the ages of 36 and 45 (26%). The majority of respondents filling out the survey were either the mother or the father to the child. Additionally, all the respondents were predominantly married. Education levels of the respondents rated lower for men than for women. Fifteen of the male respondents (43%) held education levels less than high school or at high school level, while only 20% of the women were high school graduates. Three respondents (9%) held a bachelor's degree. Regarding the higher education degrees, only 3% of each group had received a doctorate degree.

In order to understand what parents felt was most important to purchase when buying food for their family, they were asked to identify how important certain factors were in regard to the food they purchased. These factors were: 1) how safe the food was to eat, 2) nutritional value (how healthy was the food), 3) price, 4) how well the food kept, 5) how easy the food was to prepare, and 6) taste (whether the child liked the food).

The majority of respondents (97%) stated they felt the safety of the food they purchased for their children was very important (Table 1). Respondents were next asked

how important the nutritional value of the food was that they purchased. Again, the majority of the respondents (89%) felt that this factor was important. Price of food purchased was the topic of the next question. Based on 62% of the respondents choosing "very important" and "somewhat important" on the survey, respondents were price sensitive when it came to purchasing food for their family. When asked how important it was that the food they purchased kept well, the majority of respondents (80%) felt this factor was of great importance. Next, respondents were asked how important it was whether the food they purchased was easy to prepare. Seventy-one percent of the respondents felt this factor was "very important" and "somewhat important." Lastly, respondents were asked whether the taste or whether the child liked the food was an important consideration when purchasing food. Seventy-seven respondents stated this was "very important."

Next, the study determined what Hispanic parents thought were the common factors contributing to childhood obesity and their child's present and future health. Nine questions in the survey related to this research question. These questions included factors that contributed to childhood obesity obtained through the literature review, and asked the level of importance based on a Likert scale ranging from "very important" to "not at all important". These were as follows: 1) what a child eats, 2) how much a child eats, 3) how much exercise a child gets, 4) what the child weighs, 5) if a child exercises regularly, 6) if a child eats too much fast food, 7) self-control, 8) genetics/heredity weight, and 9) advertising of food companies and restaurants (Table 2).

The majority of respondents believed what a child ate contributed to childhood obesity. Eighty-three percent stated what a child ate was important to a child's present and future health. Respondents were then asked to rank by importance, whether they thought the amount of food their child ate contributed to childhood obesity. The majority of respondents (80%) found this factor very important. In contrast, only 3% found this factor not too important. Next, respondents were asked if whether a child exercised would affect childhood obesity. Most of the respondents (80%) believed it was very important to a child's present and future health; in contrast, 3% of the respondents believed the amount of exercise was not a factor in childhood obesity. When respondents were asked whether a child's current weight affected their possibility of childhood obesity, 80% stated weight was very important to a child's present and future health and 3% did not feel a child's weight was related to future childhood obesity. Respondents were also asked whether they

**Table 1. Importance factors when purchasing food.**

| Factor | Very Important | Somewhat Important | Not Too Important | Not at All Important | Not Applicable | Did Not Answer |
|---|---|---|---|---|---|---|
| Safe food | 97% | 0% | 0% | 0% | 0% | 3% |
| Nutritional value | 83% | 6% | 0% | 0% | 0% | 11% |
| Price | 51% | 11% | 14% | 0% | 0% | 24% |
| How well food keeps | 74% | 6% | 3% | 0% | 0% | 17% |
| Easy to prepare | 57% | 14% | 6% | 3% | 0% | 20% |
| Taste | 66% | 11% | 3% | 0% | 0% | 20% |

**Table 2. Factors contributing to childhood obesity.**

| Factor | Very Important | Somewhat Important | Not Too Important | Not at All Important | Not Applicable | Did Not Answer |
|---|---|---|---|---|---|---|
| What a child eats | 80% | 3% | 0% | 0% | 0% | 17% |
| How much a child eats | 71% | 9% | 3% | 0% | 0% | 17% |
| How much exercise a child gets | 74% | 6% | 3% | 0% | 0% | 17% |
| What a child weighs | 74% | 6% | 3% | 0% | 0% | 17% |
| If a child exercises regularly | 69% | 9% | 3% | 3% | 0% | 16% |
| If a child eats too much fast food | 63% | 3% | 6% | 6% | 0% | 22% |
| Self-control | 71% | 3% | 3% | 3% | 0% | 20% |
| Genetics/Hereditary weight | 57% | 6% | 6% | 3% | 6% | 22% |
| Advertising fast food | 46% | 14% | 14% | 3% | 6% | 17% |

felt how much exercise a child got was a contributing factor to childhood obesity. Over three-fourths of the respondents (78%) stated regular exercise was a very important factor. Furthermore, 6% stated exercise was not important.

Fast food was the topic of the next question. Sixty-six percent of the respondents stated that the amount of fast food a child consumed was important in regard to present and future health, while 12% of the respondents indicated it was not important. The next question involved self-control. The majority of the respondents (74%) stated self-control was important in regard to present and future health, while approximately 6% of respondents said self-control was not important. The next factor respondents were asked about was genetics or hereditary weight. A little over half of the respondents (63%) stated genetics was important to their child's present and future health, contradictory to the 9% who said it was not important.

Lastly, respondents were asked whether advertising by food companies and restaurants played a key role in their child's present and future health. A little over half of the respondents (60%) believed advertising was important, while 17% felt it was not important. It should be noted that 17% of the respondents did not answer this question. It is speculated that the respondents possibly did not understand the question or did not own the media needed to receive such advertising. However, this could be an opportunity to use nutritional education in schools and outreach programs to educate children about healthy food choices and food preparation, which could result in a reduction of childhood obesity.

In conclusion, the varying results showed the differing views respondents had in regard to factors that contributed to childhood obesity. The majority of the respondents found all the factors listed to be "very important" or "somewhat important" to their child's present and future health.

Important data were collected in regard to: "What factors did Hispanic families feel are most important when purchasing food for their children?" One probable explanation for these findings was that of the importance of family values within the Hispanic culture that had been adopted over time. In the Hispanic society, family needs take precedence over the needs of the individual (Teaching From A Hispanic Perspective, n.d.). This demonstrates the value Hispanic families place on their child's safety and health. Another important factor to the respondents was the price of the food that they purchased. According to Pew research by Kochhar (2014), the economy has become a priority among Hispanics, and the recession has hit them harder than other groups. As concluded in the Pew Research survey, price was an important factor to the Hispanic culture and most Hispanic families were purchasing foods classified as unhealthy when grocery shopping in order to spend less money; therefore, these decisions increased their child's chance of obesity. It must be noted that respondents were placing other factors above price, such as the nutritional value and safety of the food. How well the food kept was another factor that the respondents found to be very important. Once again, the economy and high unemployment rates were a possible explanation for Hispanic families' food choices.

The responses to the set of questions asking respondents what they thought were the factors of childhood obesity, were averaged by combining the number of ratings of "very important" and "somewhat important". Eighty-seven percent of respondents agreed that what a child ate, the amount of food a child ate (80%), how much the child weighed (80%), and the amount of exercise a child got (80%) were all direct contributions to childhood obesity. These factors or obesity contributors were closely followed by 78% of the respondents agreeing that how much exercise a child received and the self-control of the child (74%) were factors of childhood obesity. The final three factors were felt to be influential but were ranked the lowest in contributing to childhood obesity. These factors are: if a child eats too much fast-food (66%), genetics/heredity (63%) and lastly advertising of fast food (60%).

An interesting discovery was that the only factor outside of the parent's control was the advertising of fast food and it ranked lowest in the factors contributing to childhood obesity. This indicated there was an understanding that advertising played a significant role in childhood obesity rates. When asked directly if they thought too much unhealthy advertising was directed at children, 57% of the participants agreed. The conclusion was advertising and marketing negatively affected Hispanic children. While successful marketing campaigns increased revenue for fast food companies, it also decreased the healthy consumer choices of children (Nestle, 2013).

## IMPLICATIONS

Throughout this study, it was evident that there was a need for more Extension and Outreach Programs to help the Hispanic community. Communication barriers need to be broken in order to find solutions to educate the population and to fight childhood obesity. In order to combat the issue of childhood obesity, we suggest educating on a small scale, by spreading education county-by-county, state-by-state, and finally, educating nationally and internationally. Gradual progress has been made, and gradual progress adds up to widespread progress. For instance, in Baldwin Park, Calif. (a town east of downtown Los Angeles), People on the Move (POTM; a Healthy Eating, Active Communities program), worked with

the local school district to make physical education and physical activity a higher priority. Four years after it was instituted, the body mass index (BMI) for fifth to ninth grade students had dropped by 9% (Newbergh, 2013). In the State of Arkansas, the University of Arkansas System Division of Agriculture Cooperative Extension Service addresses issues of childhood obesity through the SNAP-ED program. This program encourages recipients to adopt healthier lifestyles through proper dietary changes and to increase the regularity of physical activity. In addition, this program assists low-income families in improving their diet and overall nutrition based on healthy choices (SNAP-ED, 2015).

After observing the families and their needs within these different organizations in this study, there were specific approaches that could be made to offer solutions in educating the Hispanic community about childhood nutrition. If educational programs were provided to families to teach healthy eating habits to practice at home, this could lead to a major decrease of childhood obesity for the community. This is especially important for the State of Arkansas. In 2012, 28% of the Hispanic children in the state were considered obese; in addition, another 20% were considered overweight (Arkansas Center for Health Improvement, 2012). Furthermore, of the Hispanic children attending Springdale's Elementary Schools in 2012, 21% were considered obese and another 17% were considered overweight (Arkansas Center for Health Improvement, 2012). These statistics made Hispanics the most obese of all ethnic groups living in the State of Arkansas. We suggest that other family members could benefit from these programs as well, by maintaining healthy habits. These would include, but are not limited to, the amount of physical activity needed each week, the importance of consuming a balanced diet, and simple lifestyle adjustments to maintain their healthier eating habits which could be practiced in the home.

In addition, important data were collected in regard to "What factors did Hispanic families feel are most important when purchasing food for their children?" These included a series of questions related to food purchases. This series had the highest number collected in the "very important" category throughout the entire survey. One probable explanation for these findings was the important family values that the Hispanic culture had adopted over time. This was an encouraging statistic and demonstrated the value Hispanic families placed on their child's safety and health. Another important factor for the respondents was the price of the food that they purchased. Fifty-one percent of the respondents said that price was a "very important" consideration. As concluded from this survey, since price was an important factor to the Hispanic culture, it could be surmised that most families were most likely purchasing foods classified in the unhealthy category in order to spend less money; and, therefore, increasing their child's chance of obesity. However, while a little over half of the respondents stated price was an important factor when purchasing food, it must be noted that the other half of respondents were placing other factors above price, such as the nutritional value and safety of the food. How well the food kept was another factor that the respondents found to be very important (74 %). Once again, the economy and high unemployment rates could be a probable explanation to this response, as Hispanic families may not be able to afford purchasing fresh food on a weekly basis.

Furthermore, participants felt that all nine factors in this study contributed to childhood obesity; some more-so than others. Participants ranked these factors in level of importance were: 1) what a child eats, 2) the amount of food a child eats, how much the child weighs, and if the child exercised, 3) how much exercise the child received, 4) self-control, 5) if a child eats too much fast food, 6) genetics/heredity, and 7) advertising of fast food. While other important conclusions were drawn from the collected data, the above conclusions resonated the most with us.

The present and future health of the Hispanic children's population in the United States warrants discussion. The researchers had two research questions that they believed would help address the issue of the childhood obesity epidemic that is sweeping the nation. Noteworthy conclusions were drawn from these research questions and will hopefully be of use to future research in order to decrease the percentage of Hispanic childhood obesity in the United States.

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# The effect of breakfast protein source on postprandial hunger and glucose response in normal weight and overweight young women

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## ABSTRACT

Breakfast consumption has been linked to health benefits such as improved weight regulation and glucose control. Studies have shown higher protein breakfasts lead to a greater reduction in hunger compared to breakfasts higher in carbohydrates. However, few studies have examined the impact of higher protein breakfasts from differing protein sources. The objective of this study was to determine if protein quality (animal (AP) versus plant (PP) protein) influences postprandial appetite, food cravings, food intake and glucose response in participants consuming a high protein breakfast (~30% energy from protein). We hypothesized that AP would be more satiating than PP. Normal weight (NW; n = 12) and overweight women (OW; n = 8) ages 18-36 were recruited to participate. All participants completed two visits in a randomized, cross-over design with one week between visits. Blood glucose and appetite were assessed at 0, 15, 30, 45, 60, and 120 min postprandial. Participants kept a 24-h dietary record for the duration of each test day. Participants preferred the appearance of the AP meal compared to the PP ($P < 0.05$). No difference was found between NW and OW participants or breakfasts for postprandial appetite responses. The AP had a significantly lower ($P < 0.05$) glucose response at 30 min compared with PP (-11.6%; 127 + 4 versus 112 + 4 mg/dL) and a slower return to baseline. There was no significant difference in daily energy intake between breakfasts. These data suggest protein source influences postprandial glucose response without significantly impacting appetite response and food intake in regular breakfast consumers.

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## MEET THE STUDENT-AUTHOR

*Christina Crowder*

I am from Tulsa, Oklahoma I graduated from the University of Arkansas in May 2015 with a major in Human Nutrition and Hospitality Innovation with a concentration in Dietetics. This project was my Honors Thesis under Dr. Jamie Baum, in which I studied the role of dietary protein on body composition, energy metabolism and metabolic health in young women. In support of my major, I accepted internships in the summer of 2013 with Chartwells Marketing at the University of Arkansas-Fayetteville, and with St. Vincent Sports Performance in Indianapolis, Ind., for the sports dietitian. I served as Director of Dining Services for the Associated Student Government from 2012-2013 and as Campus Life Director during the fall semester of 2013. I served on the Bumpers Honors Student Board as the Outstanding Project/Thesis Competition Director for 2013-2014 and in 2015 as Vice Chair. I will be completing a dietetic internship to receive my Registered Dietitian Nutritionist (RDN) credential at Duke University Hospital in Durham, N.C. next year. Then, I likely will attend graduate school for nutrition to pursue a career in teaching, research, and clinical practice. This project was made possible by Dr. Jamie Baum, Brianna Neumann, the Bumpers College, and the Honors College of the University of Arkansas.

## INTRODUCTION

Early adulthood is a vulnerable life stage for weight gain, especially among women. The average weight gain for women between the ages of twenty and thirty is 12-25 lbs (Hutchesson et al., 2013). Weight gain during early adulthood increases the risk of a number of chronic health conditions such as type 2 diabetes mellitus, depression, polycystic ovary syndrome, and infertility. After the age of eighteen years, women are 1.9 times more likely to develop type 2 diabetes if body weight increased 10-16 pounds and 2.7 times more likely to develop type 2 diabetes if body weight increased 16-22 pounds (Hutchesson et al., 2013).

Breakfast has been defined as the first meal of the day, eaten before or at the start of daily activities (e.g., errands, travel, work, etc.), within two hours of waking, typically no later than 10:00 AM, and containing an energy level between 20% and 35% of daily energy needs (Timlin and Pereira, 2007). There are many benefits associated with eating a healthy breakfast such as improved micronutrient intake, decreased incidence of overweight and obesity, and lower cholesterol levels (Ruxton and Kirk, 1997; Pollitt and Matthews, 1998; Stanton and Keast, 1989; Keski-Rahkonen et al., 2003). Several studies have shown that individuals who eat breakfast tend to weigh less than those who regularly skip breakfast (Deshmukh-Taskar et al., 2010; 2013).

Consuming more protein (20–30 g) at breakfast may increase subjective feeling of fullness and satiety, compared to a standard cereal-based breakfast containing 10–15 g of protein (Blom et al., 2006; Veldhorst et al., 2009b). A recent study found that when adults ate eggs for breakfast, they stayed fuller throughout the day (Vander Wal et al., 2008). Another study comparing a protein-based breakfast to a carbohydrate-based breakfast found that overweight women who ate the protein-based breakfast five times a week for eight weeks lost 65% more weight and reduced their waist circumference by 83% more than those participants eating a carbohydrate-based breakfast (VanderWal et al., 2008).

Protein quality may also influence postprandial (also known as post-meal) satiety response. Protein quality is defined as the ability of protein to achieve certain metabolic actions within the digestion, absorption, and assimilation process. Two important aspects of protein quality include a) the individual protein and food matrix within which it is consumed, and b) the availability of essential and conditionally essential amino acids (Millward et al., 2008). Plant-derived protein, with the exception of soy, is considered incomplete because it lacks one or more amino acids necessary for growth and development. Animal proteins are complete proteins that contain all the necessary amino acids. Protein quality is important because although equal quantities of plant and animal protein may have the same caloric content, the digestibility and content of amino acids have notable effects on blood glucose regulation (Millward et al., 2008).

One study comparing the satiating effects of whey protein as compared to casein and soy protein demonstrated that within both low and high protein diets (10% or 25% energy), whey has greater satiating effects due to decreases in subjective hunger (Veldhorst et al., 2009a). Another study compared satiety response of mixed macronutrient meals with differing protein sources (egg albumin, pea protein, soy protein, casein, gelatin, or wheat gluten) and found no differences in satiety response between protein sources (Lang et al., 1998). This finding could be attributed the addition of fat and carbohydrate from the mixed meal, which may delay gastric emptying, negating any post-absorption differences in the proteins. The studies mentioned above measured satiety following consumption of a liquid meal. However, most breakfast meals are consumed as whole foods. Therefore, the objective of this study was to determine if protein quality (plant protein versus animal protein) at breakfast influenced satiety, glucose response and decreased daily food intake.

**Table 1. Subject characteristics.**

| Characteristics | NW‡ | OW |
|---|---|---|
| Participants (n) | 8 | 12 |
| Age (y)† | 25 ± 1 | 25 ± 1 |
| Weight (kg) | 61.3 ± 2.1[a]§ | 87.8 ± 7.8[b] |
| Height (m) | 1.66 ± 1.2 | 1.65 ± 1.8 |
| BMI (kg/m$^2$) | 22.2 ± 0.6[a] | 31.9 ± 2.7[b] |
| Ethnicity | | |
| Asian | 2 | 0 |
| Caucasian | 7 | 6 |
| Indian | 2 | 1 |
| Latina | 1 | 1 |

† Age, weight, height and BMI are expressed as means ± SEM.
‡ NW = normal weight participants; OW = overweight participants.
§ Means in a row without a common letter are significantly different ($P < 0.05$).

## MATERIALS AND METHODS

*Subjects*. Recruitment was performed between October 2014 and February 2015 through the Department of Food Science at the University of Arkansas. The study protocol was approved by the Office of Research Compliance Institutional Review Board of the University of Arkansas. Subjects were recruited into the study using the University of Arkansas Newswire (the university's daily newsletter). The selection was carried out with a phone interview, and exclusion criteria included the following: underweight (BMI ≤ 18.4), current smoker, current medication usage (except hormonal birth control), food allergies or dislike of the foods served during the study, and/or diagnosis of metabolic disease (e.g. diabetes). Subjects signed a consent form before participating in the study. The participants were recruited on a rolling basis and assigned to a treatment group based on BMI (Normal Weight or Overweight).

*Study Design*. Twenty-two healthy, female adults 18-36 years of age were enrolled in the study. Subject characteristics can be found in Table 1. Once enrolled in the study, subjects were assigned to either the normal weight (NW; n = 14) or overweight (OW; n = 8) group based on BMI. The study was conducted using a randomized, cross-over design in which each participant received two different breakfasts, animal protein-based (AP) and plant protein-based (PP), with at least a one-week washout period between each test day breakfast. Subjects were instructed to fast for at least 8 hours overnight prior to the study days and limit their physical activity the day prior to data collection. On each data collection day, food items for breakfast were portioned, weighed, and labeled appropriately for each subject. Subjects were given 15 minutes to consume the test breakfast. The participants were asked to evaluate the taste and appearance of the breakfast on a visual analog scale (VAS). Blood glucose and appetite were analyzed at 0, 15, 30, 45, 60, 90, and 120 min after each test breakfast. In addition, subjects were asked and instructed to keep food records for the rest of each test day.

*Breakfast Composition*. The nutrient composition of the test breakfasts can be found in Table 2. The PP and AP breakfasts were similar in calories, carbohydrates, fat, and

**Table 2. Nutrient composition of test breakfasts.**

| Dietary Characteristics | Animal-Protein Breakfast (AP) | Plant-Protein Breakfast (PP) |
|---|---|---|
| Total Kcal | 357† | 371 |
| Protein (g) | 27 | 26 |
| Fat (g) | 12 | 11 |
| Carbohydrate (g) | 38 | 46 |
| Fiber (g) | 4 | 5 |
| Breakfast Appearance, mm[1] | 74.8 ± 3.6[a]‡ | 63.6 ± 3.5[b] |
| Breakfast Palatability, mm[1] | 73.1 ± 3.5[a] | 65.9 ± 3.8[a] |

† Values are expressed as means ± SEM, $n = 20$.
‡ Means in a row without a common letter are significantly different ($P < 0.05$).

fiber. This allows for a controlled comparison of protein source.

*Body Height and Weight, and Body Mass Index (BMI)*. Body height was measured to the nearest 0.01 cm using a stadiometer (Detecto, St. Louis, Mo.) with subjects barefoot, in the freestanding position. Body weight was measured in the fasting state with subjects without shoes to the nearest 0.01 kg using calibrated balance scales (Detecto, St. Louis, Mo.). Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared.

*Dietary Assessment*. The energy and macronutrient composition of test breakfast meals and the 1-day dietary records were analyzed using the Genesis R&D diet analysis software package (Salem, Ore.).

*Blood Glucose*. After an overnight fast, blood glucose samples were measured in duplicate via finger stick at 0, 15, 30, 45, 60, 90, and 120 min postprandial using a Lifescan One Touch UltraSmart System (New Brunswick, N.J.).

*Appetite and Palatability Assessment*. Participants were asked to rate their perceived hunger, fullness, perceived desire to eat, prospective food consumption, desire for something sweet, and desire for something savory using a 100-mm visual analog scale (VAS; Flint et al., 2000). In addition, subjects were asked to rate how much they liked the taste and appearance of the test breakfasts using a Visual Analog Scale (VAS). The VAS is a validated questionnaire incorporating a 100-mm horizontal line scale with questions worded as "how strong is your feeling of" and end anchors of "not at all" to "extremely."

*Statistical Analysis*. In order to analyze the effect of the dietary treatments (e.g. breakfast types), Repeated Measures Analysis of Variance Two-Way (ANOVA) was used and Tukey's posthoc test was used for multiple comparisons between groups. In order to analyze the effect of each breakfast over time, AUC (area under the curve) was calculated using the trapezoidal rule (Allison et al., 1995). Area under the curve was then analyzed using One-Way ANOVA using Bonferonni posthoc analysis for multiple comparisons between groups. In cases where no differences between body weight groups existed, the groups were combined to analyze AP versus PP by Paired *t*-test. These analyses were used to determine differences in blood glucose response, hunger, satiation, palatability, and 24-h energy intake between the plant protein break-fast and animal protein breakfast. GraphPad Prism Software v 6.0 (La Jolla, Calif.) was used for all data analysis.

## RESULTS AND DISCUSSION

This is one of the first studies to examine the effect of complete meals, similar in caloric content, consisting of

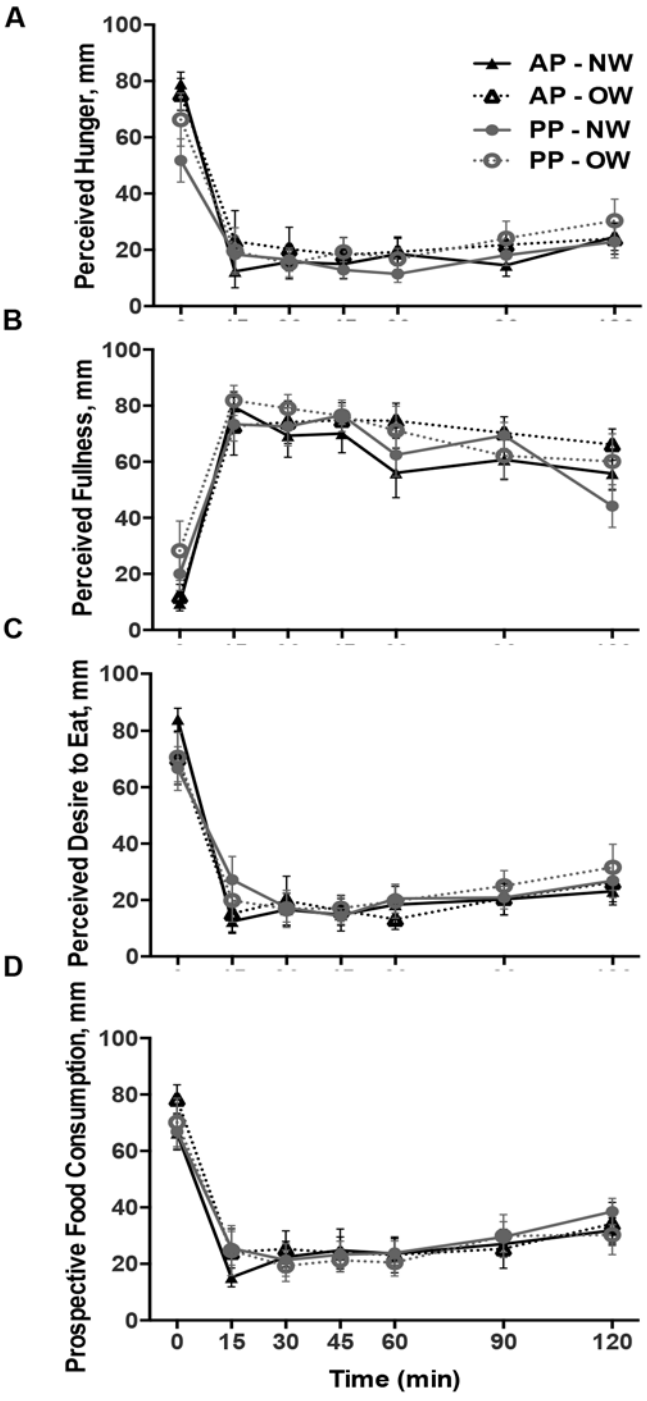


**Fig. 1.** Appetite responses following test breakfasts. Values expressed as means ± SEM. Data are depicted as appetite rating over time per weight group and breakfast type and net incremental area under the curve (niAUC). (A) Perceived hunger. (B) Perceived fullness. (C) Perceived desire to eat. (D) Prospective food consumption. AP = animal protein; NW = normal weight; OW = overweight; PP = plant protein.

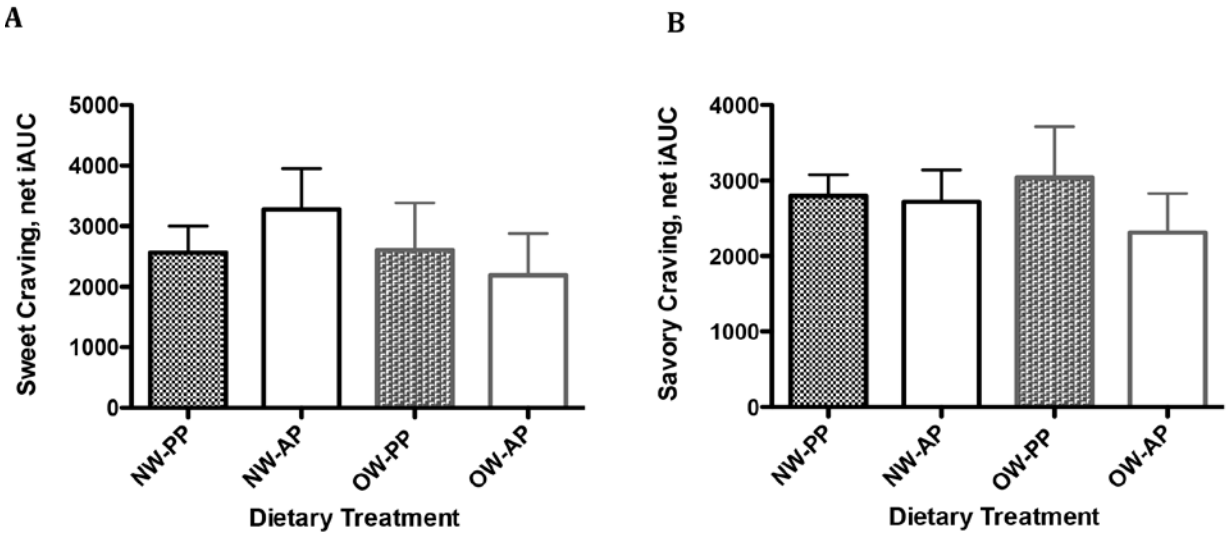


**Fig. 2.** Food craving response following the test breakfast. Values expressed as means ± SEM. Data are depicted as food craving rating net incremental area under the curve (niAUC). (A) Sweet craving following the test breakfast. (B) Savory craving following the test breakfast.

plant protein versus animal protein, on appetite and postprandial glucose response in normal weight and overweight individuals. The present study led to the conclusion that there is no difference in the effect of protein source (animal versus plant) on appetite (Fig. 1), food cravings (Fig. 2), or daily food intake (Table 3). Protein source may have an influence on postprandial glucose response at 30 min postprandial; however further studies are needed to confirm these findings (Fig. 3). Although no difference in postprandial satiety response between animal or plant protein was detected, these results were not unexpected. Several studies have compared the effect of protein source on satiety within a mixed meal (Veldhorst et al., 2009a; Lang et al., 1998; Lang et al., 1999; Marsset-Baglieri et al., 2015; Douglas et al., 2015), demonstrating equal satiety responses to plant and animal proteins within higher protein meals (>22% protein). In addition, a majority of studies have demonstrated no difference in satiety response to pure proteins, aside from some minor variations that were related to rate of absorption (Veldhorst et al., 2009b; Luhovyy et al., 2007). At lower meal concentrations (10% protein), whey protein (an animal source of protein) seems to exert a greater satiating effect, perhaps due to branched-chain amino acid concentration, but this concentration is much lower than the concentration of animal protein tested in the current study (Veldhorst et al., 2009a). This study used test meals similar in caloric content with matched macronutrient compositions; therefore, we did not expect to find large variations in postprandial satiety response between test meals (Fig. 1).

This study appears to be the first to examine how protein source influences food cravings (Fig. 2). Although we did not find any significant differences in food cravings, the OW subjects tended to have lower cravings for sweet and savory foods following the AP breakfast; however, the same response was not observed in the NW group. However, more research is needed to confirm these findings. Hoertel et al. (2014) found that subjects consuming a high protein diet had lower sweet and savory cravings than subjects who consumed normal protein or skipped breakfast. This study supports the data from our study in terms of craving. However, in our study we did not observe differences in ad libitum food intake between diets (Table 3). The specific "sweet or savory" qualities of the foods consumed post-breakfast were not recorded, but these data could be further investigated with subsequent studies.

**Table 3. Twenty-four hour nutrient intake.**

| Nutrient | AP-NW† | AP-OW | PP-NW | PP-OW |
|---|---|---|---|---|
| Energy (kcal) | 2327 ± 141 | 2417 ± 251‡ | 2041 ± 161 | 2218 ± 269 |
| Carbohydrate (g) | 271 ± 13.3 | 275.6 ± 22.9 | 308.18 ± 55.6 | 237.6 ± 35.3 |
| Fat (g) | 93.5 ± 11.4 | 100.4 ± 13.7 | 83.1 ± 19.8 | 95.6 ± 13.7 |
| Protein (g) | 123.1 ± 20.9 | 107.3 ± 20 | 107.4 ± 10.5 | 93.4 ± 14.1 |

† AP = animal protein; NW = normal weight; OW = overweight; PP = plant protein.

‡ Values are expressed as means ± SEM.

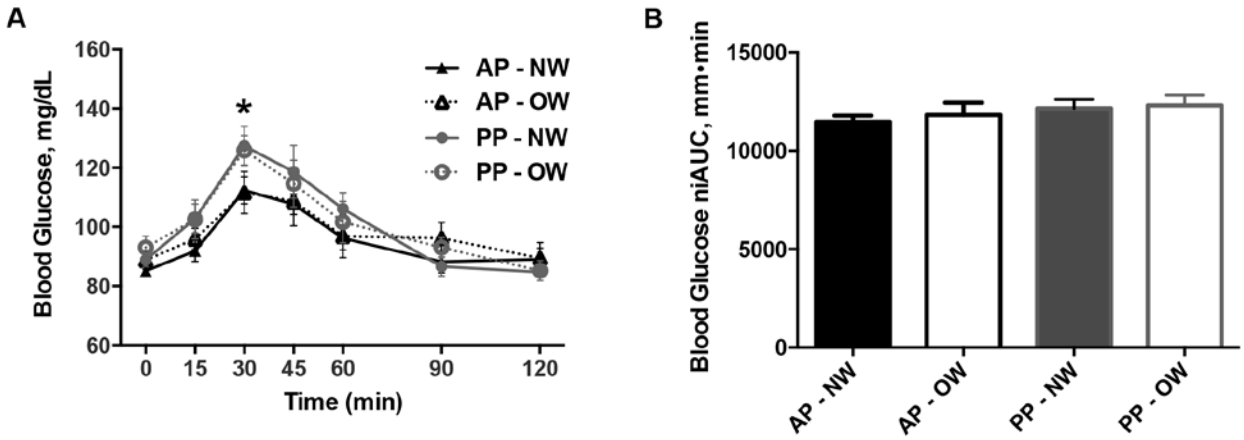


**Fig. 3.** Glucose response to the test breakfasts. (A) Glucose response to the test breakfasts over time. (B) Glucose net incremental area under the curve (niAUC). Values expressed as means + SEM. * indicates that blood glucose values for AP were significantly different than PP ($P < 0.05$). AP = animal protein; NW = normal weight; OW = overweight; PP = plant protein.

An increase in protein intake throughout the day, starting with breakfast, may help an individual to feel more satisfied and respond to neural signals of satiety and blood glucose regulation (Woods, 2009). Additionally, the OW subjects tended to consume less protein and more calories compared to the NW over the remaining 24-h period; however these values were not significant, possibly due to the small number of subjects. The underlying mechanism is still unknown, but high protein diets seem to spontaneously reduce food intake in individuals and could be attributed to protein's satiating effect (Anderson and Moore, 2004).

Despite no statistically significant differences between glucose response over the 2-h period between meals or subjects (Fig. 3), there was a trend for more stable postprandial glucose response following the AP breakfast for both NW and OW groups. In addition, subjects consuming the PP breakfast has significantly higher ($P < 0.05$) blood glucose levels 30 min postprandial. The control of postprandial glucose levels is important for diabetes risk (Leiter et al., 2005; Boden et al., 2005) and minimizing cardiovascular disease risk and pathogenesis. In general, both isocaloric and hypocaloric diets with increased protein in general lead to more stable postprandial glucose levels with lesser peak excursions and incremental area under the curve (O'Keefe et al., 2008; Farnsworth et al., 2003; Layman et al., 2003; Gannon and Nuttall, 2006). There is uncertainty as to why there were greater postprandial glucose levels for both NW and OW following the PP breakfast, but this could be attributed to the slight disparity in breakfast carbohydrate content or differing amino acid profiles. It has been observed that healthy individuals and those with postprandial glucose levels on the higher end of normal may do better with a high animal protein based breakfast, with high protein in general preferred over low protein/carbohydrate based breakfast (Leidy et al., 2014).

One of the limitations of this study is the short postprandial data collection period following breakfast consumption. Two hours postprandial may not be enough time to fully capture the postprandial satiety response, as meals are generally four to five hours apart and initiated by habit or hunger (Woods, 1991). Many studies take measurements for four hours following treatment to ensure subjects return to baseline (Leidy and Racki, 2010; Leidy et al., 2014; Douglas et al., 2015). The small discrepancy in caloric values of the meals may have been why we see small changes in postprandial blood glucose. We do not think these differences are significant enough to affect any of the glucose values, but we cannot ignore the possibility that the small difference produced some effect. In addition, food records have been proven inaccurate in terms of self-report energy intake. Dhurandhar et al. (2014) present a strong case for the discontinuance of subjective energy intake reporting methods, but until more advanced reporting methods are developed and accessible, the 24-h dietary food records will have to suffice. Additionally, assays for ghrelin, GLP-1, and serum insulin could be used for objective satiety measurements along with subject visual analog scales (VAS).

Overall, there was no difference in the response between normal and overweight subjects following either the AP or PP breakfasts. However, subjects had a higher glucose response at 30 min following the PP breakfast. There was no difference in postprandial satiety response between breakfasts. Overweight subjects tended to consume more calories following both breakfasts and more calories from fat compared to normal weight subjects and normal weight subjects consumed more calories from protein. With these

findings, recommendations are for both normal weight and overweight individuals to consume high quality, higher protein breakfasts.

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# Nutrient competition between algae and *Juncus effusus* in the Lake Fayetteville artificial spiral wetland

***Toryn D. Jones* and Thad Scott†***

## ABSTRACT

There is insufficient research focusing exclusively on how nutrient competition between algae and wetland macrophytes affects the growth of these species. This study examined the relationship between nutrient concentrations (N and P), algal concentrations, and the growth of *Juncus effusus*. *Juncus effusus* growth in the Lake Fayetteville artificial spiral wetland was monitored over a four month period during the prime growing season. Eighteen plants were taken from the wetland and replanted in 1 of 6 treatments: plant-only, algae-only, combined, plant-only +supplement, algae-only +supplement, or combined +supplement. The algae and combined environments received an inoculation of algae, and the +supplement treatments received an infusion of an N and a P supplement. An analysis of variance test was conducted to determine the presence of a significant relationship between *Juncus effusus* growth, nutrient concentrations, and/or algal growth. No significant relationship existed between *Juncus effusus* and nutrient concentrations or between *Juncus effusus* and algal concentrations. There was a significant relationship between algal growth and the presence of *Juncus effusus*, which produced an additive effect causing the greatest algal growth in the combined +supplement treatment. Results indicate that nutrient competition between *Juncus effusus* and algae in the Lake Fayetteville artificial spiral wetland is not the limiting factor in *Juncus effusus* growth in the wetland.

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† Thad Scott is a faculty mentor and Assistant Professor of Environmental Water Science.

## MEET THE STUDENT-AUTHOR

*Toryn Jones*

I am from Haskell, Oklahoma where I graduated valedictorian from Haskell High School. I chose to pursue a degree from the University of Arkansas because of its beautiful location and the research opportunities available in the Dale Bumpers College. I graduated sum cum laude with a Bachelor's of Science degree in Environmental, Soil and Water Science.

As an undergraduate, I served on the Dale Bumpers Honors Student Advisory Board and held various positions with the Baptist Collegiate Ministry. I am currently conducting research at the University of Arkansas as a graduate student working under Dr. Thad Scott. I intend to use my experience from Arkansas to acquire a research position at an environmental quality station in Southeast Asia.

I would like to thank my faculty advisor, Dr. Thad Scott for his mentorship. I would also like to thank my other board member, Dr. Lisa Wood and Dr. Curt Rom for their guidance with my thesis and throughout my undergraduate career.

## INTRODUCTION

The Lake Fayetteville artificial spiral wetland, which covered approximately 1000 square feet near the Lake Fayetteville dam, was an artificial wetland designed and built by Stacy Levy (http://www.stacylevy.com/). The Spiral Wetland was constructed in the spring of 2013 and was decommissioned in October of 2014. The purpose behind the wetland was to educate the public on the effects of eutrophication and to reduce the impact of nitrogen and phosphorus enrichment on the lake. Also, the artificial wetland provided an aesthetically pleasing view from the lake's park trail, and served as a habitat for many insects, fish, and birds. However, an unanticipated issue arose in that the plant installed in the wetland, *Juncus effuses*, did not appear to grow after being established in Lake Fayetteville.

### Eutrophication: Cause and Effect

Eutrophication can be defined as the excessive nutrient enrichment of a water body (Smith et al., 1999). The two most common nutrients involved in eutrophication are nitrogen and phosphorus. Nitrogen and phosphorus are the two limiting agents in plant growth, and, when an excess is introduced into the environment, plants in that environment can begin to grow at a consistent rate until they either reach critical mass or exhaust the excess nutrients (Koottatep and Polprasert, 1997). Unfortunately, nitrogen and phosphorus are highly concentrated in common run-off contaminants such as animal feces, leaf litter, food, and nutrient fertilizers making eutrophication of local water bodies a fairly common occurrence, especially near agricultural areas (Hammer and Knight, 1994).

The most notable effects of eutrophication are algal blooms and hypoxic zones. Algal blooms are the emergence of extremely high concentrations of algae and cyanobacteria (Stevenson et al., 1996). These blooms are characterized by their stench, deep red and green colorings, and high rates of photosynthesis. Hypoxic zones are areas where dissolved oxygen is so low that very few aquatic lifeforms can survive. Hypoxic zones are created once algal blooms die off and detritivores deplete dissolved oxygen through respiration while breaking down the algae for chemical energy (Smith et al., 1999).

Both of these results have deleterious effects leading to the slow breakdown of the aquatic ecosystem. Loss of aquatic species and resources leads to further damage by negatively impacting the surrounding terrestrial environment. For humans, eutrophication can lead to the loss of recreational waters, drinking water, food sources, and several benefits from neighboring water bodies and related terrestrial environments (Smith et al., 1999).

### Artificial Wetlands: Agents of Eutrophic Remediation

An artificial wetland is a manmade reproduction of a wetland ecosystem that serves the purpose of either replacing a damaged wetland or assisting in the remediation of a polluted waterbody (Kadlec and Wallace, 2009).

There are three primary functions by which artificial wetlands are able to prevent, manage, and reverse eutrophication. These functions are nutrient competition (Reinhardt et al., 2006), light attenuation (Kadlec and Wallace, 2009), and biological oxygen demand (BOD) reduction (Karathanasis, et al., 2003). In a water body experiencing eutrophication, algae and cyanobacteria are often the only organisms capable of using the nitrogen and phosphorus suspended away from the shore (Stevenson et al., 1996). However, when an artificial wetland is constructed and placed over the waterbody, it introduces new hydrophytes capable of utilizing large quantities of nitrogen and phosphorus for growth, thus reducing the amount of nutrients available to algae and cyanobacteria (Vymazal et al., 2007). The competition for nutrients brought on by the introduction of an artificial wetland puts a stress on algae and cyanobacteria which helps to regulate growth and prevent algal blooms (Crumpton and Van Der Valk, 1989).

A somewhat similar effect happens with sunlight. Because algae and cyanobacteria use photosynthesis as a means of energy production, sunlight is crucial in their growth process. By creating a wetland with a solid, opaque layer, light is unable to reach the algae and cyanobacteria under the constructed wetland. In this way, wetlands are able to partially manage the amount of energy available to algae and cyanobacteria (Kadlec and Wallace, 2009).

Wetlands also reduce BOD (Karathanasis, et al., 2003). The BOD is the measure of dissolved oxygen (DO) needed to completely decompose organic matter in a water body (Karathanasis, et al., 2003). High residence time and retention rate in a wetland allows for microbial organisms to break down organic matter from runoff before it enters the primary waterbody (Karathanasis, et al., 1997). This slows the depletion of dissolved oxygen within the waterbody. While the reduction of BOD does not directly remediate eutrophication, it does slow the rate of dissolved oxygen depletion which is a destructive result of eutrophication.

There are several benefits and drawbacks to constructing an artificial wetland as a remediation strategy. The key factors are time, space, money, and personnel. Wetland remediation can take several decades to have a significant effect (Turner et al., 2000). Depending on the waterbody being remediated and the wetland design, remediation by wetlands can also be costly and require heavy maintenance and monitoring for the first several years (Turner et. al, 2000). Yet, due to their resiliency and flexibility, artificial wetlands are an effective long-term and supplemental remediation strategy (Barbier, 1993). This research project seeks to examine the effectiveness of the Lake Fayetteville artificial spiral wetland at reducing the rate of eutrophication in Lake Fayetteville, and to identify the growth limitations of *Juncus effusus*.

**Research Hypotheses**

There were three hypotheses for this study:

*Hypothesis 1*. *Juncus effusus* biomass and algal biomass will be greater where they are grown independently than where they are grown together.

*Hypothesis 2*. *Juncus effusus* biomass and algal biomass will increase with increasing nitrogen and phosphorus concentrations in Lake Fayetteville water.

*Hypothesis 3*. Algae and *Juncus effusus* grown independently from the other and with added nitrogen and phosphorus will display a synergistic effect rather than an additive effect.

## MATERIALS AND METHODS

**Nutrient Competition Experiment**

To test the effects of nutrient competition on the growth of *Juncus Effusus*, a two-variable experiment was conducted that compared six varying growth conditions for algae and *Juncus effusus*. The variables were (1) the presence of a competitive organism (algae and/or *Juncus effusus*) and (2) availability of nitrogen and phosphorus. Fifteen *Juncus effusus* plants roughly similar in root and shoot length were selected from the wetland and the roots and shoots were cleaned to minimize contamination. Eighteen 5-gal buckets were laid out in 3, 2 × 3 sets and filled with 5 gal of freshwater. Four buckets in each set had a planter harnessed in just above the water using bailing wire. In each set, the two buckets without planters and two of the buckets with planters were inoculated with 75 mL of algal biomass. This resulted in each set of replicates having two buckets with only algae, two buckets with only *Juncus effusus*, and two buckets with algae and *Juncus effusus* combined. In each set, one bucket from each of these pairs was given 30 mL of trisodium phosphate and 50 mL of potassium nitrate nutrient solutions. These dosages were calculated using maximum concentrations found in Lake Fayetteville. Each set contained one algae-only bucket, one algae-only + supplement bucket, one plant-only bucket, one plant-only + supplement bucket, one combined (algae and plant) bucket, and one combined + supplement bucket (Fig. 1). Each bucket was labelled accordingly and numbered 1, 2 or 3 for the set to which it belonged. To decrease bias, the position of each bucket in a set was chosen at random using a random number generator. The buckets were filled weekly and supplied with aerators. This set-up was monitored for two months, at which time it was disassembled and the plants were harvested to measure biomass and C:N.

**Plant Biomass**

To measure the weights of the plant roots and shoots, the roots of each plant were removed beginning at the bottommost part of the soil conglomerate and the shoots

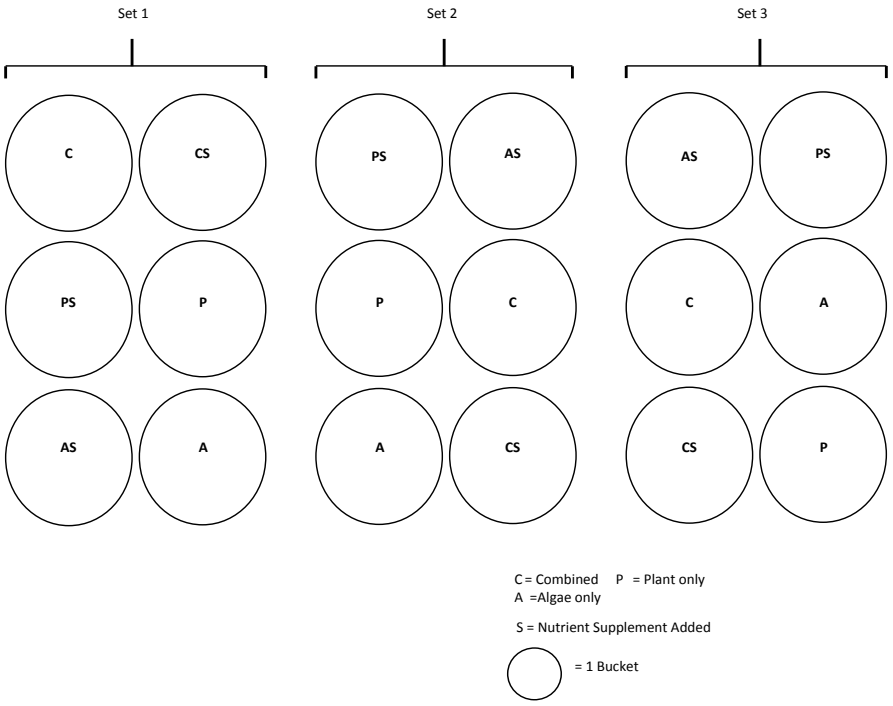


**Fig. 1.** Visual representation of experimental design.

of the plants were removed beginning at the uppermost part of the soil conglomerate. The roots and shoots were carefully gathered and put into separate bags. Each plant had its own pair of bags. The bags for each set of samples were placed in a drying oven for one week to three weeks. The dry weights of the contents of each bag were measured using a Mettler-Toledo Xs104 balance (Mettler-Toledo LLC, Columbus, Ohio). This process provided root, shoot, and total weight for each plant sample.

**Plant C:N**

Dried and weighed plant samples were ground into a powder using a plant mill followed for 45 s by a Wig-L-Bug grinder (International Crystal Labs Inc., Garfield, N.J.). Samples were analyzed for carbon and nitrogen content using a Thermo Flash 2000-C:N analyzer (Thermo Fischer Scientific Inc., Santa Clara, Calif.). Multiplying the dry biomass by the relative proportions of carbon and nitrogen provided the weights of carbon and nitrogen for each plant, shoot, and root.

**Chlorophyll-A Concentrations**

Water samples (300 mL) were collected after stirring at four irregular intervals. The water was vacuum-filtered and chlorophyll-a in the presence of 90% acetone was measured on a pre-calibrated Turner Fluorometer (Turner Designs Inc., Sunnyvale, Calif.) according to the Turner Design method.

**Statistical Methods**

Data were analyzed using SAS (SAS Institute, Inc., Cary, N.C.). A two-way analysis of variance (ANOVA) was run on the chlorophyll-a concentrations to test the significance of algae biomass concentrations across the six treatments over time. A one-way ANOVA was run on the carbon, nitrogen, and the CN ratios of each root sample, shoot sample, and whole plant harvested from the experimental phase.

## RESULTS AND DISCUSSION

**Experiment: Plants**

There were no statistically significant differences between the plant (total, root, or shoot) masses or plant C:N ratios across the various competition and/or fertilizer treatments. However, the general patterns observed in the data were worth examination. Plant weight was greatest in plant-only +supplement environments. Conversely, plant weight was least in combined +supplement environments. Plant-only and combined environments without supplements were roughly equal and intermediate in all weight measurements (Fig. 2).

Carbon and nitrogen measurements for the plants were erratic. In plant roots and shoots, plant-only +supplement displayed the greatest concentrations of both carbon and nitrogen with the other three treatments being roughly similar. Plant shoot carbon was similar to the roots in that

plant-only +supplement had the greatest concentration. Plants in treatments not receiving nutrients had roughly similar shoot carbon concentrations, while combined +supplement had a relatively low average concentration of shoot carbon. Plant shoot nitrogen was roughly equivalent for all four treatments. Plant carbon mirrored the pattern explained for plant shoot carbon, while plant nitrogen was similar with the exception of combined + supplement being slightly greater than the non-supplement receiving treatments (Fig. 3). Total plant C:N was greatest in the plant-only treatment; however, all treatments were roughly similar with a plant C:N range between 36.26 and 40.60 (Fig. 4).

**Experiment: Algal Growth**

Algal growth in relation to growing condition (algae, plant, combined) was the only variable measured in this experiment that was found to be statistically significant ($P$ = 0.0154). In all growing conditions (algae, plant, combined), algal concentrations were greater when a nutrient supplement was added. Algal concentrations were greatest in the combined environments with combined +supplement treatments reaching 800 µg chl-a $L^{-1}$, and combined treatments reaching 345.6 µg chl-a $L^{-1}$. Algae-only environments displayed the lowest concentrations of algae at 94.5 (with supplement) and 9.7 (without supplement) µg chl-a $L^{-1}$. The plant-only environments were the intermediate values at 415.7 (with supplement) and 232.3 (without supplement) µg chl-a $L^{-1}$ (Fig. 5).

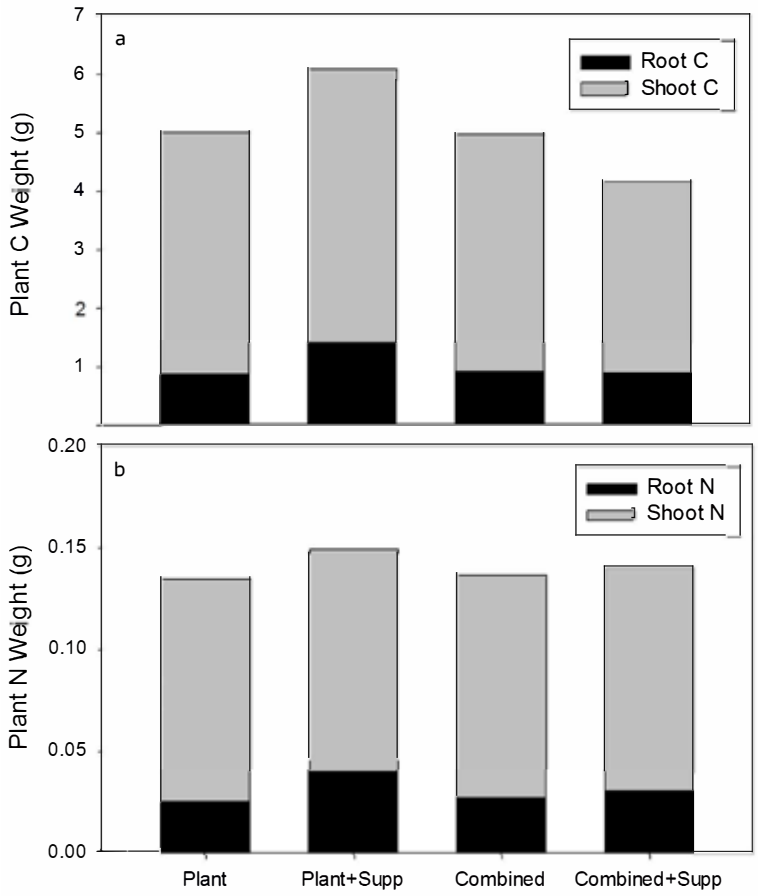


**Fig. 3.** (a) Proportions of root ($P$ = 0.491), shoot ($P$ = 0.113), and total plant carbon weight ($P$ = 0.109) in relation to competition presence and nutrient availability. (b) Proportions of root ($P$ = 0.615), shoot ($P$ = 0.247), and total plant nitrogen weight ($P$ = 0.378) in relation to competition presence and nutrient availability.

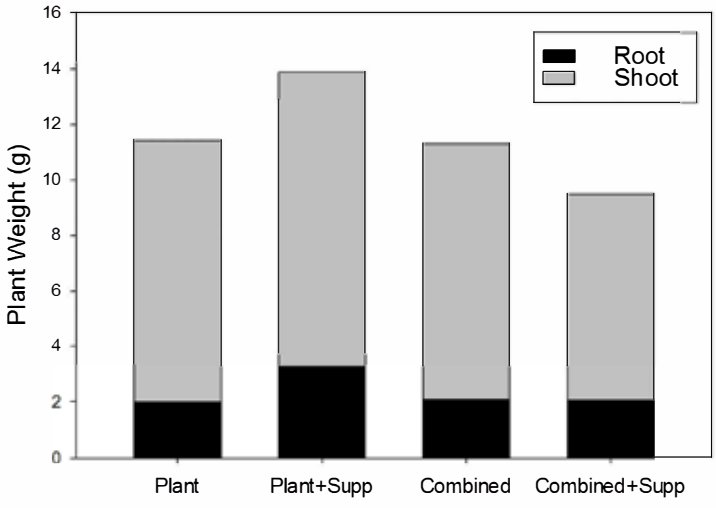


**Fig. 2.** Proportional root ($P$ = 0.478), shoot ($P$ = 0.130), and total plant weight ($P$ = 0.127) in relation to the presence of competition and nutrient availability. (Combined = plant and algae, Supp = addition of N and P supplements).

**Analysis of *Juncus effusus* Growth Limitations**

Data collected for plant growth in the various treatments supported the rejection of the hypotheses that *Juncus effusus* growth in the Lake Fayetteville artificial spiral wetland is being limited by insufficient nutrient concentrations and/or competition with algae. However, the patterns in the data support the general idea that algae outcompetes emergent plants for nutrients. The lack of statistical significance could be a function of the limited replication in this experiment.

It was hypothesized that *Juncus effusus* placed in an environment with a higher nutrient concen-

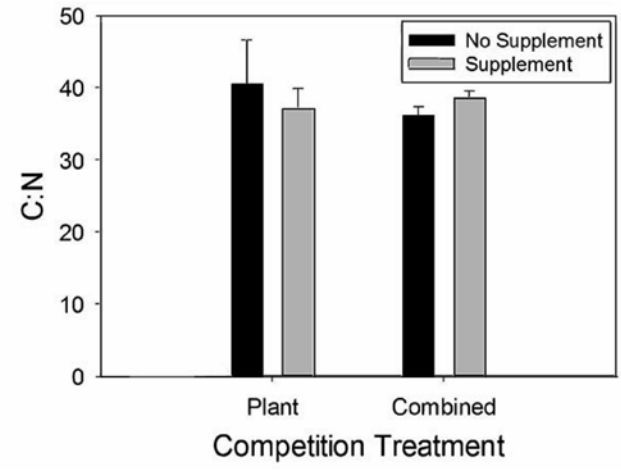


**Fig. 4.** Average carbon-nitrogen ratio of whole plants across various treatments ($P = 0.32$, $\alpha = 0.05$).

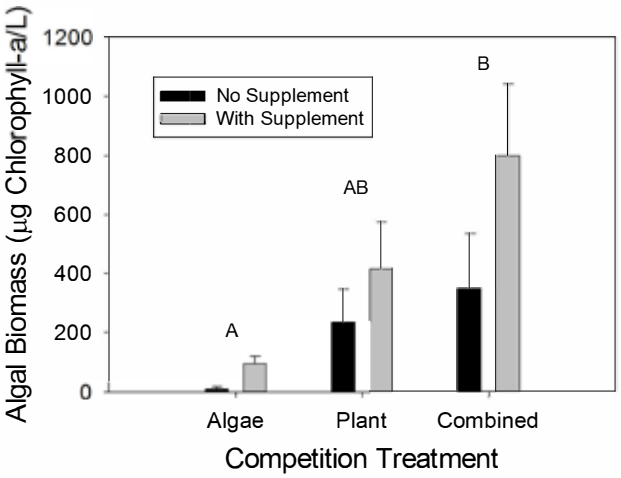


**Fig. 5.** Average, final algal concentrations across various treatments ($P = 0.0154$ , $\alpha = 0.05$).

tration would experience accelerated growth in comparison to the plant without a supplement. This hypothesis was based on data by Gusewell and Koerselman (2002). However, data from the two treatments determined that there was no significant relationship between *Juncus effusus* mass and nutrient concentration. Therefore, nutrient availability alone is not a limiting factor for plant growth in the Lake Fayetteville artificial spiral wetland.

It was further hypothesized that *Juncus effusus* placed in an environment with higher algal concentrations would display less mass and lower nutrient contents due to stress as a result of competition. This hypothesis was molded from data from Engelhardt and Ritchie (2002). Yet, ANOVA showed there was no significant relationship between algal concentrations and mass of *Juncus effusus*. Thus, algal concentration alone is not a significantly limiting factor for plant growth in the Lake Fayetteville artificial wetland.

The last variable tested as a limiting factor for *Juncus effusus* growth was a synergistic effect forged by the combination of algal and nutrient concentrations. The idea behind this comparison was that the presence of excess nutrients could accelerate the growth of algae, which would cause rapid eutrophication in the small environment and exert the greatest stress of any treatment. Despite the combined-only treatment having the highest concentration of algae, lowest mass of *Juncus effusus*, and lowest whole-plant carbon to nitrogen ratio, the ANOVA results were the same in that no significant relationship was apparent. Hence, no synergistic effect of nutrient and algal concentrations is present.

**Analysis of Algal Growth**

While no relationship was established between the presence of algae and *Juncus effusus* growth, ANOVA revealed a significant relationship between the presence of *Juncus effusus* and algal growth.

Assuming *Juncus effusus* failed to exert a significant competitive stress on algae, the concentrations in the combined + supplement replicates should be roughly equal to the concentrations in the algae-only +supplement replicates. One possible explanation is that adding the *Juncus effusus* plants to the experimental treatments also transferred algae attached to these plants. In other words, the plants seeded the experimental units with extra algae.

## IMPLICATIONS

The Lake Fayetteville artificial spiral wetland was designed to raise awareness regarding eutrophication and how nutrient enrichment in aquatic systems can be disastrous. The designers expressed a desire for the wetland to ecologically benefit the lake by reducing the rate of eutrophication. However, in the wetland's first year, there was minimal plant growth and *Juncus effusus*, which were expected to grow to their full 4 ft, scarcely reached 6 inches. The initial concern was that *Juncus effusus* was not sufficiently capable of competing with algae for nutrients needed for growth (N and P). However, after monitoring the wetland during its second summer (data not shown) and conducting this study, it is apparent that competition with aquatic vegetation was not a limiting factor in *Juncus effusus* growth. Alternative limitations which could have hindered *Juncus effusus* growth are: growing season, plant anatomy, and physical disturbance/stress.

Construction began on the artificial spiral wetland in the late spring of 2013. It is likely that, when the wetland was finished and seeds fully planted, *Juncus effusus* had missed part of its growing season and was not able to reach

expected heights. *Juncus effusus* anatomy could also have an impact on why the plants grew poorly in the first growing season. According to a *Juncus effusus* fact sheet provided by the Natural Resource Conservation Service, *Juncus effusus* seeds need to over-winter near the surface of the soil in order to grow properly (NRCS, 2002). Furthermore, *Juncus effusus* grows naturally in moist soils 6 inches or less below water (NRCS, 2002). The *Juncus effusus* growing in the spiral wetland were in moist, shallow planters sitting above the lake. This means, rather than the plants being rooted in the soil and growing up through the water as they do naturally, they were grown in soil near the surface and their roots extended down into the open water.

The last credible option for limiting *Juncus effusus* growth is the constant physical disturbance endured by the *Juncus effusus* during the course of the spiral wetland installation. While situated in Lake Fayetteville, the spiral wetland suffered ice, wind, and hail damage. Due to lack of a skeletal structure, high winds easily flipped the wetland over on itself leaving dozens of plants at a time submerged underwater with their roots in the air. The wetland displayed damage caused by large birds roosting on the soft, foam body and even tears left by boaters. Physical disturbance at that level could explain the stunted growth exhibited by the *Juncus effusus*. Due to research rejecting the hypothesis that nutrient competition was a primary factor in limiting *Juncus effusus* growth, it is likely that one (or a combination) of the aforementioned factors are responsible for limiting *Juncus effusus* growth.

## CONCLUSION

Results from this study revealed that *Juncus effusus* in the Lake Fayetteville artificial spiral wetland was not limited in growth by nutrient availability or competition with algae. The masses of plants grown in treatments containing algal inoculations and/or nutrient supplements were not significantly different from plant masses produced in the control treatments (plant-only). Similarly, there was no significant variation in the C:N ratios or the nutrient weights across the various treatments. Little research exists to evaluate the direct competition between wetland plants and algae. The results of this study were not statistically significant and could therefore not fully explain the patterns observed; however, this could have been the result of poor replication. A more comprehensive study with greater replication could show that the biological patterns observed in this study were meaningful, which could influence the future construction and maintenance of floating wetlands for aesthetic and water quality improvement purposes.

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# Maintaining a way of life: trials and tribulations of farmers' market families

*Megan M. Lankford*[*], *Catherine W. Shoulders*[†], *Curt Rom*[§], *Jennie Popp*[‡], *and Elena Garcia*[¶]

## ABSTRACT

Never before in our nation's history has there been so many ways for consumers to purchase food. From grocery stores, to super centers such as Wal-Mart and Costco, convenience stores, online purchases, community supported agriculture (CSA), and farmers' markets, Americans have a multitude of venues to choose from. Although many Americans currently purchase their foods from grocery stores, a growing number of them are buying locally at their farmers' markets and from CSAs. As the sustainability movement takes a greater foothold in the American household, local products and local foods are becoming ever more important and prevalent. Yet with all of the statistics surrounding local agriculture, the human element is often lost. A majority of small farmers and their spouses, often the ones who sell at a local level, have to work full time both on and off farm to support their families and farms. This case study examines the professional lives of five local farm families who choose to sell their products at the Fayetteville, Arkansas farmers' market. It seeks to understand farmers' reasons for farming and selling locally, as well as their biggest challenges and rewards. In addition, it seeks to fill gaps in literature regarding farmers' motivations for selling at a local level.

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† Catherine W. Shoulders, the faculty mentor, is an assistant professor in the Department of Agricultural Education, Communications and Technology.
§ Curt Rom is the Associate Dean for International Education, and a university professor in the Department of Horticulture.
‡ Jennie Popp is a professor in the Department of Agricultural Economics and Agribusiness.
¶ Elena Garcia is an associate professor in the Department of Horticulture.

## MEET THE STUDENT-AUTHOR

*Megan Lankford*

I am from Oxford, New York, and now reside with my husband in Fayetteville, Arkansas. I graduated in May 2015 summa cum laude with a major in Horticulture and a minor in Sustainability. I am a Dale Bumpers Scholar, and have also been named the Outstanding Graduating Senior of the Horticulture Department. During part of my undergraduate career I had the pleasure of being the Vice President and Garden Manager of GroGreen, the student-led organic and sustainable garden. I have also worked part time through my academic career at the University of Arkansas, and currently work as Lead Gardener at the Botanical Garden of the Ozarks. I will continue on my career path there after graduation. In my free time I enjoy growing food for my family, hiking, reading, and relaxing under an old oak listening to the birds.

I would like to thank Dr. Catherine Shoulders for her guidance and mentorship through this journey. Her expertise, countless revisions, patience, and passion have made this a memorable and pleasurable experience. I would also like to thank my committee members, Dr. Curt Rom, Dr. Jennie Popp, and Dr. Elena Garcia for guiding me through this process.

## INTRODUCTION

There are a variety of ways to define local foods; however, there is currently no official consensus on the definition. According to the Food, Conservation, and Energy act of 2008 and the United States Congress, local food can be defined by distance: "the total distance that a product can be transported and still be considered a 'locally or regionally produced agricultural food product' is less than 400 miles from its origin, or within the State in which it is produced" (Clark et al., 2010). Other definitions for local food include market arrangements such as direct-to-retail, direct-to-foodservice, and direct-to-consumers via farmers' markets, on-farm stores, and roadside stands (Clark et al., 2010).

Direct-to-consumer sales increased by 8% between 2007 and 2012 (USDA, 2014a). In 2012, sales of fresh produce sold directly to consumers totaled $1.3 billion (USDA, 2014a). The number of farmers' markets had also increased. In 1994 there were 1755 farmers' markets in the United States, in 2009 there were 5274 (Clark, et al., 2010), and by 2012 there were 8268 farmers' markets (USDA, 2014b). Additionally, in 1986 there were two community supported agriculture (CSA) organizations in operation in the United States. By 2005 there were 1144 CSAs (Clark et al., 2010), and by 2012 there were 12,617 CSAs operating in the United States (USDA, 2014a). As demonstrated by these statistics, local farming, local food, and direct-to-consumer sales have been increasing substantially. While the motivators for consumers to purchase locally have been well documented, little research has been done to determine the reasons farmers choose to sell their products locally.

According to a survey by A.T. Kearney reported in *Buying into the Local Food Movement,* consumers had various reasons as to why they purchased locally produced food. Nineteen percent of respondents chose to purchase locally to increase organic or natural production, 66% did so to help their local economy, and 60% purchased local produce to deliver a better and broader assortment of products (Ruehle and Rushing, 2013). Another survey conducted by the supermarket industry association found that consumers purchased local food for other reasons as well. Fifty-six percent of respondents purchased foods locally because the taste was better, and 83% said that it was the freshness of the produce (USDA, 2015). It was clear what consumer's reasons for purchasing local foods were, but no literature was found on why farmers chose to farm and sell produce at a local level.

The purpose of this study was to gain an understanding of local farm families, local food and farming systems, farmers' decisions to sell at a local level, and to fill gaps in literature. This project was a case study of five local farm families and their reasons for farming and selling locally, as well as their biggest challenges and rewards. It also explored the perceived outcomes (motivational factors)

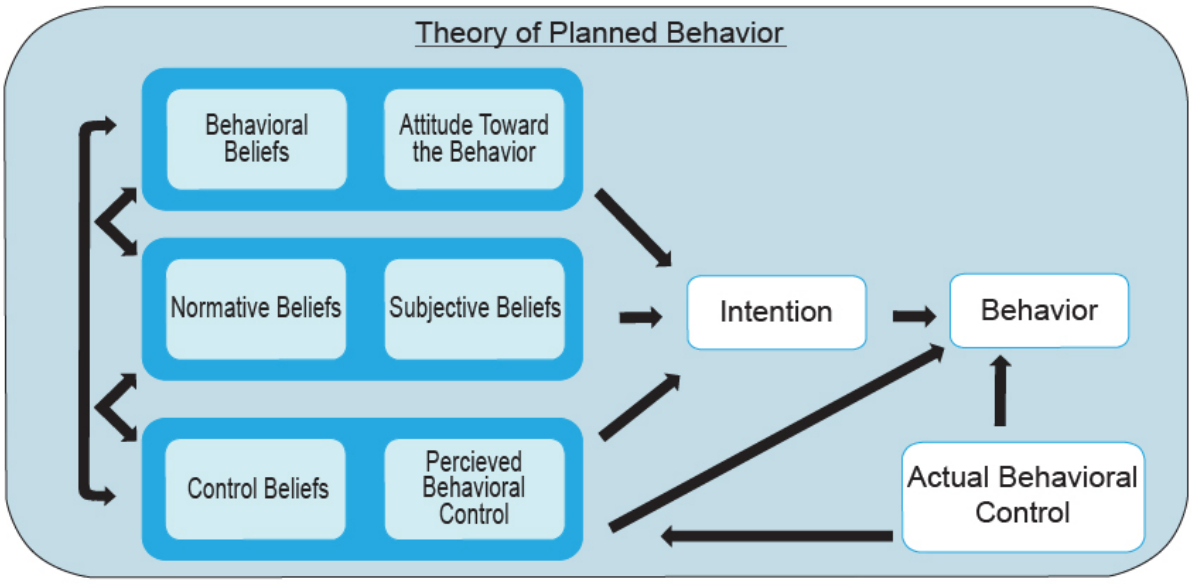


**Fig. 1.** Theory of Planned Behavior. Adapted from Ajzen (1991).

of the farmers selling at the local farmers' market. This study was guided by the following research questions:

1. What are farmers' reasons for farming?
2. Why do farmers sell at a local level, rather than at a regional or national level?
3. What are the biggest successes and challenges of local farm sales?

## MATERIALS AND METHODS

To obtain the required data, five local farm families were interviewed independently of the other participating farm families using a structured interview. The information was obtained at a time and place convenient for each farm family, and an audio recording was utilized. Transcription and translation took place once the interviews were complete by using the audio recordings. The constant comparative method of data analysis was used (Glaser, 1965).

In order to collect data, initial contact was made through a local farmers' market manager who assisted in introductions to the farmers. The local farmers' market had a Hmong population, thus a translator for the Hmong farmers was also contacted and assisted in translation and introductions. All interviews were audio recorded and later transcribed into a Word document at the conclusion of the interviews. Four of the five interviews took place on the farmers' farm. The fifth interview took place at the farmers' market per the request of the farmer.

Participants were selected from the Fayetteville Farmers' Market, which consisted of over 120 vendors. The participants were chosen from this pool based on their willingness to participate. The participants consisted of two Hmong farm families and three Caucasian-American farm families. The translator and market manager dealt with these farmers on a regular basis; therefore, they were depended upon for assistance in making initial contact with families believed to be most likely to participate. There was no discrimination between produce or protein producers.

The constant comparative method (Glaser, 1965) was used to analyze the data obtained in this study. The interviews were analyzed to develop codes and to categorize the responses, and at the same time look for trends in the codes and answers. Then to further the developing theory and understanding of the data, the categories derived from comparing and coding were integrated. Next, the theory was delimited and the data were analyzed further to write the theory. By delimiting the theory, we were able to determine if there were any limits to the theory. The use of the constant comparative method allowed a sound theory to materialize (Kolb, 2012).

The theoretical framework used in this study was the Theory of Planned Behavior, which has been used to predict human behaviors. This theory asserts that human behavior is driven by people's perceptions of self-control and personal attitudes, as well as social norms and pressures (Ajzen, 1991). As displayed in Fig. 1, the Theory of Planned Behavior asserts that ability (behavioral control) and motivation (intention) determine whether or not a behavior would occur. There are six constructs in the theory that influence a person's intention: attitudes, behavioral in-

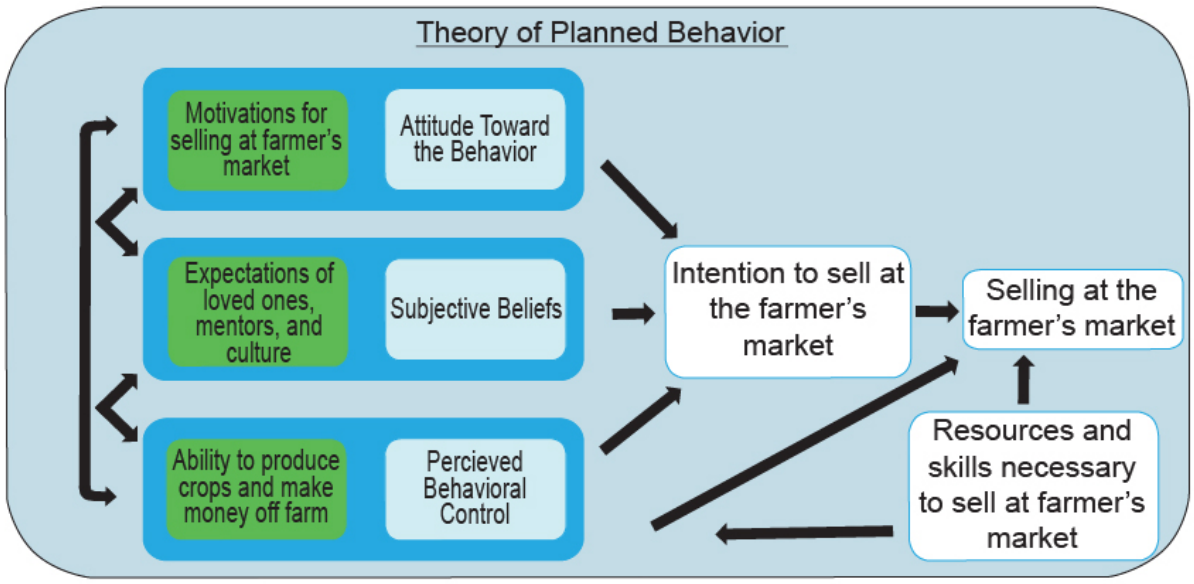


**Fig. 2.** Theory of Planned Behavior, applied to this study.

tention, subjective norms, social norms, perceived power, and perceived behavioral control (Ajzen, 1991). All six constructs influence a person's intention regarding a particular behavior and thus the actual behavior.

The actual behavioral controls of the farmers studied included the resources and skills that were necessary to sell at the farmers' market. The intention implied in this study was that the farmer intended to sell at the farmers' market. The behavior being studied was the farmer selling at the farmers' market (see Fig. 2). The three items furthest to the left are those defining the population of interest, and the three furthest to the right are the subject of examination within the study.

## RESULTS AND DISCUSSION

Data analysis brought to light seven themes, which are discussed below. The first theme revealed that farming was a way of life for these farmers. Three farmers initially began selling because they produced more food than their families could consume. The farmers' relationships with their customers were key reasons they sold at the local level. To help form relationships with their customers, they grew and sold quality produce. Along with selling quality produce, they also grew and sold a variety of vegetables and fruits. Challenges included competition at the farmers' market and weather conditions. There was no hierarchy to the findings discussed below.

For all of the farmers in this study, farming started at a young age and was a part of the fabric of their families. Farmer One talked about how it was part of his/her community, "Well in Hmong community there are a lot of people farming. Mostly [our] background is farm[ing]. In Laos and over here." For Farmer Two, a husband and wife team, the husband's journey in farming started early in life and carried over into his higher education, "I grew up on a farm and was interested in horticulture early in life, and when I went to college my major was in horticulture." Farmer Three, another husband and a wife team, stated, "We've always farmed, and my family owned small farm, basically backyard gardening. His family is from Jonesboro, so they were into more commercial, larger farms." Farmer Four's experience with farming was imprinted as a young child, "My family was into organic farming in California when I was a little kid. You know that was kind of my first memories, and I guess it kind of imprinted on me."

Three of the five farmers interviewed started selling because of an excess of produce. They had started out growing food for their families, but ended up with more than they could eat or process for later consumption. Farmer Three stated that they started selling at the farmers' market because:

> We had an excess in the first year that, you know I said the boys came, and we had more than we could eat, more than we could freeze. So we started out at smaller markets. This is our only our second year at Fayetteville.

All farmers interviewed in this study found the relationship they formed with their customers as rewarding. This was one of their motivations to sell at the farmers' market. Farmer Two stated:

> There's something about knowing your farmer and knowing your customer, and seeing, that you don't get that in the supermarket. To know who's behind [what] you fixed, who was successful at getting that and what goes into all of that.

Farmer Five enjoyed the bonding experience with their customers', "The biggest rewards we get are probably bonding, like we have a bond with our customers."

Four of the five farmers stated that having fresh, quality produce was an important part of selling at a local level. It was something that their customers wanted, and that the farmers wanted to provide for them. Farmer Four summed it up well when he/she stated:

> The external qualities, the internal qualities of you know texture, flavor, usability, shelf life and all that, is what brings people back. If people know that you're selling quality, especially the repeat customers, that really, really reduces the amount of promotion and advertising you have to do.

All of the farmers in this study stated that they grew a variety of crops. This was due in part to the fact that they felt they faced competition at the farmers' markets where they sold their produce. Some farms grew mostly vegetables, while other grew a variety of vegetables, fruits, and protein products.

Farmer One grew, "everything from asparagus, okra, zucchini squash, cucumbers, strawberries, potatoes, tomatoes, you know everything." Farmer Three sold a variety of vegetables, but also included honey products, "tomatoes, broccoli, corn, cabbage, yeah the 23 hives of honeybees, flowers, cauliflower, broccoli, lettuce, kale, arugula, [incoherent] squash, lots of squash, cucumbers." Farmer Two was investing more in fruit, while still retaining a wide variety of vegetables and protein products, "We have 65 acres. We have sheep, chicken, pigs and a garden with, with a variety of vegetables and we're leaning more towards fruit."

Three of the five farmers interviewed cited competition with other farmers at the farmers' markets. This is one reason they grow and sell a variety of products. As Farmer One stated, "at the farmers' market at Fayetteville, there's a lot of competition so you have to have a lot of different varieties of produce to be there." Additionally, according to Farmer Four, competition hindered sales, "Like tomatoes, a lot of times everybody has tomatoes at the same time and it's hard to move tomatoes. And knowing that we're only going to sell a percentage of what we have produced and brought."

Weather was a challenge that three of the five farmers in this study stated they faced. Put succinctly by Farmer Four, when asked what the biggest challenge in farming was they replied, "The weather." Farmer One explained that, "when you have very good plan, but the weather is not cooperative, then you lose a lot of your crops."

One of the primary questions for this study was why small, local farmers farm and sell at the local level. For all of the farmers in this study, farming was a way of life and something that has been a part of their lives since childhood. This study also explored the motivational factors of farmers selling at the local farmers' market. Motivational factors to begin selling included farmers having excess produce. Motivational factors to continue selling were the relationships the farmers had built with their customers. Additionally, this study focused on farmers' biggest challenges and rewards. Their biggest challenges were competition and the weather. Their biggest rewards were the relationships they built with their customers.

All of the farmers in this study grew up farming, gardening, or had early and prolonged experiences with family that imprinted on them. These experiences formed an affinity for farming, an activity in which these farmers could not only participate in, but also enjoy. Three of the farmers indicated that it was part of who they were. As Farmer Four stated, "It's kind of in your blood."

The farmers' biggest challenges in farming were weather and competition at the farmers' market. Some farmers depended on the rain for irrigation; thus if it did not rain, crops were not irrigated. Additionally, some lost crops to various weather events. Three of the five farmers cited competition as a challenge they faced. Although all of the farmers grew and sold a variety of produce, much of the produce from booth to booth was very similar.

For three of the five farmers, their initial motivation for selling at the farmers' market was an excess of produce. They had either eaten or preserved all that was possible and needed another outlet for their produce. Motivational factors to continue to sell at the farmers' market were the relationships they had built with their customers.

The farmers' relationship with customers was one of the farmers' rewards for selling at local farmers' market. Getting to know their customers as more than customers, even as friends, was something that was rewarding to them. Beyond the monetary transactions that took place between farmers and customers, there was a bond, a type of friendship that formed. These relationships built into opportunities; for example, when a customer offered to counsel one of the farmer's children in regards to college. The same farmer is also a real estate broker, and has assisted customers from the farmers' market with real estate contracts.

As stated in the introduction, this study sought to fill gaps in literature regarding farmers' motivations for farming and selling produce at a local level. Although literature

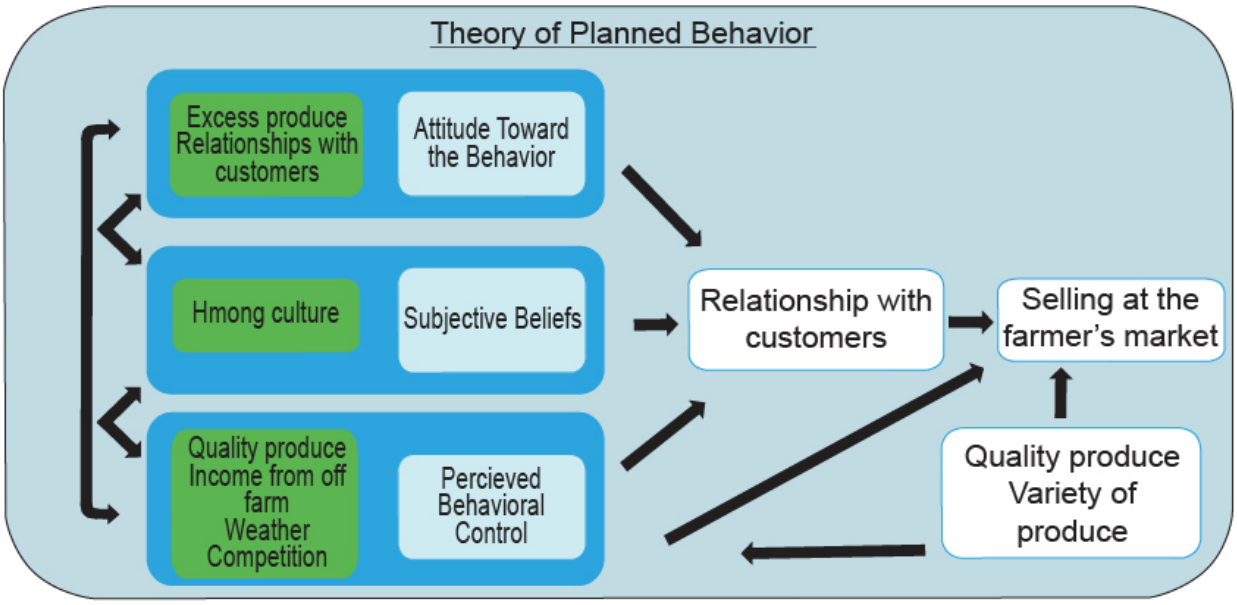


**Fig. 3.** Theory of Planned Behavior, applied to findings.

exists regarding local foods and farming, no literature has been found that explores farmers' motivations for farming and selling at a local level. For example, the United States Department of Agriculture initiative *Know Your Farmer, Know Your Food (KYF2)* is a 'USDA-wide effort to carry out President Obama's commitment to strengthening local and regional food systems' (USDA, 2015). While this initiative focuses on connecting local farmers with consumers, it does not seek to understand farmers' motivations or challenges when farming and selling locally. A joint publication from the Economic Research Service and USDA sought to understand the scale and scope of local food systems. Within this report, *Local Food Systems: Concepts, Impacts, and Issues*, the authors attempted to understand the characteristics of local food suppliers (Clark et al., 2010). Characteristics explored included the size of farms that sell directly to consumers, entrepreneurial activities other than farming, and barriers that farmers may face when trying to enter or expand a market (Clark et al., 2010).

While both the initiative and publication above sought to understand or enhance the connection between consumers and farmers, they lacked an understanding of the motivations of small farmers to sell at a local level. They also did not explore farmers' biggest challenges, things that could potentially harm their enterprise. This study was a starting point to fill in the gaps of understanding why farmers farm and sell on a local level. This study gives future researchers, and policy makers a starting point to understand farmers' motivations and challenges on a qualitative rather than quantitative basis. It also allows for further studies of this nature to be conducted, and could potentially assist policy makers understand what farmers need assistance with most.

In specific regard to the Theory of Planned Behavior, the farmers' attitude as to whether the behavior being performed was favorable or unfavorable was explored (Fig. 3). Farmers perceived selling at the farmers' market as both favorable and unfavorable. They perceived that the relationship with customers was favorable, and had a motivation to sell at the farmers' market. However, three perceived competition as unfavorable, and a hindrance to overall sales at the farmers' market.

The behavioral intentions explored were the perceived outcomes (motivational factors) of selling at a farmers' market. Three farmers stated that their initial motivation for selling at the farmers' market was an excess of food they had grown for their families. Additionally, all farmers were motivated to continue to sell at the farmers' market because of the relationship they had with their customers.

The social norms explored in this study were the expectations of the farmers' loved ones, mentors, and culture in relation to selling at the farmers' market. The researcher did not find any social norms or expectations that influenced farmers to sell at the farmers' market. However, it was found that the social norm of blemish free, high quality produce influenced four farmers to ensure they were able to provide this to customers. Additionally, it was found that the culture of the Hmong community encouraged them to farm.

Perceived power, circumstances that could aid or deter a behavior occurring, was explored in this study. It was found that three farmers perceived providing quality produce as aiding in their ability to sell at the farmers' market. The circumstance that could potentially deter farmers from selling at the farmers' market was competition.

Recommendations include that farmers find technologies to assist in mitigating damage that can be inflicted on produce from adverse weather events. Additionally, farmers should find ways to mitigate competition. Further studies should be done at the local, regional, and national level. Information gleaned from these studies should then be utilized in public awareness campaigns or marketing campaigns to increase the sale of local produce.

Although the weather cannot be controlled, there are steps that farmers can take to mitigate damage to their produce from weather events. Hoop houses and high tunnels can be utilized to extend the farming season in both the spring and fall (Orzolek and Sánchez, 2015), protect crops from freezing temperatures (Cregg and Fernandez, 2012), and even reduce hail damage when a 'thick translucent fiber cloth instead of thin high tunnel plastic' is used (Schweser, 2013). Farmers can utilize mulch to reduce the amount of water evaporating from the soil, thus reducing the amount of water needed for irrigation (Stein and Welsh). Additionally, mulch can reduce disease pressure by preventing splash up from the soil onto plants (Stein and Welsh).

Competition was identified by three farmers as being a challenge while selling at the farmers' market. Therefore it is suggested that farmers research ways to mitigate competition. Independent research, formal education, and communication with extension agents can provide farmers with appropriate strategies to address this factor.

It is suggested that additional studies be completed, not only locally, but in other areas of the United States as well. A larger scale implementation may determine if the themes hold true throughout the small farmer population. The interview could potentially be an Internet questionnaire in which farmers could input the information. The information received from farmers could then be compiled and used in public awareness and marketing campaigns to increase sales of local produce. This could be accomplished via a public marketing campaign to encourage consumers to get to know their farmers on a more personal basis by reading their stories.

In conclusion, direct-to-consumer sales have grown as the number of outlets for the sales, including farmers' markets and CSAs, have expanded in number and size, increasing accessibility for a larger consumer base. This study was a starting point for understanding the motivations and challenges of farmers who sell at a local level. For the farmers in this case study, farming was a way of life, and part of who they were. Three of the farmers initially started selling at the farmers' market because they had excess produce, and all of them farmed and sold at a local level because of the relationships that they built with their customers. The farmers' biggest challenges were competition and the weather. Farmers can utilize the knowledge of extension agents, research independently, or receive formal education to assist with mitigating competition. Additionally farmers can use technologies such as high tunnels to mitigate damage from weather events. By better understanding farmers' motivators for selling locally, researchers can assist them by helping them communicate their relationship-driven goals with potential consumers, thereby strengthening the local food economy.

## ACKNOWLEDGMENTS

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# Destination marketing organizations' stakeholders and best practices

*Bonifacio Lopez Torres* and Godwin-Charles Ogbeide†*

## ABSTRACT

As marketing practices continue to advance, the tourism industry is constantly evolving in terms of marketing strategies and in the shifting duties of its stakeholders. Different organizations plan the advancement of their marketing strategies differently, and Destination Marketing Organizations (DMOs) are no exception. With so many destination options, travelers may find themselves with too many destinations and too much information to easily make the decision on their own. The main role of the DMOs is to sell the destination using different marketing strategies and various incentives to make their destination more appealing, and by working with all of their stakeholders to be able to provide the best experience to visitors. This study examined the perception of effectiveness of various marketing channels, different social media channels, and different incentives that were being used by the DMOs. Some of the marketing channels that DMOs considered most effective in today's environment included website management, word-of-mouth, and search engine optimization; in terms of social media marketing channels, Facebook, YouTube, and Twitter were ranked as most effective. This study showed that some of the most effective incentives used by the DMOs were unique attractions accessibility, free Wi-Fi, and complimentary rentals. This study also explored the importance of various stakeholders to a DMO, and the results showed that some of the most important stakeholders were the hoteliers, the local government, and the local community.

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## MEET THE STUDENT-AUTHOR

***Bonifacio Lopez Torres***

I was born in San Felipe, Guanajuato, Mexico, but arrived to live in Lonoke, Ark. at the age of ten. I graduated with honors from Lonoke High School in 2010 and went on to pursue my career at the University of Arkansas. I chose the U of A to pursue a degree in Human Environmental Sciences, where I focused on Hospitality and Restaurant Management. I have had great opportunities at the University of Arkansas, where I got to serve as a leader in Holcombe Hall as Senate President, Core Leader for ICT (International Culture Team), President of Conexiones Latinas, and Vice President of Marketing for ESD (Eta Sigma Delta, honors hospitality organization). I completed my Food and Beverage internship at Chenal Country Club. During my fourth year, I also got the chance to spend a semester abroad in Heilbronn, Germany where I got to experience a completely different culture. After graduation I plan to move on to the next step and pursue my career in the Hospitality Industry.

I would like to thank Dr. Ogbeide for all of his time, dedication, and guidance on the completion of this project, as well as Dr. Harrington and Dr. Fosu for their time to review and approve my thesis.

## INTRODUCTION

As marketing practices continue to advance, the tourism industry is constantly evolving in terms of the marketing strategies and in the shifting duties of its stakeholders. In today's tourism industry, "travelers are now spoilt for choice of destinations, which must compete for attention in a market place cluttered with the messages of substitute products as well as rival regions" (Pike, 2004). With so many destination options, travelers may find themselves with too many destinations and too much information to easily make a decision on their own. In addition, Destination Marketing Organizations (DMOs) play a big role in the promotion of the destination, so knowing certain aspects of the DMO such as the type of incentives used, the marketing channels used, and their particular stakeholders was important to conduct this study. According to the United Nations World Tourism Organization (UNWTO) 2013 Annual Report (2014), North America has continued to increase in arrivals; for 2013, there was an increase of 4%, the same increase as reported in 2012. To create a competitive edge in the marketing strategy, DMOs' ability to differentiate their destination by practicing different marketing activities is important.

Destination marketing organizations (DMOs) focus on the marketing and selling strategies of specific places. These organizations are "charged with representing a specific destination and helping the long-term development of communities through a travel and tourism strategy" (DMAI, n.d.). These DMOs are also responsible for creating a competitive edge that will make their particular destination more appealing than their competitors'. The DMO was designed to act as the leader of the management of tourism in a destination to effectively manage all the components of the tourism system to ensure success (Bornhorst et al., 2009). It is extremely important for the DMOs to provide incentives for visitors because, in the competitive realm of destinations, the visitor is more likely to visit the destination where they see more value for their money. Incentives are defined as "inducements or supplemental rewards that serve as motivational devices for a desired action or behavior" (Business Dictionary, 2014).

The purpose of this study was to examine the effectiveness of selected marketing channels and incentives as they were used by DMOs in their marketing strategy, as well as explore and see which of selected stakeholders were more important to the DMO. To accomplish the purpose of the study, three objectives were developed and included:

1. Examine the effectiveness of certain DMOs' marketing channels.
2. Examine the effectiveness of incentives used by DMOs to attract their visitors.

**Table 1. Titles of survey respondents.**

| Title | % of Respondents by Title |
|---|---|
| President/CEO | 47% |
| Executive Director/Director | 28% |
| Director of Sales | 5% |
| Vice President | 3% |
| Coordinator, Economic Development & Tourism | 2% |
| Marketing Manager | 2% |
| VP Marketing | 2% |
| Executive Assistant | 2% |
| Director of Tourism | 2% |
| VP of Sales | 2% |
| Director of Research | 2% |
| Program Coordinator | 2% |
| PR Coordinator | 2% |
| Director of Marketing | 2% |

3. Explore the importance of various stakeholders to the DMO.

## MATERIALS AND METHODS

The instrument (survey) design for this study was based on a review of literature (Antonsen, 2010; DMAI, 2012; Tucker, 2013), with help from industry professionals and approved by University of Arkansas professors. The target population for this study was a list of DMOs in the United States of America. The list used came from CVENT's USA Convention and Visitors Bureau (CVB) directory (US CVB, n.d.); CVENT is a leader organization that focuses on event management, online event registration, venue sourcing, and mobile event app technology. The population sample used in this research was based on the availability of DMOs' contact information on their website, the total number of DMOs on the CVENT directory is 421; however, the total number of e-mail addresses for the survey to be distributed was 376, which became the total population of the study. The U.S. Census divides the U.S. into four regions: (I) Northeast, (II) Midwest, (III) South, and (IV) West. The survey was distributed for a duration of three weeks. It was distributed at various times of the day on different days of the week to try to get the best times for different regions. From these regions, there were 54 DMOs from the Northeast, 81 from the Midwest, 148 from the South, and 93 from the West.

Once all the contact information was gathered and the survey was approved by the Institutional Review Board (IRB), it was distributed via Qualtrics: Online Survey Software & Insight Platform (Provo, Utah). The questionnaire included 36 Likert-type items that ranged from 1 to 5; 1 = Not Effective and 5 = Very Effective, as well as 9 Likert-type items that also ranged from 1 to 5, 1 = Not Important and 5 = Very Important. The questionnaire also included 8 questions with regard to the demographics of the DMO and the respondent. Descriptive statistics (mean, percentage, and frequencies) of the quantitative data were analyzed using the Statistical Package for Social Sciences (IBM SPSS, Armonk, N.Y.) to evaluate the level of effectiveness of the marketing channels and incentives, as well as the importance of the stakeholders to the DMOs and the demographics of the DMOs.

## RESULTS AND DISCUSSION

The sample selection for this study included DMOs from all regions of the United States. The respondents of the questionnaire varied from Executive Directors, Presidents, Vice Presidents, CEOs, VPs of Marketing, Marketing Managers, etc. (Table 1). Throughout the data collection process, 86 surveys were received, but only 82 of them were usable—the survey was sent to 376 DMOs, so this showed a 21.8% response rate. As previously mentioned, the U.S. Census Bureau divides the states into four different regions–(I) Northeast, (II) Midwest, (III) South, and (IV) West. From the respondents (n = 71), 16% identified themselves as Northeast, 24% Midwest, 35% as South, and 25% as West. The DMOs were given options to identify themselves as National, Regional, or Local DMOs; the results showed 14%, 28%, and 58% identification, respectively. The respondents' annual budgets ranged from less than $500,000 to more than $10,000,000 (Fig. 1).

The first objective of this study was to examine the effectiveness of certain DMOs' marketing channels. The top five most effective marketing channels used by the DMOs were Website Management and Word-of-Mouth (M = 4.58), Search Engine optimization (M = 4.5), Public Relations (M = 4.45), and Social Media (M = 4.13) (Table 2). Website Management and Word-of-Mouth tied; both placing as number one in terms of effectiveness of the marketing channels according to the results. This meant that maintaining an active and accessible website was essential for the DMOs' success, as was maintaining great customer relations through word-of-mouth, which also continued to rule the DMOs' marketing strategies (Tucker, 2013). Search Engine Management followed in third place followed by Public Relations. In fifth place was Social Media. It was interesting to note that the least effective of the marketing channels used by the DMOs,

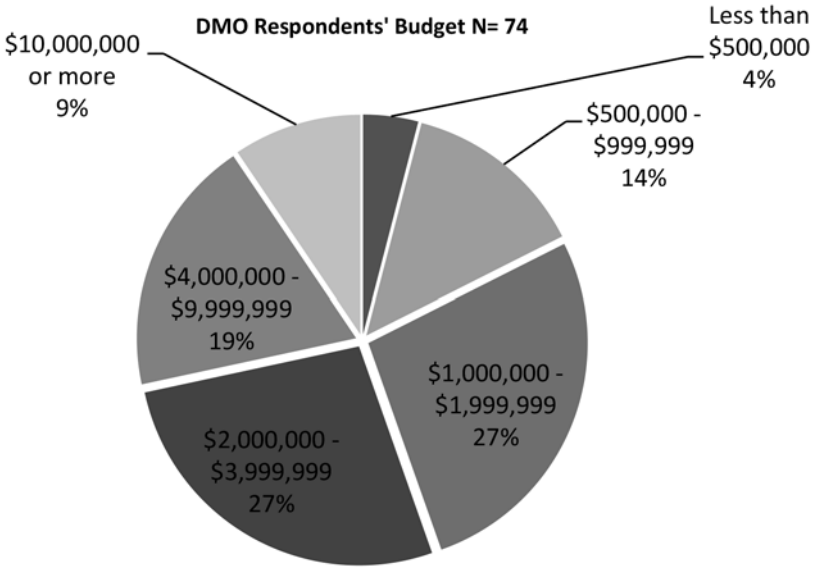


**Fig. 1.** Destination marketing organization respondents' budget distribution.

as shown by the consistency of the respondents, were the Directory (Ranked 13th), Telemarketing (Ranked 12th), and Direct Mail (Ranked 11th).

From the data collected, it was shown that eleven of the respondents belonged to the Destination Marketing Association International's (DMAI) Top 50 Meeting Destinations. The data for these Top 50 Meeting Destinations were analyzed separately from the total number of respondents (Table 2). In comparison to the results from all of the respondents, the total mean for the Top 50 Meeting Destinations, the most effective five channels were (1) Website Management, (2) Word-of-Mouth, (3) Search Engine Optimization, (4) Public Relations, and (5) E-Mail Marketing. Surprisingly, E-mail Marketing and Social Media switched positions in the overall rankings. For the bottom two, Telemarketing and Directory switched rankings; whereas, the use of Directory marketing seemed to be more effective than Telemarketing for the Top 50 Meeting Destinations, although due to the variability in responses, the difference of the rankings is not of much importance.

**Table 2. Destination marketing organizations' ranking of effectiveness of marketing channels.**

| | All Respondents (N = 74) | | Only Top 50 Meeting Destinations (N = 11) | |
|---|---|---|---|---|
| **Rank** | **Marketing Channel** | **Mean** | **Marketing Channel** | **Mean** |
| 1 | Website Management | 4.58 | Website Management | 4.44 |
| 2 | Word-of-Mouth | 4.58 | Word-of-Mouth | 4.44 |
| 3 | Search Engine Optimization | 4.50 | Search Engine Optimization | 4.44 |
| 4 | Public Relations (e.g. News, PSA) | 4.45 | Public Relations (e.g. News, PSA) | 4.22 |
| 5 | Social Media | 4.13 | E-Mail Marketing | 4.10 |
| 6 | TV Advertising | 3.96 | TV Advertising | 4.00 |
| 7 | E-Mail Marketing | 3.87 | Social Media | 3.89 |
| 8 | Print Advertising | 3.40 | Sponsorship (e.g. Expositions, Events | 3.56 |
| 9 | Sponsorship (e.g. Expositions, Events | 3.40 | Print Advertising | 3.40 |
| 10 | Radio Advertising | 3.37 | Radio Advertising | 3.43 |
| 11 | Direct Mail | 3.30 | Direct Mail | 3.33 |
| 12 | Telemarketing | 2.19 | Directory (e.g. Telephone, Association) | 2.11 |
| 13 | Directory (e.g. Telephone, Association) | 2.16 | Telemarketing | 2.00 |

**Table 3. Ranking of most effective social media marketing channels.**

| | All Respondents (N = 74) | | Only Top 50 Meeting Destinations (N = 11) | |
|---|---|---|---|---|
| Rank | Social Media Channel | Mean | Social Media Channel | Mean |
| 1 | Facebook | 4.15 | Facebook | 4.25 |
| 2 | YouTube | 4.01 | YouTube | 4.13 |
| 3 | Twitter | 3.85 | Twitter | 3.89 |
| 4 | Instagram | 3.74 | Flickr | 3.50 |
| 5 | Pinterest | 3.49 | Tumblr | 3.50 |
| 6 | Flickr | 3.14 | Instagram | 3.14 |
| 7 | LinkedIn | 3.09 | Pinterest | 3.00 |
| 8 | Tumblr | 2.76 | LinkedIn | 3.00 |

Since social media has become such a phenomenon in the marketing field the past decade, this study also examined the most effective marketing channels that the DMOs were using in today's marketing strategies. The top four most effective of the social media marketing channels analyzed were Facebook (M = 4.15), YouTube (4.01), Twitter (M = 3.85), and Instagram (M = 3.74), all ranked respectively from first to fourth. The least effective (and least used) were Pinterest (M = 3.49), Flickr (M = 3.41), LinkedIn (M = 3.09), and Tumblr (M = 2.76) (Table 3). Initially, it was hypothesized that, because of its accessibility by businesses and professionals, LinkedIn would be in the top four, but surprisingly it ranked seventh, followed only by Tumblr which ranked eighth.

The same calculations and analysis were done for eleven of the Top 50 Meeting Destinations. Below the top three, rankings of effectiveness of social media channels differed between the Top 50 Meeting Destinations and the entire set of survey respondents (Table 3). Facebook, YouTube, and Twitter still ranked in the top three; however, the lowest rankings were received by Instagram (M = 3.14), followed by Pinterest (M = 3.0), followed by LinkedIn (M = 3.0). In the results from the Top 50 Meeting Destinations, both Flickr and Tumblr ranked higher than Instagram in overall effectiveness.

The second objective of this study was to examine incentives used by the DMOs to attract their visitors. The top five ranked as most effective incentives were Unique Attractions Accessibility (M = 4.07), WiFi (M = 4.02), Complimentary Rentals (M = 3.87), Convention Discounts (M = 3.81), and Complimentary Shuttle to Meeting Venue (M = 3.76) (Table 4). The lowest ranked incentives were, re-

**Table 4. Ranking of most effective incentives used by destination marketing organizations.**

| | All Respondents (N = 74) | | Only Top 50 Meeting Destinations (N = 11) | |
|---|---|---|---|---|
| Rank | Incentive | Mean | Incentive | Mean |
| 1 | Unique Attractions Accessibility | 4.07 | Free WiFi | 4.50 |
| 2 | Free WiFi | 4.02 | Convention Discounts | 4.20 |
| 3 | Complimentary Rentals | 3.87 | Unique Attractions Accessibility | 4.00 |
| 4 | Convention Discounts | 3.81 | Complimentary Rentals | 4.00 |
| 5 | Complimentary Shuttle to Meeting Venue | 3.76 | Complimentary Shuttle to Meeting Venue | 4.00 |
| 6 | Room Discounts | 3.73 | Room Discounts | 3.83 |
| 7 | Welcome Table and Information | 3.68 | Welcome Table and Information | 3.67 |
| 8 | Food Discounts | 3.58 | Food Discounts | 3.67 |
| 9 | Promotion Packages | 3.53 | Promotion Packages | 3.25 |
| 10 | Free Festivals | 3.38 | Goody Bags | 3.17 |
| 11 | Goody Bags | 3.29 | Free Festivals | 3.00 |
| 12 | Free Museum Tickets | 2.93 | Free Museum tickets | 2.40 |

**Table 5. Ranking of importance of stakeholders to the destination marketing organizations.**

| | All Respondents (N = 74) | | Only Top 50 Meeting Destinations (N = 11) | |
|---|---|---|---|---|
| **Rank** | **Stakeholder** | **Mean** | **Stakeholder** | **Mean** |
| 1 | Hoteliers | 4.79 | Hoteliers | 4.40 |
| 2 | Local Government | 4.58 | Local Government | 4.33 |
| 3 | Local Community | 4.41 | Local Community | 4.20 |
| 4 | Media (e.g. Newspapers, Radio) | 4.08 | Media | 3.89 |
| 5 | F&B Operators | 3.99 | Sponsors | 3.63 |
| 6 | Sponsors | 3.93 | F&B Operators | 3.56 |
| 7 | Service Contractors (e.g. AV, Catering) | 3.34 | Service Contractors | 3.22 |

spectively, Promotion Packages (M = 3.53), Free Festivals (M = 3.38), Goody Bags (M = 3.29), and Free Museum Tickets (M = 2.93). Even though there was only a difference of 0.78 between unique attractions and goody bags, being able to provide access to a unique attraction was felt to be far more effective than providing goody bags when promoting a destination, based on the consistent responses provided by the collected data. In today's environment, destinations should not overlook the ability to provide free WiFi at the destination because, with advancement and technology, the satisfaction of the visitor could increase with the ability to navigate their electronic devices for free—as these findings show that internet accessibility is a valued incentive taken into account by the visitors.

The same analysis was done exclusively for those respondents ranked in Top 50 Meeting Destinations. In comparison with the rankings of the incentives from among all survey respondents, the results of the top 50 Destinations ranked the top incentives to be in first place, Free WiFi (M = 4.5); second, Convention Discounts (M = 4.2); and, third was tied between Unique Attractions Accessibility, Complimentary Rentals, and Complimentary Shuttle to the Meeting Venue (all at M = 4.0; Table 4). It might be assumed that Free WiFi ascended in ranking because of its popularity in larger events such as large conferences: as it was essential for the organizers to provide WiFi for the attendees for increased satisfaction. Ogbeide et al. (2013) showed "the Millenial Generation appreciated the use of technology for communication (e.g. Wi-Fi and audience polling for immediate feedback) and expected it to be accessible during meetings and events." The bottom three, however, were respectively tenth place, Goody Bags (M = 3.17); eleventh place, Free Festivals (M = 3.0); and, twelfth place, Free Museum Tickets (M = 2.4).

The third objective of this study was to analyze the importance of various stakeholders to a DMO. The DMOs were asked to rank the most important stakeholders to their organization and the results showed that Hoteliers (M = 4.79) were the most important when it came to marketing of destinations (Table 5). The Local Government (M = 4.58) and Local Community (M = 4.41) also ranked highly as the top two and three stakeholders, respectively, when the DMO marketed destinations. The DMOs ranked Food and Beverage (F&B) Operators (M = 3.99), Sponsors (M = 3.93), and Service Contractors (M = 3.34) as their least important stakeholders. It was important to notice that Media ranked fourth in terms of importance.

For the third objective, the same analysis was also run for the Top 50 Meeting Destinations. These results showed that the top three ranking stakeholders were Hoteliers (M = 4.4), Local Government (M = 4.33), and Local Community (M = 4.2; Table 5). These rankings showed the same results as obtained from the entire set of survey respondents. The bottom three rankings were also similar to that of all surveyed DMOs. Ranking fifth were Sponsors (M = 3.63); sixth, F&B Operators (M = 3.56); and seventh, Service Contractors (M = 3.22). These findings continue to support that the main stakeholder for destination marketing continues to be the "destination promotion triad," which includes the DMO, the city, and the hotels (Tucker, 2013).

Destination Marketing Organizations have been in charge of promoting the destinations for a long time. With the ongoing changes in marketing strategies, the application and practice of these results can lead to increased performance by DMOs. Future studies can further research the continuous changing marketing activities and performance of DMOs; as technology keeps advancing and markets become more diverse, new research is essential. Furthermore, this study shows some of the current practices that should be applied by the DMOs to improve or continue their performance rates.

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# Conjugated linoleic acid-rich chocolate paste production and characterization

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## ABSTRACT

Conjugated linoleic acid (CLA) is an 18-carbon fatty acid with multiple health benefits, including anti-obesity and anti-carcinogenic properties. CLA-rich soy oil (CLARSO) can be produced through a heterogeneous catalysis process, and this oil was previously used to produce CLA-rich margarines and shortenings. The objective of this study was to produce CLA-rich chocolate pastes by replacing a portion of the fat with CLARSO and compare the rheological (flow), textural, and thermal properties of these pastes to controls made with either soy oil or traditional fats. CLARSO was used to prepare pastes. Rheology, firmness, and thermal behavior of the pastes were determined. The CLARSO chocolate pastes contained no additional saturated fat relative to soy oil controls but the pastes had more solid-like rheology and were firmer. Relative to non-soy controls, CLARSO pastes had similar rheology, despite containing less saturated fat. The fat crystals of all samples were in the same polymorphic form. Therefore, it was successfully demonstrated that CLARSO has the ability to produce chocolate pastes with similar physical properties as traditional products containing more saturated fat.

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## MEET THE STUDENT-AUTHOR

***Sarah Mayfield***

I am from San Antonio, Texas and graduated from Smithson Valley High School in 2011. I spent 4 years at the University of Arkansas studying Food Science and Biochemistry and graduated in the spring of 2015. This fall, I will be pursuing a Ph.D. in Food Science at the University of Arkansas under the direction of Dr. Andy Proctor.

During my undergraduate career, I was president of the Food Science Club, a Bumpers College Student Ambassador, and a Co-Chair for the American Oil Chemists' Society Student Division. I had the opportunity to travel to the University of Gent in Ghent, Belgium during the summer of 2014 to conduct a portion of my honors thesis research. In addition to providing me with valuable research experience, this taught me the importance of inter-institutional collaboration, particularly in an international setting.

I would like to thank Dr. Andy Proctor for providing me the opportunity to conduct research under his supervision and for serving as an excellent research mentor. I would also like to thank the University of Gent, and in particular Dr. Koen Dewettinck and Dr. Ashok Patel, for allowing me to work in their laboratories and for helping me with numerous manuscript edits. Lastly I would like to thank all of the institutions that have provided funding for this project: the Dale Bumpers College, the University of Arkansas Honors College, the Arkansas Department of Higher Education SURF Grant, and the University of Gent.

## INTRODUCTION

Conjugated linoleic acid (CLA) is an 18-carbon dietary fatty acid found mostly in dairy and bovine foods (Whigham et al., 2000). Conjugated linoleic acid has many positive human health benefits, including anti-carcinogenic properties (Cesano et al., 1998; Kim et al., 2002), and the ability to fight atherosclerosis (Feitoza et al., 2009; Nicolosi et al., 1997), lower the risk of diabetes (McGuire and McGuire, 1999), and improve immune function (Gilbert et al., 2011). However, the typical diet provides only a fraction of the 3.2 grams of CLA needed daily to gain these health benefits, and increasing dietary CLA by increased consumption of bovine foods is unadvisable as they are also high in saturated fat and cholesterol (Ip et al., 1991; Mougios et al., 2001). Therefore, a CLA-rich food source that is low in saturated fats and cholesterol would be desirable.

Soy oil contains approximately 50% linoleic acid (LA), a fatty acid with the potential to be isomerized to CLA, and could therefore be used to produce CLA-rich food products that are low in saturated fat and cholesterol (Gangidi and Proctor, 2004). Jain and Proctor (2006) developed a process to produce a 20% CLA-rich soy oil (CLARSO) through the photoisomerization, or the excitation of molecules by light to induce a structural change, of soy oil LA in the presence of an iodine catalyst. However, it was necessary to remove the iodine in this process, which therefore made it difficult to commercialize. Shah and Proctor (2013) developed a heterogeneous catalysis process that produces 20% CLARSO in 2 hours without the use of solvents. A ruthenium-on-carbon catalyst is combined with soy oil in a high temperature, vacuum distillation technique, similar to the deodorization process routinely used in industry. Unlike the iodine-catalyzed photoisomerization process (Jain and Proctor, 2006), the ruthenium catalyst easily can be centrifuged and filtered out of the oil (Yettella et al., 2012).

Ruan and Proctor (2014) found that CLARSO had greater solid fat properties relative to conventional soy oil, including increased viscosity and a higher melting point temperature. A CLARSO margarine was developed by Shah et al. (2014) and the firmness, rheology (flow behavior), thermal behavior, and microstructure were compared to a soy oil control and a commercially available margarine. The CLARSO margarine was firmer, better able to tolerate high levels of stress without deformation, and had a higher solid fat content than the soy oil control, while having physical properties comparable to those of commercial margarine. Five typical servings of this mar-

garine would provide the recommended daily value of CLA and 185 Calories. Mayfield et al. (2015) subsequently developed CLA-rich shortenings and compared their rheology, thermal properties, and microstructure to those of soy oil controls and commercially available shortenings. The CLA-rich shortenings possessed more solid-like rheological properties and had a more stable crystal structure, as indicated by differential scanning calorimetry (DSC) analysis, than did the soy oil controls. Furthermore, CLA shortenings also had similar physical properties to commercial controls. The results of the margarine and shortening studies illustrate the effectiveness of CLARSO as a replacement for conventional saturated fats in food products, while providing additional health benefits.

Chocolate, like shortening, is a fat-based food whose physical properties are dependent upon its polymorphic crystal structure. Therefore, the oils and fats used to produce chocolate products have a significant effect on product quality. It will be of interest to know how such a replacement of palm oil with CLARSO in chocolate paste will affect chocolate products.

Therefore, the objective of this study was to determine the functional physical properties of chocolate paste prepared by replacing 25% of a palm oil/canola oil mixture with CLARSO, relative to control pastes obtained by replacing 25% of the palm/canola mixture with soy oil, and a control made solely with the palm/canola oil mixture.

## MATERIALS AND METHODS

### Conjugated Linoleic Acid-Rich Soy Oil Production and Analysis

The heterogeneous catalytic process of Shah and Proctor (2013) was adopted to produce CLA-rich soy oil from refined, bleached, deodorized (RBD) soy oil (Riceland Foods, Stuttgart, Ark., USA), which was used to produce chocolate pastes and bars. The method of Lall et. al. (2009) was used to determine the fatty acid profile of RBD and CLARSO duplicate samples as fatty acid methyl esters (FAMES). Each sample was analyzed by gas chromatography with a flame ionization detector (GC-FID).

### Chocolate Paste Production and Analysis

*Chocolate Paste Preparation*. Chocolate pastes were prepared according to the method of Patel et al. (2014). There were three types of chocolate paste produced: CLARSO, soy oil control, and non-soy oil control. Each paste contained 30% (wt.) of a fat blend, the composition of which differed based on the type of paste. The fat blend used for the control paste consisted of 70% palm oil and 30% canola oil (Vandemoortele R&D, Izegem, Belgium). The fat blends used for the CLA-rich and soy oil pastes were prepared by making the control fat blend (70% palm oil and 30% canola oil) and then replacing 25% of this with either CLARSO or soy oil, so that these final fat blends contained 52.5% palm oil, 22.5% canola oil, and 25% of either CLARSO or soy oil.

One kilogram of each type of chocolate paste was prepared with these fat blends, as described in Table 1. Eighty percent (wt/wt) of the fat blend and Palsgaard Oil Binder (Palsgaard A/S, Denmark) were combined in a Stephan UMC 5 mixer (Stephan Machinery, Hameln, Germany) set to a temperature of 60 °C and stirred until the Oil Binder was completely dissolved. Milk powder (Friesland, Campina, Belgium), cocoa powder (Cargill, Wormer, The Netherlands), and crushed sugar (Barry Callebaut, Wieze, Belgium) were then added to the mixture which was stirred for approximately 2 min. The particle size of the mixture

**Table 1. Composition of conjugated linoleic acid-rich oil, soy oil, and control chocolate pastes.**

| | CLARSO paste | | Soy oil paste | | Control paste | |
|---|---|---|---|---|---|---|
| Ingredient | % By mass | Amount (g) | % By mass | Amount (g) | % By mass | Amount (g) |
| Palm oil | 15.75 | 157.5 | 15.75 | 157.5 | 21.0 | 210.0 |
| CLARSO | 7.5 | 75.0 | --- | --- | --- | --- |
| Soy oil | --- | --- | 7.5 | 75.0 | --- | --- |
| Canola oil | 6.75 | 67.5 | 6.75 | 67.5 | 9.0 | 90.0 |
| Palsgaard Oil Binder | 1.50 | 15.0 | 1.50 | 15.0 | 1.50 | 15.0 |
| Crushed sugar | 47.85 | 478.5 | 47.85 | 478.5 | 47.85 | 478.5 |
| Skim milk powder | 14.0 | 140.0 | 14.0 | 140.0 | 14.0 | 140.0 |
| Cocoa powder | 6.0 | 60.0 | 6.0 | 60.0 | 6.0 | 60.0 |
| Palsgaard PGPR 4150 | 0.15 | 1.5 | 0.15 | 1.5 | 0.15 | 1.5 |
| Palsgaard AMP 4448 | 0.5 | 5.0 | 0.5 | 5.0 | 0.5 | 5.0 |

was reduced through refining using an Exakt 80S 3-roll mill (Exakt Technologies Inc., USA) with a roll temperature of 35 °C, a roll distance of 3-1, and a speed of 400 rpm. The refined mixture was placed back into the Stephan Mixer, the remaining fat blend, Palsgaard PGPR 4150, and Palsgaard AMP 4448 (Palsgaard A/S, Denmark) were added, and the mixture was stirred for approximately 2 min. The chocolate paste was transferred into 20 cylindrical plastic containers (1 in. diameter × 1 in. height) for texture analysis and into 6-50-mL centrifuge tubes for rheology and thermal analysis. Pastes were stored at 20 °C for one week prior to analysis.

*Rheology Determination*. The rheology of the pastes was determined in sample duplicate after one week of storage at 20 °C (deemed "week 1") and after two weeks of storage at 20 °C (deemed "week 2") with an AR 2000 Rheometer (TA Instruments, New Castle, Del., USA). Strain and frequency sweeps were performed to determine gel strength and viscoelastic behavior of the samples. A cross-hatched parallel plate geometry (diameter = 40 mm) was used with a geometry gap set at 1000 μm. The strain sweep involved increasing the strain from 0.0001 to 100 while keeping the temperature constant at 20 °C. The complex modulus G' was measured as a function of strain to analyze the resistance of the samples to deformation as there was increased stress applied to the sample. The frequency sweep involved increasing the frequency from 0.1 to 100 Hz while keeping the temperature at 20 °C.

*Firmness Analysis*. Firmness analysis was performed on chocolate paste samples after one and two weeks of storage at 20 °C. Five sample replicates were analyzed using a 5942 Instron TA 500 Texture Analyzer (Lloyd Instruments, Bognor Regis, West Sussex, UK). Firmness was defined as the force required to penetrate the samples using an 11 mm diameter cylindrical probe which entered the samples to a depth of 10 mm at a rate of 10 mm/min with a 0.1 N trigger value.

*Thermal Analysis*. Fat blends as used in each chocolate paste sample were prepared. The control blend contained 70% palm oil and 30% canola oil; the CLARSO blend contained 52.5% palm oil, 22.5% canola oil, and 25% CLARSO; and the soy oil blend contained 52.5% palm oil, 22.5% canola oil, and 25% soy oil. The melting behavior of triplicate samples was determined by differential scanning calorimetry (DSC) using a Q1000 Tzero DSC (TA Instruments, New Castle, Del., USA). Indium (enthalpy and temperature), azobenzene (temperature), and undecane (temperature) were used to calibrate the instrument. The instrument was purged with nitrogen and an empty pan was used as reference. Five to ten mg of each fat blend was placed in hermetic aluminum pans and the pans were sealed. The melting behavior of the samples was determined by equilibrating the pans at 20 °C for 10 min and then increasing the temperature at a rate of 5 °C/min to a final temperature of 70 °C. The heat flow was measured as a function of temperature and the resulting DSC curves were analyzed using the Universal Analysis software (TA Instruments, New Castle, Del.). A single inverted peak (endothermic peak) was observed and four parameters of this peak were analyzed: the onset temperature, the temperature at which the maximum heat flow was observed (the peak temperature), the offset temperature, and the enthalpy absorbed (the peak integration).

**Data Analysis**

All statistical analyses were performed using JMP 10 (SAS Institute, Inc., Cary, N.C.) statistical software. The fatty acid composition, rheology, texture, and thermal results were analyzed by comparing the overall means in a one-way analysis of variance using Tukey's honest significant difference test with an α-level of 0.05. The strain and frequency sweep G' values were transformed logarithmically to obtain a better comparison, as the data .

## RESULTS AND DISCUSSION

**Conjugated Linoleic Acid-Rich Soy Oil Fatty Acid Analysis**

There was no significant difference between the total saturated fat content of CLARSO and soy oil, as shown in Table 2. The CLARSO contained a total saturated fat content of 18.74% and the soy oil contained a total saturated fat content of 18.09%. The CLARSO contained 20.83% CLA. Therefore, 15.4 g of this oil would need to be consumed daily in order to receive the recommended 3.2 g of CLA.

**Table 2. Fatty acid data for conjugated linoleic acid-rich soy oil (CLARSO) and soy oil used to produce chocolate pastes and bars.**

| Fatty Acid† | CLARSO % | Soy Oil % |
|---|---|---|
| C16:0 | 13.54 ± 0.03a‡ | 13.98 ± 0.70a |
| C18:0 | 5.20 ± 0.03a | 4.112 ± 0.80b |
| C18:1 | 26.78 ± 0.03a | 23.25 ± 1.22b |
| C18:2 | 31.85 ± 0.03b | 54.74 ± 1.58a |
| C18:3 | 1.80 ± 0.01b | 5.41 ± 0.80a |
| CLA *cis,trans/trans,cis* | 15.76 ± 0.41 | - |
| CLA *trans,trans* | 5.07 ± 0.41 | - |
| Total CLA | 20.83 ± 0.00 | - |
| **Total saturated fat** | **18.74 ± 0.04a** | **18.09 ± 1.07a** |

† Samples were analyzed in duplicate and error indicates standard deviation. Statistical analysis was performed to identify significant differences between individual fatty acids.

‡ Samples connected by same letter are not significantly different.

**Table 3. Overall mean G' values for one decade of strain (0.01-0.1) from the strain sweep analysis of conjugated linoleic acid-rich, soy oil, and control chocolate paste samples.**

| Sample | Overall mean G'† |
|---|---|
| Control week 1 | 15.98 ± 0.22 a‡ |
| CLARSO week 1 | 14.98 ± 0.14 c |
| Soy oil week 1 | 13.69 ± 0.30 d |
| Control week 2 | 15.97 ± 0.21 a |
| CLARSO week 2 | 16.02 ± 0.28 a |
| Soy oil week 2 | 15.51 ± 0.25 b |

† Analysis was performed in duplicate and error indicates standard deviation. The means were transformed logarithmically to obtain a better comparison.

‡ Samples with the same connecting letter are not significantly different.

**Table 4. Overall mean G' values from the frequency sweep analysis of conjugated linoleic acid-rich, soy oil, and control chocolate paste samples.**

| Sample | Overall mean angular frequency (rad/s)† |
|---|---|
| Control week 1 | 15.87 ± 0.22a‡ |
| CLARSO week 1 | 13.53 ± 0.17de |
| Soy oil week 1 | 13.50 ± 0.18e |
| Control week 2 | 15.65 ± 0.27b |
| CLARSO week 2 | 15.30 ± 0.21c |
| Soy oil week 2 | 12.95 ± 0.21f |

† Analysis was performed in duplicate and error indicates standard deviation. The means were transformed logarithmically to obtain a better comparison.

‡ Samples with the same connecting letter are not significantly different.

**Chocolate Paste Characterization**

*Rheology Determination*. The mean G' values for one decade of % strain, from 0.01 to 0.1, were compared to identify any statistically significant differences in solid-like behavior among samples (Table 3). For both the CLARSO and soy oil samples, the week 2 samples had significantly higher G' values than their respective week 1 values. Therefore, post-production isothermal crystallization and hardening occurred in both of these samples, increasing their solid-like behavior. There was no significant difference between the control week 1 and week 2 samples. The CLARSO week 1 and week 2 samples had significantly higher mean G' values than the soy oil week 1 and week 2 samples, respectively. This indicated that CLARSO provided the chocolate paste with a more solid crystal structure, without the addition of saturated fats. The CLARSO week 2 sample was not significantly different from the control week 2 sample. The control sample contained a greater portion of solid fat but had solid behavior similar to that of the CLARSO sample. Therefore, CLARSO behaved more like a solid fat without contributing additional saturated fatty acids.

The overall mean G' values were compared to determine any statistically significant differences among samples in angular frequency (Table 4). Similar to the strain sweep analysis, this was an indication of solid behavior.

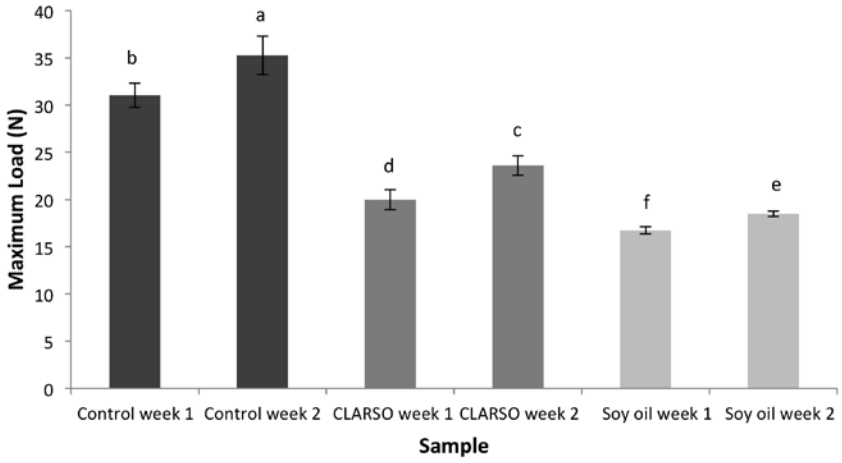


**Fig. 1.** Bar graph displaying the mean maximum load measured during firmness analysis of conjugated linoleic acid-rich, soy oil (CLARSO), and control chocolate pastes. Measurements were taken after one and two weeks of storage at 20 °C. Five sample replicates were analyzed for each type of paste and error bars indicate standard deviation. Samples with the same connecting letter are not significantly different.

The CLARSO week 2 sample had a significantly higher mean G' value than did the CLARSO week 1 sample. However, the control and soy oil week 2 samples had significantly lower mean G' values than did their respective week 1 samples. Therefore, the CLARSO sample displayed post-production isothermal crystallization hardening in this case but the control and soy oil samples did not. Although the CLARSO and soy oil week 1 samples were not significantly different, the CLARSO week 2 sample had a significantly higher G' value than did the soy oil week 2 sample. This was consistent with the strain sweep results: the CLARSO provided a more solid-like structure without contributing additional saturated fats.

**Firmness Analysis**

Figure 1 shows the maximum force achieved when samples of CLARSO, soy oil, and control chocolate pastes were penetrated with a cylindrical probe, as an indication of the firmness of the samples. All week 2 samples showed significantly greater firmness than their respective week 1 samples. This indicates that significant amounts of post-production isothermal crystallization/hardening occurred, which is consistent with the results of the strain sweep analysis. Both the CLARSO week 1 and week 2 samples were significantly firmer than their respective soy oil samples. This was attributed to the ability of CLARSO to provide the samples with a more solid-like structure without the addition of saturated fats, as also seen in the rheology results. The control week 1 and week 2 samples were significantly firmer than the respective CLARSO and soy oil samples, indicating that although CLARSO offered improved texture over soy oil, it did not behave similarly to the more saturated palm oil with regards to texture.

**Thermal Analysis**

Table 5 shows the values and statistical comparisons for the onset temperature, peak temperature, offset temperature, and enthalpy of the CLARSO, soy oil, and control chocolate paste fat blends. There were no significant differences in melting onset temperatures among any of the samples. This indicated that the fat crystals were in the same polymorphic form in all of the samples (Braipson-Danthine and Deroanne, 2004). There was no significant difference between the peak melting temperature of the CLARSO and soy oil fat blends. However, the control sample had a significantly higher peak temperature. This result was expected due to the greater amount of saturated fat in the control fat blend (Damodaran et al., 2007). There were no significant differences in offset temperature among any of the samples, indicating that their most saturated fraction, the palm oil, finished melting at the same temperature, as was expected. No significant differences in enthalpy were observed among any of the samples. This result illustrated that all samples had similar levels of thermodynamic stability and similar solid-like crystal matrices (Himawan et al., 2006). Addition of CLARSO did not significantly affect the thermodynamic stability and solid behavior of the sample relative to the control fat blend. This is consistent with the strain sweep results and again indicated the potential of CLARSO to replace more saturated fats.

The typical serving size for chocolate pastes is 1 Tablespoon, or approximately 40 g (U.S. FDA, 2014). To obtain the recommended daily value of CLA (3.2 g), it would be necessary to consume 5 servings of chocolate paste.

## CONCLUSIONS

Although the CLARSO paste contained no additional solid fats in relation to the soy oil paste, it displayed more solid-like physical properties. The CLARSO paste had more solid rheological and textural properties relative to the soy oil control. Therefore, CLARSO provided samples with a more solid crystalline matrix without actually containing additional saturated fat.

Thermal analysis indicated that all samples displayed the same polymorphic crystal form, despite containing different fat blends. Therefore, partial replacement of palm oil with CLA-rich and conventional soy oils did not change the form in which the fats crystallized.

The CLARSO paste displayed similar physical properties relative to the control paste. The rheology and crystalline thermodynamic stability of the CLARSO paste was similar to that of the control paste. Therefore, the solidity of the fat crystal matrices of the CLARSO and control chocolate pastes were similar despite the control samples

**Table 5. Differential scanning calorimetry measurements from the melting analysis of conjugated linoleic acid-rich, soy oil (CLARSO), and control chocolate pastes.**

| Sample | Onset Temp. (°C) | Peak Temp. (°C) | Offset Temp. (°C) | Enthalpy (J/g) |
|---|---|---|---|---|
| CLARSO fat blend | 29.46 ± 0.04a† | 42.36 ± 0.06b | 44.87 ± 0.07a | 4.04 ± 0.24a |
| Soy oil fat blend | 29.60 ± 0.10a | 42.43 ± 0.16b | 44.93 ± 0.14a | 3.89 ± 0.20a |
| Control fat blend | 29.47 ± 0.13a | 43.13 ± 0.23a | 44.77 ± 0.35a | 4.42 ± 0.28a |

† Analysis was performed in triplicate and error indicates standard deviation. Samples with the same connecting letter are not significantly different.

containing more solid fats than the CLARSO samples. This demonstrated the ability of CLARSO to replace more saturated fats without compromising solid behavior.

The CLARSO chocolate pastes demonstrated commercialization potential because they had comparable quality to the control pastes and had the ability to provide the recommended daily value of CLA in 5 servings.

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# Use of endocrine and immune responses as predictors of bull sperm motility

*Lydia M. Mitchener*[*], *Rick W. Rorie*[†], *Michael L. Looper*[§], *and Charles F. Rosenkrans Jr*[‡]

## ABSTRACT

Research has shown that peripheral blood cell populations change in response to an immune challenge, and hormone concentrations directly affect sperm characteristics. The objective of this study was to utilize immune responses and hormone concentrations as biomarkers for yearling bull sperm motility. Seventeen Brahman-influenced bulls (mean age 1.1 ± 0.1 yr; body weight 478 ± 38 kg) were administered an intraperitoneal injection of lipopolysaccharide (*Salmonella typhimirium* 0.7 μg/kg of body weight). Blood was collected 0, 3, 6, 9, and 24 h after LPS injection then analyzed for differential cell count and endocrine concentrations of prolactin, insulin-like growth factor-1 (IGF), and cortisol. Semen was collected using electroejaculation every month for five months then analyzed for motility and morphology characteristics. Hormone concentrations and immune response had an effect on sperm characteristics. Number of sperm was correlated ($r > 0.65$; $P < 0.01$) with the IGF to prolactin ratio. Using stepwise regression analysis, we predicted that number of sperm = 172.43 + 12.8 (IGF:prolactin), $r^2 = 0.43$, and progressive sperm motility = -1469.6 + 1.63 (IGF:cortisol) + 14.41 (average temperature during immune challenge), $r^2 = 0.43$. This study showed that endocrine response to stress and activation of the immune system was associated with subsequent sperm motility characteristics. Our results suggest that endocrine and immune responses may be used as biomarkers for sperm motility. Those biomarkers may be useful in selecting replacement bulls.

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## MEET THE STUDENT-AUTHOR

*Lydia Mitchener*

I am from St. Louis, Missouri and graduated from Kirkwood High School in 2011. After four years at the University of Arkansas, I graduated in 2015 with a Bachelor of Science degree in Animal Science and a minor in Spanish. This fall, I am moving to Columbia, Missouri to pursue a Doctor of Veterinary Medicine degree at the University of Missouri.

During my undergraduate career I was a member of the Pre-Veterinary Club, Delta Delta Delta sorority, Global Greeks, National Society of Leadership and Success, and the Racquetball Club. I also worked at a local veterinary clinic, Animal Medical Clinic.

I would like to thank Charles Rosenkrans for providing me with his guidance and support while I completed my research. I would also like to thank Jeremy Powell and Ken Coffey for providing advice and serving on my committee. Special thanks should be given to Marites Sales for teaching me laboratory technique.

## INTRODUCTION

Production animals, like bulls, in addition to experiencing considerable amounts of stress from the environment, experience stress internally due to infections that can negatively or positively affect their fertility. Research has shown that immune cells increase from an immune response, and hormone concentrations directly affect sperm characteristics (Jones and Mann, 1976; Hansson et al., 1989; Grattan et al., 2007). The objective of this study was to identify biomarkers for yearling bull sperm motility associated with endocrine response and activation of the immune system.

One of the most essential mechanisms in an animal's body is the immune system, a defensive composition of cells that maintain health (Erich, 2015). It protects animals against foreign pathogens caused by parasites, bacteria and viruses (Lin et al., 2014). There are various immune cells that make up the immune response. White blood cells, also referred to as leukocytes, are the primary immune cells. Leukocytosis can be an indicator that an animal has a disease, an infection, or cancer (Carroll and Burdick Sanchez, 2014). Types of leukocytes are lymphocytes, neutrophils, basophils, eosinophils, and monocytes. Leukocytes have various functions, including phagocytosis, inflammation, and regulation of adaptive immunity. In this study, an immune response was caused by lipopolysaccharide (LPS). Lipopolysaccharide is a membrane component from gram-negative bacteria that signals inflammation and destruction of tissues (Gao et al., 2015). The body interprets LPS as a microorganism invasion so the neutrophils move to tissues or lymph nodes (Carroll and Burdick Sanchez, 2014).

During stressful times, it is very important for the animal to maintain homeostasis using the stress axis. Cortisol is considered the primary stress steroid hormone and it is released from the adrenal cortex in response to environmental stress (Carroll and Burdick Sanchez, 2014; Hopster et al., 2002). Increased cortisol concentrations and white blood cell count is an acute stress response (Chase et al., 1995).

Insulin-like growth factor (IGF) is a hormone primarily involved in growth and development. Insulin-like growth factor is released by the liver under the direction of growth hormone (GH), which also plays a large role in protein synthesis (Mitra et al., 1972). Secretion of IGF varies depending on many factors, including age and stress. In bulls, it is at its highest concentration at birth, and decreases as the bull gets older (Purchas et al., 1970; Trenkle, 1971). During stress or immune challenge, GH is released, causing IGF to increase (Bernton et al., 1987). Testosterone is a sex steroid hormone that is immunosuppressive (Bernin and Lotter, 2014). The primary effect of testosterone and other sex hormones is the reduction of immature T lymphocytes (Giefing-Kroll et al., 2014). Prolactin is a hormone that decreases during stress or immune system activation (Bernton et al., 1987).

There are many traits that contribute to a bull's overall fertility including sperm characteristics. Scrotal circumference, sperm motility, and sperm morphology all largely affect a bull's reproductive capability (Sylla et al., 2007). Scrotal circumference has a positive relationship with sperm quality in beef cattle (Lunstra et al., 1978). Quality sperm is important in order to fertilize an egg. In one study, for instance, researchers found that the percentage of normal spermatozoa had the greatest influence on the calf crop percentage (Fitzpatrick et al., 2002). Sperm motility is important because in mammals, spermatozoa cannot fertilize an egg unless they achieve hyperactivated motility (Yanagimachi, 1994).

If bulls have reduced fertility, this negatively affects their reproductive and production value, creating economic strain for farmers. In order to improve production and selection processes, we need to have a better understanding of the relationships between immune response, hormone concentrations, and fertility in bulls. Our hypothesis was that a bull's immune response would serve as a predictor of future fertility.

## MATERIALS AND METHODS

*Description of Animals*. The committee for animal welfare at the USDA-ARS, Dale Bumpers Small Farms Research Center in Booneville, Ark., and the University of Arkansas Institutional Animal Care and Use Committee approved the animal procedures used in this study. Seventeen Brahman-influenced bulls were kept near Booneville, Ark. at The Dale Bumpers Small Farms Research Center. They had a mean age of 1.1 ± 0.1 year and a mean body weight of 478 ± 34 kg at the time of immune challenge.

*Blood Collection and Immune Challenge*. An intraperitoneal injection of LPS derived from *Salmonella typhimirium* (0.7 µg/kg of body weight) was given in front of the right hip bone, pointed posteriorly and ventrally. Blood was collected 0, 3, 6, 9, and 24 h after LPS injection using EDTA vacuum tubes and serum separator tubes.

*Assays*. Whole blood samples were analyzed for differential cell count on a Cell-Dyn 3500 (Abbott Diagnostics, Abbott Park, Ill.). Concentrations of prolactin, insulin-like growth factor-1 (IGF), and cortisol were quantified using validated radioimmunoassays (D. Hallford, New Mexico St. Univ.). Hormone concentration ratios were calculated for IGF to cortisol, IGF to prolactin, and prolactin to cortisol.

*Sperm Collection and Evaluation*. Semen was collected by electroejaculation using an Electroejac IV (Ideal Instruments/Neogen Corp., Lansing, Mich.) every month beginning in February when the bulls were yearlings. Ejaculates were placed in a water bath maintained at 35.5 °C in 15-mL conical centrifuge tubes. Within 30 min of collection, semen samples were diluted 20:1 in Dulbecco's Phosphate-Buffered Saline and sperm motility evaluated using a Hamilton Thorne IVOS computerized sperm analysis system (Hamilton-Thorne Biosciences, Beverly, Mass.). We evaluated motility and morphology characteristics listed in Table 1 using Animal Motility Software, v. 12.1 in 10 different fields to determine averages for sperm characteristics. Thirty video frames were captured

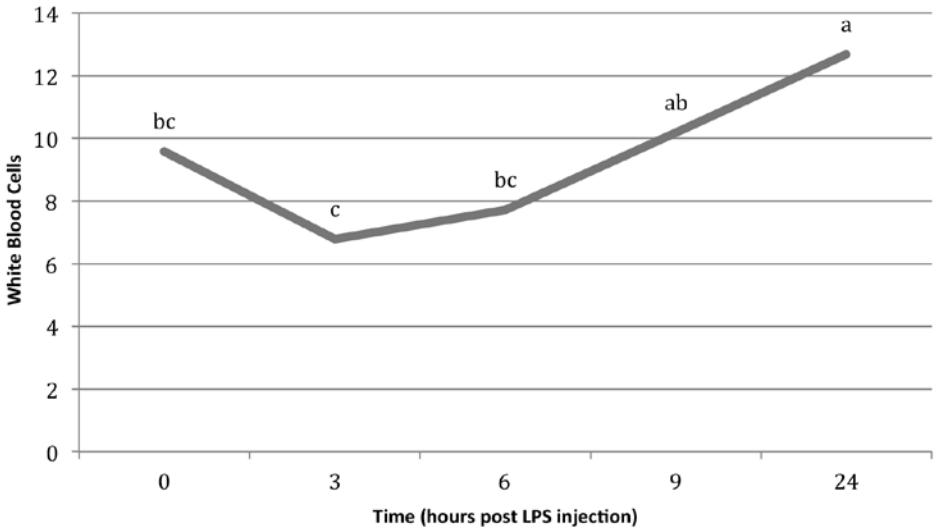


**Fig. 1.** Number (x 1000) of circulating white blood cells following LPS injection. Time affected ($P < 0.001$) white blood cell concentration. a,b,c = means without common superscript differ ($P < 0.05$; SE ± 1.06).

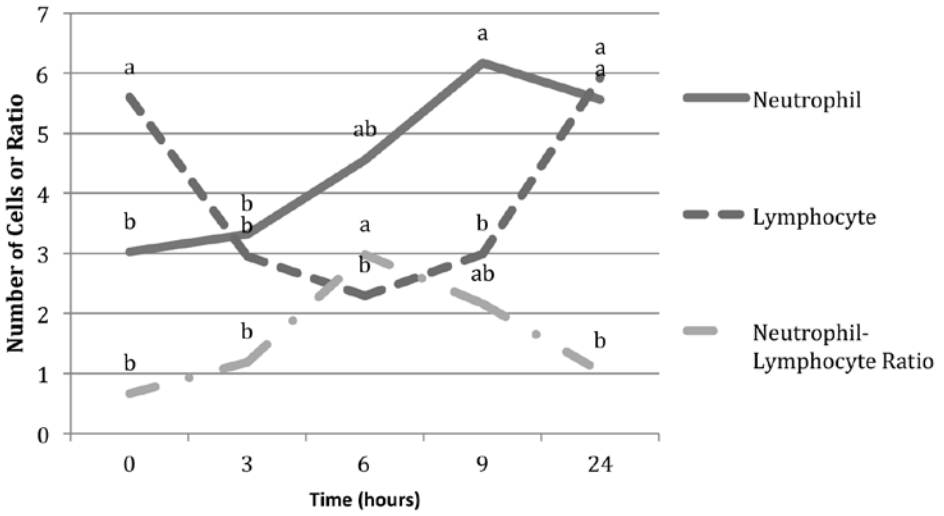


**Fig. 2.** Number (x 1000) of circulating neutrophils, lymphocytes, and their ratio following LPS injection. Time affected ($P < 0.001$) cell concentrations and ratio. a,b = means, within a cell type or ratio, without common superscript differ ($P < 0.05$; neutrophils SE ± 0.728; lymphocytes SE ± 0.473; neutrophil:lymphocyte SE ± 0.515).

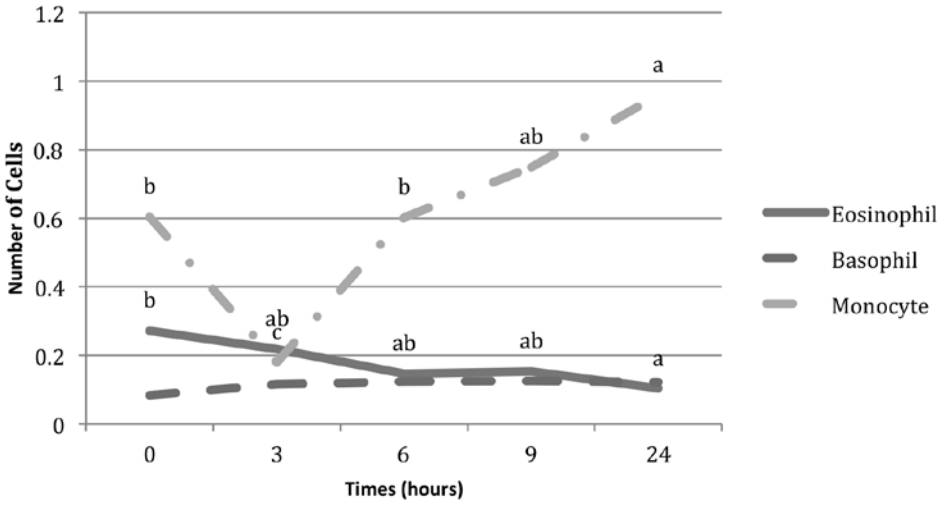


**Fig. 3.** Number (x 1000) of circulating eosinophils, basophils, and monocytes following LPS injection. Time affected ($P < 0.001$) eosinophil, and monocyte concentrations. a,b,c = means, within a cell type, without common superscript differ ($P < 0.05$; eosinophils SE ± 0.049; basophils SE ± 0.017; monocytes SE ± 0.09)..

**Table 1. Effects of month of collection on spermatozoa characteristics.**

| | Month | | | | | | |
|---|---|---|---|---|---|---|---|
| Item† | February | March | April | May | June | SE‡ | *P* < |
| Sperm | 229.9[b] | 127.7[b] | 171.7[b] | 562.5[a] | 609.5[a] | 98.9 | 0.001 |
| Area | 5.2[a] | 4.7[b] | 4.8[b] | 4.7[b] | 4.7[b] | 0.08 | 0.001 |
| Live | 38.3[a] | 63.3[b] | 62.2[b] | 74.2[bc] | 80.8[c] | 4.9 | 0.001 |

† Sperm = millions of spermatozoa/mL of ejaculate); Area = size of sperm heads ($\mu m^2$); Live = percentage of live spermatozoa.

‡ SE = mean of standard errors.

[ab] Means within rows without common superscripts differ ($P < 0.05$).

within each field in order to analyze sperm motility. An eosin-nigrosin-based live-dead stain (Jorvet Stain, Jorgensen Laboratories, Lovelend, Colo.) was used to fix and evaluate spermatozoa for morphology. Each slide had approximately 100 spermatozoa and was analyzed for percentage live (dye exclusion) and dead.

*Statistical Analysis*. Data were analyzed using SAS procedures (SAS Institute, Inc., Cary, N.C.). Time was treated as a repeated measure and bull was the subject in the analysis of variance. Stepwise regression was used to determine the relationship between and among different measures of immune function and hormone concentrations on sperm characteristics.

## RESULTS AND DISCUSSION

Time after LPS injection had an effect ($P < 0.05$) on the immune cell distribution. Figures 1-3 present the effects of time after LPS injection on immune response. White blood cells (WBC), neutrophils, lymphocytes, the neutrophil-lymphocyte ratio, monocytes, eosinophils, and basophils were affected ($P < 0.05$) by time after LPS.

**Table 2. Correlations between weaning physiology and sperm characteristics.**

| | | Sperm Characteristic† | | |
|---|---|---|---|---|
| | | Sperm | Progressive | Live |
| Item‡ | Mean | 448 | 44.7 | 72.3 |
| Prolactin | 23.1 | -0.55* | ----- | ----- |
| I:P | 22.5 | 0.65** | ----- | ----- |
| P:C | 0.85 | -0.53* | ----- | ----- |
| I:C | 11.5 | ----- | 0.53* | 0.53* |

*$P < 0.05$.

**$P < 0.01$.

† Sperm = millions of sperm per milliliter of ejaculate averaged over five collections; Progressive = percentage of spermatozoa moving at path velocity ≥ 50 µm/sec and straightness ≥ 70%; Live = percentage of spermatozoa that were deemed alive by excluding dye; dashed lines indicate that the correlation was not significant ($P > 0.1$).

‡ Prolactin (ng/mL), I:P = IGF1/prolactin; P:C = prolactin/cortisol; I:C = IGF1/cortisol

Table 1 shows the effects of time on sperm characteristics. As bulls aged and matured, both the number of spermatozoa and the percentage of live spermatozoa increased ($P < 0.001$). However, sperm head area decreased ($P < 0.001$) as the bulls aged.

Table 2 presents the correlation between traits collected at weaning and their relationship with average sperm characteristics. Number of sperm was correlated positively ($r > 0.65$; $P < 0.01$) with IGF:prolactin and negatively ($r \geq -0.53$; $P < 0.05$) with prolactin (ng/mL) and prolactin:cortisol. This coincides with research reporting that hyperprolactenemia caused infertility (Grattan et al., 2007). The percentage of spermatozoa that were alive, and had progressive motility was correlated ($r = 0.53$; $P < 0.05$) with IGF:cortisol. This corresponds with past research that states IGF enhances spermatogonial DNA production, therefore improving sperm number and function (Hansson et al., 1989). Few correlations existed between blood cell characteristics and sperm characteristics. Mean number of spermatozoa per ejaculate was correlated ($r > 0.51$; $P < 0.05$) with mean red blood cell hemoglobin concentration (MCHC). Research connecting MCHC with fertility is very limited. It is known that hemoglobin prevents oxidative damage, which damages sperm (Carroll and Burdick Sanchez, 2014). Therefore, an increase in MCHC should have a positive effect on fertility.

Using stepwise regression analysis, we predicted the variance for number of sperm, progressive, and path velocity (VAP). The following relationships were determined:

number of sperm = 172.43 + 12.8 (IGF:prolactin), $r^2 = 0.43$;

progressive sperm = -1469.6 + 1.63 (IGF:cortisol) + 14.41 (average temperature during immune challenge), $r^2 = 0.43$;

VAP = -337.52 + 0.846 (age, days at weaning) 0.41 (IGF, ng/mL) + 8.39 (cortisol, ng/mL) + 13.1 (IGF:cortisol) + 3.29 (lymphocyte number / 1000), $r^2 = 0.84$.

Just like all animals, cattle depend on their immune response in order to survive. The typical im-

mune response in bulls causes an increase in immune cells and changes in hormone concentrations that can affect their fertility. For example, spermatogonial DNA is synthesized in response to IGF; therefore, increases in IGF positively affect fertility (Hansson et al., 1989). On the other hand, previous findings show negative relationship between leukocytes and sperm function (Jones and Mann, 1976), and prolactin and fertility (Grattan et al., 2007). An increase in leukocytes damaged sperm (Jones and Mann, 1976) through reactive oxygen species (ROS) that inhibit ATP production (Villegas et al., 2005; De Lamirande and Gagnon, 1992). When ATP production is decreased, sperm function and motility are affected negatively, resulting in infertility (Pentyala et al., 2007). If an animal exhibits an overproduction of prolactin, it is said to have hyperprolactinemia, which is a cause of infertility (Grattan et al., 2007).

This study showed that endocrine response to stress and activation of the immune system was associated with subsequent number of spermatozoa and motility characteristics. Our research results suggest that hormone concentrations at weaning combined with bull response to an immune challenge may be useful in selecting replacement bulls that have greater fertility.

## ACKNOWLEDGMENTS

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Yanagimachi, R. 1994. Mammalian fertilization. In The Physiology of Reproduction (eds. Knobil, E. and Neill, J.D.). Raven Press, New York, 2nd ed., pp. 189–317.

# Development of a nutrition education tool to reduce the risk of childhood obesity in a northwest Arkansas Hispanic population

*Katherine G. Ross*[*], *Mallori C. Sando*[†], *Maria I. Barrenechea*[§], *and Cynthia K. Moore*[‡]

## ABSTRACT

The goal of this qualitative research project is to create a bilingual education tool to equip the participants of the English as a Second Language (EASL) class at the Elmdale Elementary School, in Springdale, Ark., to reduce the risk of childhood obesity in their children. Adults of Hispanic descent are at a high risk for developing obesity and so are their children. Children who are overweight and/or obese have a high risk of developing heart disease, diabetes, high blood pressure, and other health complications. As a side effect of the language barrier some Hispanics experience, it may be difficult for them to fully understand nutrition resources in English. A thorough review of the literature was conducted so that the content of the tool conveyed the evidence-based practice in the prevention of childhood obesity. Feedback from two focus groups of twelve adult Hispanic males and females was analyzed to design and validate the content of the tool and an accompanying assessment instrument. All interactions were conducted in English and in Spanish. The developed nutrition education tool is sensitive to language and cultural factors of the Hispanic community. This service-learning project is designed to provide Hispanic families with evidence-based nutrition information in order to reduce the risk of childhood obesity.

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## MEET THE STUDENT-AUTHORS

***Katherine Ross***

My hometown is Benton, Arkansas, and I graduated in May 2015 with a Bachelor of Science degree in Food, Human Nutrition, and Hospitality with a concentration in Dietetics, and a minor in Spanish. I was honored to be Vice President of the Student Dietetic Association this past year. In 2013 I received a Study Abroad Grant from the Honors College that allowed me to study in Quito, Ecuador for a semester. There, I gained fluency in Spanish and my love for the Hispanic culture grew. I plan on continuing to pursue opportunities to work with the Hispanic community as I complete my Dietetic Internship at the University of Puerto Rico Medical Sciences.

I cannot thank my thesis mentor, Dr. Cynthia Moore, and also, Mrs. Mechelle Bailey enough for their support and encouragement throughout this process. I am also honored to have received funding for this honors thesis/project from the Dale Bumpers College of Agricultural, Food, and Life Sciences.

***Mallori Sando***

I am from Highland Village, Texas, and I graduated from the University of Arkansas in May 2015 with a Bachelor of Science degree in Human Environmental Sciences with a major in Food, Human Nutrition, and Hospitality with a concentration in Dietetics and a minor in Human Development and Family Sciences. I have a passion for health, building relationships, and helping others. I plan on using this passion in my future endeavors. In my spare time I enjoy playing volleyball, exploring outside, snowboarding, and spending time with family and friends.

Thank you to the incredible dietetic faculty, Dr. Moore and Mrs. Bailey, for their continuous support. In addition, thank you Dr. Moore for mentoring me through this project. Lastly, thank you to the Dale Bumpers College of Agricultural, Food, and Life Sciences and its faculty for funding and supporting this honors thesis/project. I am forever grateful.

## MEET THE STUDENT-AUTHORS (CONTINUED)

***Maria Barrenechea***

I was born in Santa Cruz, Bolivia. I moved to Fayetteville in 2011 to initiate my undergraduate education at the University of Arkansas. I graduated in May 2015 with a Bachelor of Science degree in Human Environmental Sciences with a major in Food, Human Nutrition, and Hospitality with a concentration in Dietetics. I have a passion for the Hogs and in 2012 I had the privilege to represent the U of A as an Orientation Mentor.

Being from Bolivia, I have always had an interest to work with the Latino population. In the summers of 2013 and 2014 I had the opportunity to assist a Bolivian Registered Dietitian at Hospital Caja Petrolera de Salud, which increased my passion for the dietetic profession, along with my interest in working with people of Latino descendant. This past year, I have had the opportunity to assist the Wellness Director of Nahbolz Construction in interpreting nutrition consultations for her Latino employees. What really inspired my two partners and me to initiate this research was the 2014 SEC symposium with a focus on the Prevention of Obesity. We saw a need to help prevent obesity, which inspired us to create a nutrition education tool to reduce the risk of childhood obesity. My goals for the future are to become a Registered Dietitian and to make an impact in the community to help improve the health of others.

I want to thank Dr. Cindy Moore for mentoring us through this challenging, yet exciting process. Also, thank you to Ms. Mechelle Bailey for her constant support and advice. Thank you to Dr. Godwin-Charles Ogbeide for serving on our committee. Finally, thank you to the Dale Bumpers College for funding this honors thesis/project.

## INTRODUCTION

Obesity is defined as a "Body Mass Index (BMI) at or above the 95th percentile for children of the same age and sex" (CDC, 2012). The prevalence of obesity in the United States is higher among Hispanics and African Americans than any other racial and ethnic group. An estimated 22.4% of Hispanic children and adolescents are obese (Boudreau et al., 2013; CDC, 2014; Greaney et al., 2012). A very limited amount of research has been conducted on the prevention of overweight and obesity among high-risk populations such as Hispanics (Boudreau et al., 2013; Greaney et al., 2012; Pottie et al., 2013).

Language may function as a barrier to delivering services for ethnic populations, especially when the primary language of the individual is not being used (Pottie et al., 2013). The language barrier may not always be evident, as there are reports of individuals who believe to be proficient in another language, but in fact are not (Schyve, 2007).

Latin American women are more likely to initiate lactation, but not likely to exclusively breastfeed for at least six months, which is the accepted prevention method that is seen to lower childhood obesity rates (Birch and Ventura, 2009; Fisher et al., 2000; Harder et al., 2005; Locke, 2002; Menella et al., 2001; Metzger and McDade, 2010; Sullivan and Birch, 1994; Singhal and Lanigan, 2007; Spiegel et al., 2004; Taveras et al., 2010). The longer an infant is breastfed, the less likely the child is to be obese later in life (Thompson and Bentley, 2012). The naturally occurring hormone Leptin is considered to increase satiation (Fisher et al., 2000; Heinig et al., 1993; Lawrence, 2010; Locke, 2002; Spiegel et al., 2004). This allows an infant to recognize when he or she is full, preventing him or her from overeating. Leptin is found in breast milk, but not in formula (Fisher et al., 2000; Heinig et al., 1993; Lawrence, 2010; Locke, 2002; Spiegel et al., 2004).

Hispanic mothers exert greater control over the eating habits of their children and are more likely to have restrictive feeding practices than their white/non-Hispanic counterparts (Taveras et al., 2010). Hispanic mothers are also more likely to pressure or coerce their children to eat more (Taveras et al., 2010). Children whose parents frequently coerce or pressure them to eat have a higher chance of developing childhood obesity.

A greater consumption of fast food is linked with a poorer quality diet, higher BMI, and obesity among adolescents (French et al., 2001; Guthrie et al., 2002). African American and Mexican-American children consume more sugar-sweetened beverages (SSB) in comparison to their Caucasian counterparts, and rates of obesity are more prevalent among Mexican-American boys (Dodd et al., 2013). Reducing the frequency of eating fast food can lead to a lower risk of childhood obesity (French et al., 2001; Guthrie et al., 2002).

Approximately 38% of Hispanics in the United States are obese, and 77% are obese or overweight (Greaney et al., 2012). The number one determinant of childhood obesity is whether one or both parents are obese. Higher percentage of body fat and weight are highly correlated with parental BMI, and family eating habits are among the major predictors of obesity (Salbe et al., 2002; Whitaker et al., 1997). Eating meals as a family is correlated with lower rates of childhood obesity, a healthier BMI, and diet (Fulkerson et al., 2008; Gillman et al., 2000; Jerica et al., 2014).

Adequate sleep is protective against childhood obesity (Taveras et al., 2008; Anderson and Whitaker, 2010; Taheri et al., 2004; Chen et al., 2008). In certain households, five to seven hours may be considered "sufficient" sleep; however, the National Sleep Foundation recommends children receive ten to eleven hours of nighttime sleep (National Sleep Foundation, 2015). Inadequate sleep reduces Leptin, which decreases the ability of the body to detect satiation. Not enough sleep also increases Ghrelin, which increases appetite (Taheri et al., 2004). Latino children are less likely to get adequate sleep (National Sleep Foundation, 2015; Hassan et al., 2011). Not enough sleep at night leads to decreased performance during the daytime, resulting in lower caloric expenditure, low activity level, and a tendency to be more sedentary (Chen et al., 2008).

Limited screen time is linked to beneficial effects on children's BMIs and a decrease in rates of obesity (Epstein et al., 2008; Dennison et al., 2002). The more a child engages in screen-related activities, the less likely he or she is to be physically active (McClure et al., 2013; U.S. Department of Health and Human Services, 2008). Therefore, screen time should limited to less than two hours per day (Epstein et al., 2008; Dennison et al., 2002). The more children engage in sedentary activities, the more likely they are to develop obesity. In order to counteract this tendency, it is recommended that children ages 6 and older get at least sixty minutes of physical activity a day (U.S. Department of Health and Human Services, 2008).

The goal of the qualitative research was to develop a nutrition education tool in order to reduce the risk of childhood obesity, and use focus groups to refine that tool targeted at a Hispanic community in northwest Arkansas. The nutrition education tool was developed and designed to be sensitive to the perceived needs from the focus groups, but supported by current evidence-based literature. It is a bilingual tool, with copies in both Spanish and English.

## MATERIALS AND METHODS

An initial review of the literature was conducted in order to gather information to form the content of the nutrition education tool. To obtain appropriate content and language for the nutrition education tool, Hispanic focus groups were consulted and a comprehensive review of the literature was conducted. A focus group is an in-depth and open-ended discussion conducted with a small group of individuals on a specific topic (Greaney et al., 2012; Robinson, 1999). Participants qualified to take part in the study if they were Hispanic and had at least one child under the age of 18 years old. Groups were formed from English as a Second Language (EASL) classes at Elmdale Elementary School in Springdale, Ark. The adults chose to take part in this study on a voluntary, non-incentive basis.

Participants were given a pre-evaluative quiz consisting of eight questions. The quiz was designed to direct the goals of the nutrition education tool, not to measure knowledge or conduct quantitative research. The questions were in English and Spanish, side by side, translated by bilingual members of the research team. After the pre-evaluative quiz, the focus group discussion was initiated. The research team facilitated conversation, but the majority of the open discussion was encouraged to be from the participants. Questions that probed for more details related to the pre-evaluative quiz were asked.

## RESULTS AND DISCUSSION

The content of the tool was designed based on current evidence-based literature. The majority of evidence-based literature agrees upon the following methods to reduce the risk of childhood obesity: breastfeeding, discouraging the use of restrictive and coercive feeding practices, reducing the energy density of food, emphasizing parental role-model behavior, adequate sleep, limiting screen time, eating meals as a family, and physical activity.

There were twelve parents involved in the EASL class present to take the pre-evaluative quiz during the researchers' first visit. There were eleven females and one male. All twelve participants gave permission for their responses to be used for research. The results are shown in Table 1.

After the pre-evaluative quiz, the researchers began the focus group discussion questions.

**Table 1. Responses from the pre-evaluative and post-evaluative quiz.**

| Question | Option | Number of Responses (n = 12) | |
|---|---|---|---|
| | | Pre-Evaluation | Post-Evaluation |
| **"I believe _____ can reduce the risk of obesity in my child"** | Physical activity level of my child | 11 | 11 |
| | If my child eats breakfast | 12 | 12 |
| | The foods I eat | 9 | 9 |
| | Breastfeeding my child | 9 | 11 |
| | My weight | 9 | 9 |
| | Smoking during pregnancy | 0 | 0 |
| | Adequate sleep | 11 | 12 |
| | Healthy weight | 8 | 9 |
| | Limiting screen time | 11 | 11 |
| | Nutrition education | 10 | 11 |
| | How often I exercise | 12 | 12 |
| | Family meals | 11 | 11 |
| | If I eat breakfast | 9 | 11 |
| | Healthy weight gain during pregnancy | 8 | 9 |
| **"I am more likely to be aware of my eating choices if I am"** | At a healthy weight | 5 | 6 |
| | Overweight | 4 | 5 |
| | No response | 2 | 1 |
| | "I eat for health" | 1 | 0 |
| **"I use the nutrition facts label to make choices about the food I buy"** | Never | 2 | 3 |
| | Rarely | 1 | 0 |
| | Sometimes | 5 | 6 |
| | Usually | 2 | 1 |
| **"I would rather read a nutrition label in"** | English | 0 | 0 |
| | Spanish | 7[a] | 10 |
| | Spanish and English (Both) | 7[a] | 2 |
| | Doesn't matter | 0 | 0 |
| **"I feel confident in selecting healthy food/snacks for my family"** | Yes | 12 | 11 |
| | No | 0 | 1 |
| **"I am concerned about my child's weight"** | Never | 1 | 1 |
| | Rarely | 4 | 2 |
| | Sometimes | 3 | 6 |

**Table 1. *Continued*.**

| Question | Option | Number of Responses (n = 12) | |
|---|---|---|---|
| | | Pre-Evaluation | Post-Evaluation |
| **"I am concerned about my child's weight", *continued*** | Usually | 1 | 1 |
| | Almost always | 3 | 2 |
| **"I attempt to limit the amount my child eats"** | Never | 1 | 1 |
| | Rarely | 3 | 3 |
| | Sometimes | 5 | 5 |
| | Usually | 0 | 1 |
| | Almost always | 3 | 2 |
| **"I encourage my child to eat more"** | Never | 2 | 4 |
| | Rarely | 1 | 1 |
| | Sometimes | 8 | 6 |
| | Usually | 1 | 1 |
| | Almost always | 0 | 0 |

[a] Two individuals marked two answers (marked "Spanish" and "Both," accounting for fourteen answers).

During the discussion, the participants exhibited the ability to discern "healthy" foods; although, they admitted to frequent enjoyment of sweets and junk foods. In addition, they mentioned time and work as major barriers that prevented them from eating healthier. The participants stated that were not accustomed to eating three meals per day. In the Hispanic culture adults were more likely to eat two larger meals per day. Many of the participants stated that their children ate three meals per day. The majority of participants worked full-time jobs, which presented a time barrier that could discourage healthier cooking. Many also indicated they did not have time to eat dinner as a family, while others insisted they had family meals most nights. The participants believed it was easier to eat healthily in their home country because healthier foods were more available and affordable. In addition, there were more organic options and no genetically modified organisms (GMO), which they believed to be "unhealthy." Organic foods in their countries were less expensive due to greater availability. Lastly, it was noted that the participants were more likely to exercise when the weather was warm. The researchers concluded that the participants may perform more physical activity outdoors rather than inside. Weather conditions seemed to be a major hindrance to being physically active.

The same 12 individuals involved in the EASL class were present to take the post-evaluative quiz during the researchers' second visit. The post-evaluative quiz was the same as the pre-evaluative quiz and the results are included in Table 1. In the post-evaluative quiz, the participants were encouraged to use the nutrition education tool to answer the questions. However, it was not until the group conversation of the nutrition education tool began that the participants fully comprehended the details of the content. After further focus group discussion, it was evident that there was a greater gap in the nutrition knowledge base of the participants than had been expected.

A crucial role the focus groups played in this study was to provide insight about the content and design of the nutrition education tool. The feedback from the focus groups confirmed that the content of the nutrition education tool was appropriate for this audience. Likewise, based on the input of the participants, the researchers were able to further tailor the content of the tool for their intended audience.

Many changes involved colors, resizing of font, general design, and layout of the nutrition education tool based on feedback from the participants; however, one significant change was made in regard to vocabulary and reading level. Participants also voiced that they would prefer to read a nutrition facts label in English with a Spanish explanation of the information provided. Through this study, the researchers recognized a need for further study of this population. While the development of the nu-

trition education tool is complete, additional pilot and field-testing of the tool, as well as focus group discussions could validate and improve the content and effectiveness of the tool.

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# Intake and digestibility of tall fescue supplemented with co-product feeds

*Omega J. Sanders*[*], *Kenneth P. Coffey*[†], *Ashley N. Young*[§], *and Kristopher A. Bottoms*[‡]

## ABSTRACT

Cows offered low quality hay require supplementation to meet their nutritional requirements. Our objective was to determine the impact of supplementation with soybean hulls (SH), distiller's dried grains with solubles (DDGS), or a 50:50 mixture of each (MIX) at 0.5% of body weight on ruminal fermentation characteristics and in situ forage disappearance in lactating (n = 3) and non-lactating (n = 3) ruminally cannulated cows (679 ± 18.7 kg body weight). Tall fescue was offered free-choice from large round bales for 6, 21-d periods. Dacron bags containing ground fescue hay were placed into the rumen of each cow at specified intervals over a 7-d period and removed on d 21. Rumen fluid samples were collected on d 21 of each period at 2 h intervals from 1600-2400 h for analyses of ruminal ammonia and volatile fatty acids (VFA). Ruminal forage disappearance was not affected ($P \geq 0.44$) by diets. Total VFA were greater ($P < 0.05$) from SH but the propionate percentage was greater ($P < 0.05$) from DDGS. Therefore, supplementation with DDGS should improve the energy status of cows fed poor-quality hay compared with SH or MIX.

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† Kenneth P. Coffey is the faculty mentor and a professor in the Department of Animal Science.
§ Ashley N. Young is a Masters student in the Department of Animal Science.
‡ Kristopher A. Bottoms is a May 2015 honors program graduate with a major in Animal Science and a concentration in Pre-Veterinary Medicine.

## MEET THE STUDENT-AUTHORS

***Omega Sanders***

I was born and raised in Hot Springs, Arkansas, and I graduated from Lakeside High School in 2011. I graduated in May 2015 from the University of Arkansas with a Bachelor of Science in Animal Science. This fall, I will begin my new adventure in Baton Rouge, Louisiana, where I will be pursuing a Doctor of Veterinary Medicine at Louisiana State University.

During my undergraduate career, I was a member of the University of Arkansas Pre-Veterinary Club and Gamma Beta Phi. I served at the Vice-President for the Pre-Veterinary Club I also worked as a veterinary assistant at Wedington Animal Hospital. In the spring of 2012 and spring of 2013, I attended the APVMA symposium in Gainesville, Florida and Ames, Iowa. I was able to tour the host vet schools during this symposium and take various labs and lectures covering all aspects of veterinary medicine.

My inspiration for my honors research project was to gain large animal handling experience as well as learning more about large animals since I had no previous experience. I would like to thank Dr. Ken Coffey for all of his help with this project and for all of the encouragement and advice he gave throughout this project. I would also like to thank Ashley Young for providing assistance with both the animals and lab work, and Kristopher Bottoms for providing assistance with animal handling.

***Kristopher Bottoms***

I am from Oklahoma City, Oklahoma, and graduated from Southmoore High School in 2010. I graduated in 2015 from the University of Arkansas with a Bachelor of Science degree in Animal Science. This fall, I will begin pursuing a Doctor of Veterinary Medicine degree at Oklahoma State University.

During my undergraduate career at the U of A, I served as Treasurer and President for the Pre-Veterinary Club. I also worked as a Veterinary Assistant at Wedington Animal Hospital. During my time with the Pre-Veterinary Club, I was fortunate enough to attend the APVMA National Symposium at North Carolina State and the University of Florida. This symposium allowed me to learn about many areas of the veterinary industry that I had not known about previously. These conferences also allowed me to create friendships with people that share similar interests as mine, as well as strengthen my interest in small animal and exotic animal medicine.

During my time working on this research project, I learned many valuable skills about the 'research' side of animal science, as well as many animal care and animal handling techniques. I would like to thank Dr. Ken Coffey and Omega Sanders for allowing me to assist with the research project, and for teaching me the 'tricks of the trade' to working with cattle. My experiences will benefit me in vet school and throughout my life. I would also like to thank the Dale Bumpers College and the University of Arkansas for allowing me to strengthen my passion for animal science, and for getting me one step closer to my life-long dream of becoming a veterinarian.

## INTRODUCTION

Low-quality forages, such as tall fescue, often require supplementation in order to meet the nutritional requirements of ruminant animals. Previous studies have evaluated the effects of supplementation on low-quality forage intake and digestibility by supplementing with co-product feeds such as soybean hulls (SH) (Grigsby et al., 1992; Slater et al., 2000) and distiller's dried grains with solubles (DDGS) (Ham et al., 1994; Klopfenstein et al., 1978). Increased concentrations of volatile fatty acids (VFA) and increased digestibility of dry matter (DM) have been reported from feeding SH as a supplement (Grigsby et al., 1992; Slater et al, 2000). Distiller's dried grains with solubles fed as a supplement has been reported to act as an adequate protein and energy source when fed up to 40% of a finishing diet, and cattle require less fiber from forage in the diet to maintain rumen function (Ham et al., 1994; Klopfenstein et al., 1978). Feeding a combination of SH and DDGS resulted in improved digestibility compared with either co-product fed individually in a limit-feeding concentrate scenario (Smith, 2014). However, little information is available about the associative effects of feeding combinations of co-product feedstuffs on a basal diet of low-quality forage. Therefore, the objectives of this study were to determine the impact of supplementation with SH, DDGS, or a 50:50 mixture of the two (MIX) on ruminal fermentation characteristics and *in situ* forage disappearance kinetics in lactating and non-lactating ruminally cannulated beef cows fed tall fescue hay.

## MATERIALS AND METHODS

This experiment was conducted in accordance with procedures approved by the University of Arkansas Institutional Animal Care and Use Committee (Protocol #12023). Three lactating and three non-lactating ruminally cannulated Angus × Gelbvieh crossbred beef cows (679 ± 18.6 kg body weight; BW) were offered tall fescue hay for *ad libitum* consumption from large round bales along with supplements fed at 0.5% of BW of each individual cow. Supplements fed included SH, DDGS, and MIX.

Cows within each production status (lactating or non-lactating) were allocated to separate 3 × 3 Latin Squares, and those squares were repeated for a total of six observations on each supplement within each production status. During the course of the experiment, the cows were housed together in a drylot pen and then sorted randomly into individual pens each day and offered their respective supplements at 1600 h. Calves of the lactating cows were not allowed in the pen with their dams while their dams were offered their supplements. The cows were allowed thirty min to consume the supplements and then were returned to their drylot pen. Each period lasted 21 d, having a 14-d adaptation period at the beginning of each period.

On d 8 of each period, 100 grams (± 0.01 g) of a supplement containing 10 g of an external marker of $TiO_2$ along with 90 g of a mixture of SH, DDGS, and liquid molasses (42.5:42.5:5) was added to each supplement prior to being given to each cow and was fed for the remainder of each period. During the last 7 d of each period, various samples were taken. Samples included fecal grab samples from each cow during the morning and afternoon along with samples of the tall fescue hay, SH, and DDGS each day during this 7-d period. Fecal and feed samples were dried to a constant weight at 50 °C in a forced-air drying oven and then ground to pass through a 1-mm screen using a Wiley mill (Arthur H. Thomas, Philadelphia, Pa., USA). Fecal samples were composited by cow and period, and feed samples were composited by type and period prior to grinding.

On d 15 of the study, an extra cow was used to gather a sample of consumed hay via the ruminal evacuation technique. Total ruminal contents were removed, and the cow was returned to the drylot pen and allowed to consume tall fescue for fifteen minutes. After the allotted time, the masticate sample was removed from the rumen, and the original contents were returned to the rumen. Masticate samples were lyophilized, ground, and composited by period for further analyses. This process was repeated on d 21 of each period. During the last 7 d of each period, Dacron bags (10 × 20 cm; 50 μm pore size) containing approximately 5 g of tall fescue that was ground to pass through a 2-mm screen using a Wiley mill were sealed with rubber bands and then placed inside of a mesh bag which was placed inside of the rumen of each cow. The bags were inserted at specified intervals to achieve ruminal incubation times of 0, 6, 12, 22, 34, 52, 76, 100, 124, and 148 h.

At 2000 h on d 21 of each period, the mesh bags containing the Dacron *in situ* bags were removed from the rumen of each cow and immediately submerged in cold water to suppress further microbial activity. The *in situ* bags were then removed from the mesh bag, rinsed again in cold water, and washed in a top loading washer 10 times with 1 min of agitation followed by 2 min of spinning for each cycle. The *in situ* bags were then placed into a drying oven and dried to a constant weight at 50 °C.

Also on d 21 of each period, rumen fluid samples were taken from each cow at 2-h intervals from 1600 h through 2400 h to correspond to times immediately prior to feeding and 2, 4, 6, and 8 h after feeding. Rumen contents were removed from various parts of the rumen and placed in a plastic bucket. The contents were then mixed and folded into eight layers of cheesecloth and the rumen fluid was strained into a specimen cup. The rumen contents were placed back into the rumen of each cow after straining.

The cows remained in their respective pens without access to hay during the period between 1600 and 2400 h.

Immediately after taking rumen fluid samples, the pH of each rumen fluid sample was recorded. Rumen fluid samples (1000 µL) from each cow at each time period were combined with 200 µL of a metaphosphoric acid solution containing 2-ethylbutryic acid as an internal standard in a centrifuge tube for later volatile fatty acid (VFA) analysis and placed into a cooler on ice. Also, 800 µL of rumen fluid was combined with 400 µL 0.1 *M* HCl in a centrifuge tube for ammonia-N analysis and placed in a cooler on ice. These samples were then placed into a freezer at 0 °C and frozen until analyses were completed. At the end of the sampling period, the cows were returned to their drylot pen. The following morning, the cows were gathered, weighed, and assigned to their new supplement for the beginning of the next period.

Dry matter (DM) was determined on all hay, feed, and fecal samples by being dried to a constant weight at 105 °C. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed non-sequentially using the ANKOM 200/220 Fiber Analyzer (ANKOM Technology Corporation, Fairport, N.Y., USA; Vogel et al., 1999). Organic matter was determined on all samples in a muffle furnace (Method 942.05; AOAC, 2000). Acid-detergent insoluble ash (ADIA) content of feed and fecal samples was determined using the methods outlined for the ADF procedure followed by combustion in a muffle furnace. Volatile fatty acids were analyzed by gas chromatography using the methods and equipment described by Akins et al. (2009). Ammonia-N concentrations in frozen rumen fluid samples were determined colorimetrically (Broderick and Kang, 1980). All samples were corrected to a DM basis.

Titanium dioxide concentrations of the supplement and fecal samples were determined using the procedures of Myers et al. (2004). Alkaline-peroxide lignin (APL) concentrations of masticate and fecal samples were determined using the procedures of Cochran et al. (1988). Fecal output was determined by dividing the daily dosage of $TiO_2$ by the $TiO_2$ concentration in the feces. Digestibility and forage intake were then determined by the following equations:

$$\text{DM digestibility} = 100 - 100 \times \frac{\text{APL concentration in the feed}}{\text{APL concentration in the feces}}$$

$$\text{DM intake} = \frac{\text{Fecal DM Output}}{1 - \left(\frac{\text{diet digest}}{100}\right)}$$

Statistical analysis was conducted using the mixed models procedure of SAS® (SAS Institute Inc., Cary, N.C., USA). The experimental design of this project was a replicated 3 × 3 Latin Square design within production status. There were two cows per supplement per period (one lactating and one non-lactating), and each cow was considered the experimental unit since each cow received her daily supplement allocation individually. Fixed effects in this model included the effects of supplement, production status, and the supplement × production status interaction. Random effects in this model include the period and the animal. The model for VFA and ammonia-N concentrations included sampling time as a repeated measurement and cow (supplement × period) as the subject.

The proportion of DM remaining in the *in situ* bags at each incubation time was fit to the non-linear model of Mertens and Loften (1980) using PROC NLIN of SAS. This model fractionated the forage into multiple fractions and assessed the disappearance characteristics of the forage from the Dacron bags. Fraction A is the immediately soluble fraction and fraction B is that fraction that disappeared at a measurable rate (fraction B). The disappearance lag time, and the rate of DM disappearance ($k_d$) were also derived directly from the model. The undegradable fraction (fraction U) was calculated as 100 – B – A. Effective ruminal disappearance was estimated as $A + B[k_d/(k_d + k_p)]$ (Ørskov and McDonald, 1979) where $k_p$ is the rate of passage that was estimated at 0.035 $h^{-1}$. Data derived from the non-linear model were analyzed using mixed-models procedures of SAS as described previously. Statistical significance was designated as ($P < 0.05$) and ($0.05 < P < 0.10$) was considered a tendency in all instances.

**Table 1. Quality measurement of soybean hulls, distillers dried grains with solubles, tall fescue hay and masticate offered to lactating and non-lactating cows.**

| Item[†] | Soybean Hulls | Distillers dried grains + solubles | Hay | Masticate[§] |
|---|---|---|---|---|
| | ----------% of DM---------- | | | |
| Ash | 5.3 | 4.6 | 7.5 | 8.9 |
| NDF | 64.2 | 45.4 | 73.9 | 73.7 |
| ADF | 49.7 | 18.3 | nd[‡] | 46.6 |
| ADIA | 0.36 | 0.05 | nd | 3.48 |
| CP | 12.2[¶] | 30.4[¶] | nd | nd |
| Fat | 2.1[¶] | 10.7[¶] | nd | nd |

[†] NDF = neutral detergent fiber; ADF = acid detergent fiber; ADIA = acid detergent insoluble ash; CP = crude protein.
[§] Masticate represents samples of hay selected by a ruminally cannulated cow following total ruminal evacuation.
[‡] nd = not determined.
[¶] represents values reported by NRC (2000).

## RESULTS AND DISCUSSION

Fiber concentrations of DDGS and SH were similar to published values for these commodities (Table 1). Masticate samples gathered by the rumen evacuation procedure were high in NDF and indicative of a poor-quality tall fescue hay.

Although BW differed ($P < 0.05$) because of status, effects of supplement ($P = 0.47$) or status ($P = 0.19$) were not observed for BW change during the 21-d feeding periods (Table 2). Forage and total DM intake (g/kg BW) were greater ($P < 0.05$) from lactating cows compared with open cows, but were not different ($P \geq 0.19$) among supplements (Table 2). *In situ* forage disappearance measurements were not different ($P \geq 0.46$) among DDGS, SH, or MIX (Table 3). *In situ* effective ruminal disappearance was greater ($P < 0.05$) and rate of forage disappearance tended ($P = 0.05$) to be greater in non-lactating cows compared with lactating cows (Table 3). The supplement × production status interaction tended ($P = 0.06$) to affect effective ruminal disappearance, but other ruminal disappearance kinetic measurements were not different ($P \geq 0.19$) among supplements or production status.

Concentrations of ruminal $NH_3$-N and total VFA were affected ($P < 0.05$) by supplement and sampling time, but not by status ($P = 0.94$) or the supplement × sampling time interaction ($P = 0.19$; Table 4). Ruminal $NH_3$-N concentrations were greater ($P < 0.05$) from DDGS than

**Table 2. Body weight and change, intake, and digestibility in lactating and non-lactating cows offered a basal diet of tall fescue hay and supplemented with soybean hulls, distillers dried grains, or a mix of the two at 0.5% of cow body weight.**

| | Supplement | | | | Status | | | |
|---|---|---|---|---|---|---|---|---|
| Item[†] | Distillers | Mix | Soyhulls | SE | Lactating | Open | SE | Effect[§] |
| Body wt, kg | 677 | 675 | 678 | 18.6 | 625 | 729 | 25.6 | St |
| Body wt change, kg | -1 | 5 | 2 | 3.3 | 0 | 5 | 2.8 | ns |
| Forage intake, kg/d | 18 | 18 | 14 | 2.9 | 19 | 15 | 2.9 | ns |
| Forage intake, g/kg bw | 27 | 27 | 22 | 4.2 | 30 | 20 | 4.1 | St |
| Total DM intake, kg/d | 21 | 21 | 18 | 2.9 | 22 | 18 | 2.9 | ns |
| Total DM intake, g/kg bw | 31 | 32 | 26 | 4.2 | 35 | 25 | 4.0 | St |
| Forage DM digest., % | 72 | 72 | 67 | 4.3 | 72 | 69 | 4.17 | ns |
| Diet DM digest., % | 72 | 73 | 69 | 3.3 | 72 | 71 | 3.2 | ns |

[†] kg/d = kilograms per day; g/kg bw = grams per kilograms of body weight; DM = dry matter.
[§] ns = not significant; St = status effect ($P < 0.05$).

**Table 3. *In situ* forage dry matter disappearance characteristics of tall fescue hay in lactating and non-lactating cows offered a basal diet of tall fescue hay and supplemented with soybean hulls, distillers dried grains, or a mix of the two at 0.5% of cow body weight.**

| | Supplement | | | | Status | | | |
|---|---|---|---|---|---|---|---|---|
| Item[†] | Distillers | Mix | Soyhulls | SE | Lactating | Open | SE | Effect[§] |
| A, % | 15.8 | 15.6 | 15.6 | 0.84 | 15.7 | 15.7 | 0.81 | ns |
| B, % | 59.0 | 59.5 | 60.1 | 1.46 | 59.6 | 59.5 | 1.44 | ns |
| U, % | 25.3 | 24.9 | 24.3 | 1.20 | 24.8 | 24.9 | 1.23 | ns |
| k, $h^{-1}$ | 0.029 | 0.030 | 0.027 | 0.0019 | 0.026 | 0.031 | 0.0020 | ns |
| lag, h | 2.6 | 2.4 | 2.7 | 0.54 | 2.7 | 2.5 | 0.49 | ns |
| Extent of disappearance, % | 74.8 | 75.1 | 75.7 | 1.20 | 75.2 | 75.2 | 1.22 | ns |
| Effective disappearance, % | 42.3 | 42.6 | 41.4 | 1.24 | 40.6 | 43.6 | 1.25 | St |

[†] A= immediately soluble fraction; B = fraction that disappeared at a measurable rate; U = undegradable fraction and was calculated as 100 – B – A, k = rate of disappearance from the Dacron bags; lag = time from bag insertion until measurable disappearance of the B fraction occurred; Extent of disappearance = A + B; Effective disappearance = A + B[$k_d/(k_d+k_p)$].
[§] ns = not significant ($P \geq 0.10$).

from SH or MIX; whereas, total VFA were greater ($P < 0.05$) from SH compared with MIX and from MIX compared with DDGS.

The supplement × sampling time interaction affected ($P < 0.05$) molar concentrations of acetate (Fig. 1). Immediately prior to feeding, molar concentrations of acetate did not differ ($P > 0.10$) among supplements (Fig. 1). At 2 h post-feeding, molar concentrations of acetate were greater ($P < 0.05$) from SH compared with MIX, and did not differ ($P > 0.10$) between MIX and DDGS. From 4 h to 8 h post-feeding, molar concentrations of acetate were greatest ($P < 0.05$) from SH compared with MIX and from MIX compared with DDGS.

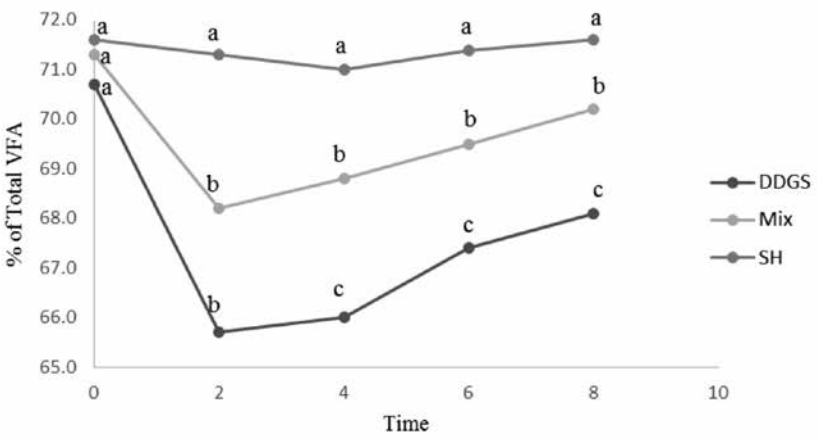


**Fig. 1.** Molar percent of acetate over time after feeding co-product feedstuffs. DDGS = distillers dried grains with solubles; MIX = 50:50 mixture of DDGS and soybean hulls; SH = soybean hulls; VFA = volatile fatty acids. a,b,c = means within a sampling time without a common superscript differ ($P < 0.05$).

The supplement × sampling time interaction also affected ($P < 0.05$) molar concentrations of propionate (Fig. 2). Immediately prior to feeding, molar concentrations of propionate did not differ ($P > 0.10$) between SH and MIX, or between MIX and DDGS, but were greater ($P < 0.05$) from DDGS compared with SH. At 2 h to 8 h post-feeding, molar concentrations of propionate were greater ($P < 0.05$) from DDGS compared with MIX and from MIX compared with SH.

Isobutyrate concentrations were greater ($P < 0.05$) from DDGS and MIX than from SH (Table 4). There was no supplement × sampling time interaction for isobutyrate ($P = 0.32$). The supplement × sampling time interaction affected ($P < 0.05$) the molar concentrations of butyrate (Fig. 3). Immediately prior to feeding, molar concentrations of butyrate did not differ ($P > 0.10$) among supplements. From 2 h to 8 h post-feeding, molar concentrations

**Table 4. Ruminal fermentation measurements from cows offered a basal diet of tall fescue hay and supplemented with soybean hulls, distillers dried grains, or a mix of the two at 0.5% of cow body weight.**

| | Supplement | | | | Status | | | |
|---|---|---|---|---|---|---|---|---|
| Item | Distillers | Mix | Soyhulls | SE | Lactating | Open | SE | Effect[†] |
| Rumen $NH_3$-N, mM | 6.1[a] | 4.4[b] | 3.8[b] | 0.63 | 4.8 | 4.7 | 0.71 | S, T, St*T |
| total vfa, mM | 90.5[c] | 94.2[b] | 100.9[a] | 3.59 | 96.2 | 94.2 | 3.82 | S, T |
| | ---------- mole/100 mole ---------- | | | | | | | |
| acetate | 67.6 | 69.6 | 71.4 | 0.28 | 69.9 | 69.2 | 0.26 | S, T, St, S*T, St*T |
| propionate | 19.3 | 18.5 | 17.5 | 0.22 | 18.4 | 18.5 | 0.20 | S, T, S*T, St*T |
| isobutyrate | 0.9 | 0.8 | 0.8 | 0.04 | 0.8 | 0.8 | 0.04 | S, T, St, St*T |
| butyrate | 10.3 | 9.2 | 8.6 | 0.17 | 9.2 | 9.6 | 0.17 | S, T, St, S*T, St*T |
| isovalerate | 1 | 1 | 0.9 | 0.06 | 0.9 | 0.9 | 0.07 | S, T, S*T, St*T |
| valerate | 1 | 0.9 | 0.8 | 0.04 | 0.8 | 0.9 | 0.04 | S, T, S*St, S*T, St*T |
| total branched chain vfa | 1.8 | 1.8 | 1.7 | 0.10 | 1.7 | 1.8 | 0.10 | S, S*T, St*T |

[†] S = supplement effect ($P < 0.05$); T = time effect ($P < 0.05$); St = status effect ($P < 0.05$); S*T = supplement × time effect ($P < 0.05$); St*T = status × time effect ($P < 0.05$); S*St = supplement × status effect ($P < 0.05$).

[a,b,c] Main effect means within a row and either supplement or production status category without a common superscript letter are different ($P < 0.05$).

of butyrate were greater ($P < 0.05$) from DDGS compared with MIX and from MIX compared with SH.

The supplement × sampling time interaction affected ($P < 0.05$) the molar concentrations of isovalerate and valerate, but these concentrations were very low and are therefore not displayed in a figure. Immediately prior to feeding, molar concentrations of isovalerate were greater in SH compared with MIX or DDGS. At 8 h post feeding, molar concentrations of isovalerate were greater (P < 0.05) from DDGS compared with those from SH and MIX (data not shown). However, molar concentrations of isovalerate did not differ ($P > 0.10$) among supplements from 2 h to 6 h post-feeding. Valerate concentrations on the other hand were not different ($P > 0.10$) among supplements at the time of feeding, but were greater ($P < 0.05$) from DDGS compared with MIX and from MIX compared with SH at all sampling times after feeding.

The supplement × sampling time interaction affected ($P < 0.05$) the molar concentrations of total branched-chain VFA, but the data are not shown in a figure because of the low concentrations (<2% of total VFA). Immediately prior to feeding and 2 h post-feeding, total branched chain VFA did not differ ($P > 0.10$) between DDGS and MIX, but these concentrations were greater ($P < 0.05$) than those from SH. Molar concentrations of total branched-chain VFA did not differ ($P > 0.10$) among supplements at 4 h and 6 h post-feeding. At 8 h post-feeding, total branched-chain VFA were greater ($P < 0.05$) from DDGS compared with those from MIX and SH which did not differ ($P > 0.10$) from each other.

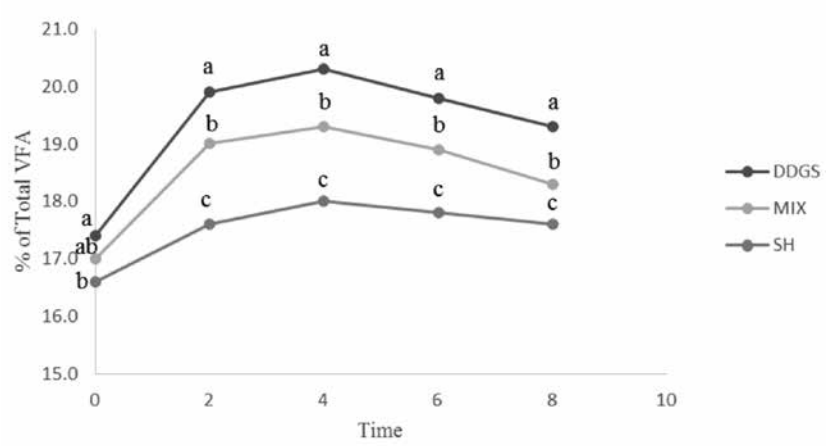


**Fig. 2.** Molar percent of propionate over time after feeding co-product feedstuffs. DDGS = distillers dried grains with solubles; MIX = 50:50 mixture of DDGS and soybean hulls; SH = soybean hulls; VFA = volatile fatty acids. a,b,c = means within a sampling time without a common superscript differ ($P < 0.05$).

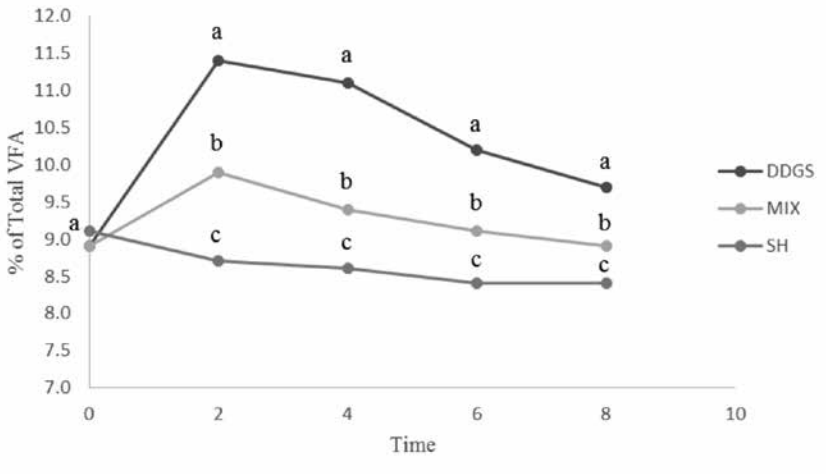


**Fig. 3.** Molar percent of butyrate over time after feeding co-product feedstuffs. DDGS = distillers dried grains with solubles; MIX = 50:50 mixture of DDGS and soybean hulls; SH = soybean hulls; VFA = volatile fatty acids. a,b,c = means within a sampling time without a common superscript differ ($P < 0.05$).

In the present study, it is feasible that differences in *in situ* forage disappearance were not detectable due to the low amounts of supplements fed or that all supplements were offered at the same proportion of BW. In a previous study (Smith, 2014), initial *in situ* forage disappearance was reduced ($P < 0.05$) when cows were offered limit-fed SH and limit-fed distillers dried grains with solubles but not from cows offered a mix of SH and DDGS. In that study, the different co-product feedstuffs were offered to meet the metabolizable energy requirement of the cows which meant that they were offered at considerably greater levels than those offered in the present study. Each cow in the present study was only offered supplements at 0.5% of total BW. This was done in order to meet the NRC (2000) requirements for the lactating cows while attempting to still meet the majority of their energy requirements with the poor-quality hay. Lactating cows had a higher level of forage intake and total DM intake in this study. This could be due to the fact that lactating cows have higher energy requirements than non-

lactating cows and require more forage to meet these energy requirements.

Ruminal ammonia-N concentrations and molar concentrations of propionate were greatest when cows were fed DDGS. Therefore, DDGS may better meet both the energy and protein requirements of cows offered poor-quality hay than SH or MIX. Although supplementation with SH resulted in greater total VFA and acetate concentrations, propionate is utilized more efficiently in the body once absorbed resulting in greater energy return compared with the other VFA. A study by Aschenbach et al. (2011) makes a point that measurements taken from ruminal fluid can vary. They state that ruminal fluid is not homogeneous throughout the rumen and that different sampling techniques will produce varied results (Aschenbach et al., 2011). It is possible that the technique used in this study for rumen fluid collection caused VFA results to vary. However, samples were pulled from four different sections of the rumen, mixed together, and strained through cheesecloth in the present study to minimize these effects.

Supplement × sampling time interactions were observed in the molar concentrations of acetate, propionate, butyrate, and total branched-chain amino acids. It appears that the differences in molar concentration occurred during later hours of the afternoon and into the evening (after 1800 h). No differences were detectable in most cases immediately prior to feeding, which implies that the impacts of the different supplements had subsided by that time.

## CONCLUSION

Overall, minimal differences were observed for *in situ* forage disappearance measurements among lactating and non-lactating cows and none were observed because of the supplements offered. Forage intake and total DM intake were greater in lactating cows as compared to non-lactating cows. Supplementation with DDGS improved molar concentrations of propionate and butyrate for at least 8 h after feeding. Since these VFA result in greater energy production once absorbed by the cow, combined with the greater ruminal ammonia-N concentrations, DDGS should improve the energy and protein status of cows offered poor-quality tall fescue hay compared with those offered supplementation with SH or MIX.

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# Impact of environmentally friendly packaging on consumers' attitudes and patronage intentions toward apparel retail brands

*Madalyn M. Smith* and Eunjoo Cho†*

## ABSTRACT

Consumer interest in social responsibility (SR) has greatly increased in recent years. Providing environmentally friendly packaging (recycled and reusable bags) is one example of how apparel retail brands can engage in SR. The objective of this research was to explore the impact of using environmentally friendly packaging on consumers' attitudes and patronage intentions toward apparel retail brands. To conduct this research, undergraduate and graduate students from a major mid-Southern university completed an online survey testing consumers' perceptions, environmental consciousness, attitudes, and patronage intentions. Results from this study revealed that young consumers' perceptions of environmentally friendly packaging has a positive impact on their environmental consciousness and their attitudes toward apparel retail brands engaged in SR. This study also found that consumers' environmental consciousness has a positive impact on their attitudes toward apparel retail brands engaged in SR, which lead to patronage intentions toward the brand. These findings imply that providing environmentally friendly packaging is important in enhancing positive attitudes and patronage intentions toward apparel retail brands. Retailers are advised to consider changing their current packaging to environmentally friendly packaging.

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## MEET THE STUDENT-AUTHOR

*Madalyn Smith*

My hometown is Girard, Kansas and I graduated high school in 2011. I chose the University of Arkansas to pursue a degree in Apparel Merchandising and Product Development with a minor in Marketing.

During my undergraduate career, I was a New Student Orientation Mentor, a Resident Assistant in Humphreys Hall, a Student Ambassador, a member of Students of Retailing Excellence, and involved in the International Conversation Club. During the summer of my sophomore year, I studied fashion design in Florence, Italy. Throughout my junior year, I completed internships at Walt Disney World in Orlando, Fla. and the Space Needle in Seattle, Wash. Throughout these four years in Arkansas, I have learned so many valuable skills I will use later in life. Upon graduation, I will be moving to Seattle, Wash. to be a Junior Buyer for the Space Needle.

My honors research project was inspired by my passion for the environment. I would like to thank Dr. Cho, Dr. Smith, and Mr. Cheramie for all of their guidance on this project.

## INTRODUCTION

Social responsibility (SR) in the apparel and textile businesses involves "an orientation encompassing the environment and its' people, a philosophy balancing ethics/morality with profit, and an emphasis on the business actions and strategies resulting in positive outcomes for people and the environment" (Dickson and Eckman, 2006). As consumer interest in social responsibility (SR) has greatly increased in the last two decades, SR takes an important role in consumer attitudes and behaviors (Gam, 2011; Hiller Connell, 2011). Recent industry literature has consistently found that two-thirds of U.S. consumers are likely to purchase products and services offered by firms engaging in SR business practices (Cahan, 2013; Nielsen Company, 2012).

To satisfy these socially minded consumers, many companies are incorporating SR activities (e.g. use of recycled or reusable bags) into their businesses to benefit current and future generations by enhancing environmental sustainability. For example, Nike, one of the best one hundred global brands (Interbrand, 2014), is concerned with their environmental impact on employees, consumers, and other communities. Nike has set a long-term goal to manufacture all products with zero waste. One of their efforts is using environmentally friendly packaging such as recycled and reusable bags in the store (Nike, 2014). As an SR initiative, other apparel retail brands (e.g., Lululemon and Urban Outfitters) are interested in providing reusable shopping bags to all customers making a purchase.

Empirical studies in the context of the apparel industry mainly focused on the environmental impact of consumer knowledge and environmental concerns (Gam, 2011; Hiller Connell, 2011; Hill and Lee, 2012; Morgan and Birtwistle, 2009). However, little research has investigated consumers' responses to plastic shopping bag regulations (Gupta and Somanathan, 2011). To fill this research gap, the current study investigates the effects of using recycled or reusable shopping bags on consumers' attitudes and purchase behaviors in the context of apparel shopping.

The purpose of this study is to examine the effectiveness of recycled or reusable bags, used as a tool of SR activities, in predicting a consumer's attitudes and patronage intentions toward an apparel retail brand that engages in SR initiatives. The theory of reasoned action (TRA) was adopted to explain the formation of consumer attitudes and behavioral intentions (Ajzen and Fishbein, 1980). Due to limited research on reducing plastic bag use, an examination of consumer perceptions on SR initiatives may provide insights into the antecedent role of implementing recycled or reusable bag use in predicting attitudes and patronage intentions toward apparel retail brands.

Previous studies have revealed a positive relationship between consumer perceptions of companies and brands engaged in SR initiatives, their environmental conscious-

ness, and their environmentally friendly behaviors (Lee et al., 2012). Consumer perceptions of SR initiatives appear to indicate a strong influence on consumer awareness of SR activities in turn impacting environmentally friendly behaviors of consumers (Lee et al., 2012). Accordingly, the following hypothesis is proposed (Fig. 1):

> Hypothesis 1–Consumers' perceptions of environmentally friendly packaging will have a positive impact on their environmental consciousness.

Previous studies have found consumers' positive perceptions toward the quality of sustainable products have a greater impact on purchase intentions than on consumers' beliefs or opinions (De Pelsmacker and Janssens, 2007; Straughan and Roberts, 1999). Previous research also indicated that consumers show more interest and knowledge of environmentally friendly products as attitudes shift toward being more environmentally conscious (Stisser, 1994). Accordingly, the following hypothesis is proposed:

> Hypothesis 2–Consumers' perceptions of environmentally friendly packaging will have a positive impact on their attitudes toward apparel retail brands engaged in SR.

Previous studies have indicated that environmental consciousness leads to eco-friendly behaviors such as recycling and patronage intentions towards environmentally friendly products (Minton and Rose, 1997; Ohtomo and Hirose, 2007). Results from previous studies suggested that a consumers' interest in SR business practices has a strong influence on their attitudes and purchase decisions (Dickson, 2001; Kozar and Hiller Connell, 2010; Ogle et al., 2004). Accordingly, the following hypothesis is proposed:

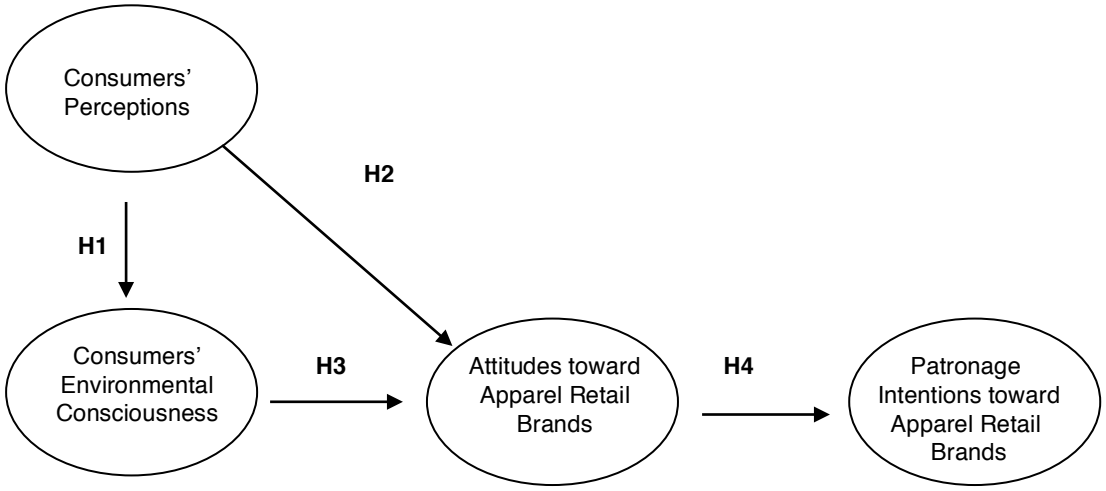
> Hypothesis 3–Consumers' environmental consciousness will have a positive impact on their attitudes toward apparel retail brands engaged in SR.

Research has found that consumers who have a positive attitudes toward SR programs are likely to purchase environmentally friendly products (Morel and Kwakye, 2012). Findings from previous studies confirmed that consumers committed to the environment are willing to participate in environmental activities and pay a premium for environmentally friendly products (Kangun and Polonsky, 1995; Ottman, 1995; Polonsky et al., 1997). Accordingly, the following hypothesis is proposed:

> Hypothesis 4–Consumers' attitudes toward apparel retail brands engaged in SR will have a positive impact on their patronage intentions toward the apparel retail brands.

## MATERIALS AND METHODS

Students from a major mid-Southern university were recruited to conduct a web-based survey. The sample included both males and females, and participants were all 18 years or older. The sample was recruited by sending an invitation email to current undergraduate and graduate students and alumni. The invitational email included the




H1 = Hypothesis 1; H2 = Hypothesis 2; H3 = Hypothesis 3; H4 = Hypothesis 4

**Fig. 1.** A proposed research model showing the hypothesized relationships between the variables.

purpose of the study, survey procedures, benefits, confidentiality, participant rights, and an online survey link.

A self-administered questionnaire was used for the online survey. Established measures from previous research were used for all variables. Items were slightly modified to fit the focus of the present research topic. A 5-point Likert-type scale ranging from 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), 5 (strongly agree) was used for all items. All reliable and valid scale items measuring consumers' perceptions of environmentally friendly packaging, consumers' environmental consciousness, attitudes, and patronage intentions toward apparel retail brands engaged in SR were adopted from existing literature (Table 1).

The present study collected data by conducting an online survey using Qualtrics software (Qualtrics, LLC, Provo, Utah). Approval from the university's Institutional Review Board (IRB) was obtained before collecting data for the study. The first page of the survey was the informed consent form, which addressed the purpose of the study, participants' rights and their benefits. Each participant was asked to read the informed consent form and voluntarily decide his or her participation. There were six

**Table 1. Instruments for online survey.**

| Variables | Items | Source |
|---|---|---|
| Consumers' Perceptions | • I am satisfied with this activity.<br>• This activity is one that I agree with.<br>• Participating in this activity is well worth it.<br>• I think an apparel retail brand engaging in this activity is more valuable than other brands. | Lee et al. (2012) |
| Consumers' Environmental Consciousness | • We should devote some part of our national resources to environmental protection.<br>• It is important to me that we try to protect our environment for our future generations.<br>• The increasing destruction of the environment is a serious problem.<br>• We are not doing enough in this country to protect our environment.<br>• It would mean a lot to me if I could contribute to protecting the environment.<br>• The environment is one of the most important issues facing the world today. | Gam (2011) |
| Consumers' Attitudes | If I were actually shopping at an apparel retail store, this brand would be:<br>• Good<br>• Superior<br>• Pleasant<br>• Excellent<br>• Worthwhile<br>• Useful | Lee, Kim and Fiore (2010) |
| Consumers' Patronage Intentions | • I would buy apparel from an apparel retail brand that engages in this activity to help support recycling.<br>• If available, I would seek an apparel brand that engages in this activity.<br>• I would pay more for apparel from an apparel retail brand that engages in this activity.<br>• Next time when I go apparel shopping, I am likely to buy apparel from an apparel retail brand that engaged in this activity.<br>• Whenever possible, I buy apparel from an apparel retail brand that engages in this activity.<br>• I am willing to recommend an apparel retail brand that engages in this activity. | Gam (2011) |

parts to the survey; (1) general background of the study, (2) consumers' perceptions of environmentally friendly packaging, (3) consumers' environmental consciousness, (4) attitudes toward apparel retail brands engaged in SR, (5) patronage intentions toward apparel retail brands engaged in SR, and (6) demographic information.

Descriptive statistics were conducted to analyze frequency distribution, means, and standard deviation of data. This study employed exploratory factor analysis (EFA) to extract one factor dimension for each variable. Internal consistency for all factors was assessed using Cronbach's alpha (α) coefficient. Finally, all hypotheses proposed in Fig. 1 were tested through simple linear regression analysis. For all data analyses, IBM SPSS v. 21 (IBM Corp., Armonk, N.Y.) was used.

**Table 2. Demographic characteristics of sample (n = 212).**

| Demographic Chararcteristics | Frequency | Percent (%) |
|---|---|---|
| Age | | |
| 18-24 | 193 | 91 |
| 25-29 | 9 | 4.2 |
| 30-34 | 5 | 2.4 |
| 35-39 | 2 | 0.9 |
| 40-44 | 0 | 0 |
| 45-49 | 1 | 0.5 |
| 50-54 | 0 | 0 |
| 55-59 | 2 | 0.9 |
| 60 or older | 0 | 0 |
| Gender | | |
| Male | 33 | 15.6 |
| Female | 177 | 83.5 |
| Ethnicity | | |
| Native American | 2 | 0.9 |
| Black or African American | 6 | 2.8 |
| Asian American | 6 | 2.8 |
| Hispanic or Latino | 13 | 6.1 |
| Native Hawaiian | 1 | 0.5 |
| White or European | 175 | 82.5 |
| Two or more races | 8 | 3.8 |
| Other | 1 | 0.5 |
| Education | | |
| Less than High School | 0 | 0 |
| High School Graduate | 32 | 15.1 |
| Some College, no degree | 148 | 69.8 |
| Associate's degree | 20 | 9.4 |
| Bachelor's degree | 10 | 4.7 |
| Graduate or professional degree | 2 | 0.9 |
| Employed | | |
| Yes | 133 | 62.7 |
| No | 79 | 37.3 |
| Household Income (US $) | | |
| 0-19,999 | 50 | 23.6 |
| 20,000-29,999 | 12 | 5.7 |
| 30,000-39,999 | 12 | 5.7 |
| 40,000-49,999 | 16 | 7.5 |
| 50,000-74,999 | 33 | 15.6 |
| 75,000-99,999 | 31 | 14.6 |
| 100,000 or more | 55 | 25.9 |

## RESULTS AND DISCUSSION

A total of 242 students participated in the online survey. Of the 242 completed responses, 212 were used for data analysis because 30 had missing data. Most of the respondents (91%) were either undergraduate or graduate students between the ages of 18 and 24 (Table 2). The sample consisted of a higher percentage of female respondents (83.5%) than male (15.6%). In terms of ethnic background, a majority of the sample was White or European (82.5%), followed by Hispanic or Latino (6.1%); the rest were either mixed/biracial (3.8%), Black or African-American (2.8%), Asian American (2.8%), Native American (0.9%), Native Hawaiian or Pacific Islander (0.5%), or other (0.5%). Most of the participants had completed some college with no degree (69.8%). The next largest group was high school graduates (15.1%) followed by those who have completed their Associates degree (9.4%), their Bachelors degree (4.7%), and their Graduate or Professional degree (0.9%). The sample consisted of a higher percentage of employed (62.7%) than unemployed (37.3%). Participants were to state their annual family income. If the participant was an independent they were to state their income and if the participant was a dependent they were to state their parents' income. Almost sixty percent of the participants reported their family income was more than $50,000.

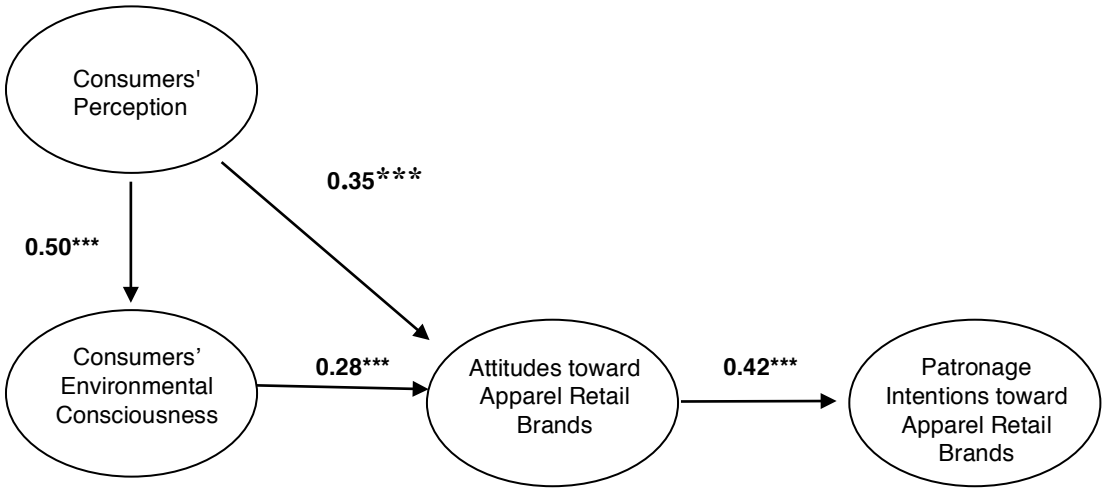
The EFA was conducted to extract one factor dimension for each variable (i.e., consumers' perceptions of environmentally friendly packaging, environmental consciousness, attitudes and patronage intentions toward apparel retail brands engaged in SR). An eigenvalue measuring greater than 1.0 determined the number of factors extracted for each construct. Items with factor loadings of 0.50 or higher on one factor, or lower than 0.30 on the other factor, were retained on one factor. A Cronbach's alpha value above 0.70 was used as evidence of high internal consistency for each factor (Nunnally and Bernstein, 1994). Table

3 shows the results from EFA and reliability tests for all variables.

Simple linear regression analysis was conducted to test four hypotheses. The results showed that all hypotheses were significantly supported as predicted in the proposed model (see Fig. 2). Hypothesis 1 posited that consumers' perceptions of environmentally friendly packaging would have a positive impact on their environmental consciousness. The results indicated that consumers' perceptions of environmentally friendly packaging positively impacted consumers' environmental consciousness ($\beta = 0.71$, $t = 14.531$, $P \leq 0.001$; Table 4). Hypothesis 2 posited that consumers' perceptions of environmentally friendly packaging have a positive impact on their attitudes toward apparel retail brands engaged in SR. The results indicated that consumers' perceptions of environmentally friendly packaging impacted consumers' attitudes toward apparel retail brands engaged in SR ($\beta = 0.59$ , $t = 10.60$, $P \leq 0.001$). Hypothesis 3 posited that consumers' environmental consciousness has a positive impact on their

**Table 3. Results of exploratory factor analysis and reliability for all variables (n = 212).**

| Construct and Items | Factor Loadings |
|---|---|
| **Consumers' Perception of Environmentally Friendly Packaging (α = 0.83)** | |
| Regarding using environmentally friendly packaging such as paper bags and reusable shopping bags, | |
| 1. I am satisfied with this activity. | 0.75 |
| 2. This activity is one that I agree with. | 0.86 |
| 3. Participating in this activity is well worth it. | 0.87 |
| 4. I think an apparel retail brand engaging in this activity is more valuable than other brand. | 0.52 |
| **Consumers' Environmental Consciousness (α = 0.83 )** | |
| 1. We should devote some part of our national resources to environmental protection. | 0.75 |
| 2. It is important to me that we try to protect our environment for our future generations. | 0.77 |
| 3. The increasing destruction of the environment is a serious problem. | 0.90 |
| 4. We are not doing enough in this country to protect our environment. | 0.80 |
| 5. It would mean a lot to me if I could contribute to protecting the environment. | 0.83 |
| 6. The environment is one of the most important issues facing the world today. | 0.79 |
| **Attitudes toward Apparel Retail Brands Engaged in SR (α = 0.91 )** | |
| If I were actually shopping at this apparel retail store, this brand would be: | |
| 1. Good | 0.82 |
| 2. Superior | 0.75 |
| 3. Pleasant | 0.83 |
| 4. Excellent | 0.84 |
| 5. Interesting | 0.71 |
| 6. Worthwhile | 0.85 |
| 7. Useful | 0.81 |
| **Patronage Intentions toward Apparel Retail Brands Engaged in SR (α = 0.92)** | |
| 1. I would buy apparel from a brand that engages in this activity to help support recycling. | 0.68 |
| 2. If available, I would seek an apparel retail brand that engages in this activity. | 0.84 |
| 3. I would pay more for apparel from an apparel retail brand that engages in this activity. | 0.73 |
| 4. Next time when I go apparel shopping, I am likely to buy apparel from an apparel retail brand that engages in this activity. | 0.82 |
| 5. Whenever possible, I buy apparel from an apparel retail brand that engages in this activity. | 0.84 |
| 6. I am willing to recommend an apparel retail brand that engages in this activity. | 0.75 |




*** $P \leq 0.001$

**Fig. 2.** The research model showing the hypothesized relationships between the variables.

attitudes toward apparel retail brands engaged in SR. The results indicated that consumers' environmental consciousness positively impacted their attitudes toward apparel retail brands engaged in SR ($\beta = 0.53$, $t = 8.92$, $P \leq 0.001$). Hypothesis 4 posited that consumers' attitudes toward apparel retail brands engaged in SR have a positive impact on their patronage intentions toward the apparel retail brands. The results indicated that consumers' attitude toward apparel retail brands engaged in SR positively impacts their patronage intentions toward apparel retail brands ($\beta = 0.65$, $t = 12.16$, $P \leq 0.001$).

This study was designed to examine the positive impact of environmentally friendly packaging initiatives (e.g., recycled or reusable bags) in predicting consumers' attitudes and patronage intentions toward apparel retail brands that engage in the SR initiatives. Simple linear regression analysis reveals positive relationships between consumers' perceptions of environmentally friendly packaging, consumers' environmental consciousness, attitudes, and patronage intentions toward the apparel retail brands engaged in SR. The more favorable the consumers' perceptions of environmentally friendly packaging, the stronger the consumers' concern for the environment and the more favorable attitudes they have toward apparel retail brands engaged in the SR initiatives. The higher concern for the environment consumers have, the stronger attitudes they have toward apparel retail brands engaged in the SR initiatives. The stronger attitudes a consumer has toward apparel retail brands engaged in SR initiatives, the stronger patronage intentions the consumer has toward those apparel retail brands.

The findings confirmed that young consumers value apparel retail brands that engage in the SR initiatives, such as providing environmentally friendly packaging. Providing environmentally friendly packaging increases young consumers' positive attitudes and patronage intentions toward those apparel retail brands. These findings emphasizes that retailers should consider changing their current packaging to environmentally friendly packaging.

This study empirically verified the theoretical path in the proposed model which confirms TRA is relevant in predicting the effects of consumers' perceptions of environmentally friendly packaging and environmental consciousness on consumers' attitudes toward apparel retail brands engaged in SR and patronage intentions toward the apparel retail brands engaged in SR. The findings of

**Table 4. Summary of simple linear regression analysis results (n = 212).**

| Variables | *B* | SE | *β* | F | $R^2$ | *P*-value |
|---|---|---|---|---|---|---|
| H1. Perception → Environmental Consciousness | 0.75 | 0.05 | 0.71 | 211.16 | 0.50 | 0.0001 |
| H2. Environmental Consciousness→ Attitudes | 0.53 | 0.05 | 0.59 | 112.38 | 0.35 | 0.0001 |
| H3. Perception→ Attitudes | 0.44 | 0.05 | 0.53 | 79.59 | 0.28 | 0.0001 |
| H4. Attitudes→ Patronage Intentions | 0.83 | 0.07 | 0.65 | 147.79 | 0.42 | 0.0001 |

*B* = regression coefficients; SE = standard deviation; $\beta$ = standardized coefficients; F = F statistic; $R^2$ = R square.

this study revealed that young consumers are likely to purchase apparel products from retail brands engaged in providing environmentally friendly packaging. Providing environmentally friendly packaging will increase profitability by enhancing consumers' positive attitudes and patronage intentions toward that apparel retail brand.

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I would like to thank my family for their continued love and support. Without them I would not have been able to reach this significant point in my academic career. Financial assistance to support this project was provided through a research grant by the University of Arkansas Honors College and the Dale Bumpers College of Agricultural, Food and Life Sciences.

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# Earthworm populations in a wheat-soybean double-crop system under seven years of established residue management practices

*Jill E. Thomason*[*], *Mary Savin*[†], *Kristofor Brye*[§], *and Donn T. Johnson*[‡]

## ABSTRACT

Earthworms improve soil structure, distribute litter and microbes, stimulate microbial activity, facilitate decomposition, and increase nitrogen (N) availability for plant growth. Earthworm density is often reduced in low organic matter soils that are intensively managed to grow row crops. This study was designed to relate earthworm density and community composition to residue management after seven years of established management practices in a wheat (*Triticum aestivum* L.)-soybean (*Glycine max* (L.) Merr.) double-crop system maintained in Marianna, Ark. Residue management practices included conventional tillage (CT) and no-tillage (NT), N fertilization to produce high and low wheat residue amounts left in the field, and burning and non-burning of residue after wheat harvest. Total earthworm densities ranged from 271 to 508 $m^{-2}$ across treatments. Both exotic *Aporrectodea trapezoides* (Duges) and native *Diplocardia sylvicola* (Gates) adult earthworms were present with very little difference in diversity among sampled communities; however, more than 50 % of adults were *D. sylvicola* in all treatments. Residue level and burning influenced total, juvenile, and native earthworm densities differently in CT and NT. Adult native earthworms predominated over a common exotic species in a wheat-soybean double-crop system in Arkansas with residue management practices interacting to impact the density of earthworms.

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‡ Donn T. Johnson is a professor in the Department of Entomology.

## MEET THE STUDENT-AUTHOR

***Jill Thomason***

I am from Fayetteville, Arkansas and graduated from Fayetteville High School in 2011. I graduated in May 2015 from the Dale Bumpers College of Agricultural, Food and Life Sciences at the University of Arkansas with a degree in Animal Science, a concentration in Pre-Veterinary Medicine and a minor in German. In August 2015, I plan to begin pursuit of a Doctor of Veterinary Medicine degree at the Louisiana State University School of Veterinary Medicine in Baton Rouge, La. As a student at the University of Arkansas, I was a member of the Pre-Veterinary club, as well as the German Honors Society, Delta Phi Alpha, while also working at a local veterinary clinic, Stanton Animal Hospital.

I would like to thank my faculty advisor, Dr. Mary Savin, for all of the help and insight she provided throughout the completion of this project. I would also like to thank the other members of my committee, Dr. Kristofor Brye and Dr. Donn T. Johnson, for the additional assistance they provided for completion of this project. Special thanks are also given to Dr. Bruce Snyder at Kansas State University for assistance in identification of the earthworms found in this study and Dr. Edward Gbur at the University of Arkansas for performing much of the statistical analyses necessary for completion of this project.

## INTRODUCTION

Understanding the factors affecting earthworm population densities is important because earthworms are ecological engineers and keystone species (Lavelle et al., 1989). Earthworms play a number of important roles in improving soil quality. Their presence impacts nutrient cycling as well as many soil characteristics, such as soil aggregate structure, litter and microorganism distribution, microbial activity, decomposition rates and extent, and timing and amount of available N (Lavelle et al., 1989).

Typically, agricultural management practices that decrease residue, such as conventional tillage (CT), largely affect invertebrate community composition in the southern United States, causing less diversity and resulting in communities made mostly of a few, often exotic species (Callaham et al., 2006). Increased residue increases food for earthworms, so earthworm densities are expected to increase. A previous study by Eriksen-Hamel et al. (2009) shows that CT and practices that increase crop residue amount can increase organic carbon in soil, providing earthworms with more organic resources for growth. However, this study also showed that earthworm movement might be physically restricted due to barriers created as a result of tillage in fields subjected to repeated CT. Tillage practices that reduce soil disruption and return more crop residues to the soil tend to increase earthworm population densities (Eriksen-Hamel et al., 2009).

In the southern United States, there are native and exotic earthworms. Previous research shows that native and exotic earthworms interact in a number of ways, primarily competing for soil nutrients (Kalisz and Wood, 1995; Winsome et al., 2006). Often, the introduction of exotic earthworms coincides with increased disturbance and reductions in native earthworm densities, especially in disturbed soils characteristic of urban and rural areas (Kalisz and Wood, 1995; Winsome et al., 2006). Winsome et al., 2006) found that an exotic species, *Aporrectodea trapezoides* (Duges), consistently had greater relative increase in density than a native species, *Argilophilus marmoratus* (Eisen) in a California grassland, but differences in densities declined with decreasing habitat quality. However, research is not definitive as to whether exotic earthworms will replace native earthworms in managed agroecosystems and to what extent species predominate or coexist with differences in residue management in row crop systems.

Earthworm abundance observationally appeared to increase over time in plots established to investigate residue management (CT versus NT; fertilization to produce HIGH amount versus LOW amount of wheat residue; and burning (BURN) versus not burning (NO BURN) residue) in a wheat-soybean double-crop system in east-

ern Arkansas. Thus, the goal of this research was to determine if seven consecutive years of consistent residue management treatment combinations resulted in distinguishable differences in density, diversity, or species identity of earthworms. The null hypothesis for this research was that there would be no significant differences in densities, diversity, or identities of earthworm species after seven years of different residue management treatments.

## MATERIALS AND METHODS

The field experiment evaluating residue management practices in a wheat-soybean double-crop system was established at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in the spring of 2002 in Marianna, Arkansas as described in Brye et al. (2007). Plots (48, $3 \times 6$ m$^2$) have been managed each year according to the original timeline as briefly described below. Prior to the establishment of the site, soybean was grown in a non-double-cropped system under CT management. Land was prepared by disking twice followed by field cultivation and broadcast application of 20 kg N ha$^{-1}$, 22.5 kg P ha$^{-1}$, 56 kg K ha$^{-1}$ and 1120 kg ha$^{-1}$ of pelletized limestone to adjust pH levels prior to planting of the first wheat crop in Fall 2001. All plots received 101 kg N ha$^{-1}$ as urea in early March beginning in 2002, while the HIGH plots were fertilized with an additional 101 kg N ha$^{-1}$ broadcast application of urea in late March for the first 3 years. After the first 3 years, LOW plots received 0 kg N ha$^{-1}$ and HIGH plots received 101 kg N ha$^{-1}$. Wheat was harvested in June, with the aboveground wheat residue mowed to the soil surface. Mowed residue was raked uniformly back onto its respective plot, and the burn treatment imposed on the BURN plots only. Mowed residue was then raked uniformly back onto its respective unburned plot. Following the burning, CT consisting of disking twice, and seedbed smoothing with a soil conditioner was imposed before planting of a glyphosate-resistant soybean seed in mid-June. All 48 plots were furrow-irrigated as needed throughout the season for the first 3 years of the study, after which only the first 24 plots were furrow-irrigated and the last 24 plots were not irrigated. In early November, soybean was harvested by hand, and the remaining soybean stubble was left standing in the plots before replanting of the wheat crop.

Earthworms for this study were collected in March 2009. Earthworms were sampled by the hand-sorting dig-and-sort method from a randomly located $30 \times 30 \times 20$ cm$^3$ sub-plot within 24 non-irrigated treatment plots. All possible combinations of tillage (CT versus NT), wheat residue (HIGH versus LOW) and burn (BURN versus NO BURN) treatments were sampled (n = 3). Earthworms were boiled at the collection site, preserved in 5% formalin solution, and stored in vials. Formalin was increased to a 10% concentration to maintain preservation for long-term storage. Juvenile, adult and total earthworms were counted in February 2014 after 5 years of storage in formalin. Adult earthworms were identified in spring and summer 2014 using relevant identification keys (Causey, 1958; Dindal, 1990; Eisen, 1899; Gates and Reynolds, 1968). Juvenile earthworms were considered unidentifiable due to lack of reproductive structures which are necessary for identification.

A Poisson distribution was assumed for the earthworm counts, which were log transformed, and evaluated by analysis of variance as a split-split plot in which the whole plot portion of the design was a randomized complete block with three blocks and tillage as the main treatment factor. The split plot factor was the burn treatments and the split-split plot factor was residue level. Least square means for significant effects ($P < 0.05$) were compared using a protected least significant difference (LSD) procedure where appropriate. Statistical analyses were carried out using SAS® v. 9.4 (SAS Institute Inc., Cary, N.C.).

## RESULTS AND DISCUSSION

Mean total and juvenile earthworm abundances were significantly affected by the three-way interaction of tillage by burn treatment by residue level ($P < 0.0001$ for both total and juvenile abundances; Tables 1 and 2). There were no significant differences in densities between tillage treatments; however, the effect of burning and residue level was significantly different within a tillage treatment for both mean total and juvenile earthworm densities. Within CT, the highest mean total (Table 1) and juvenile earthworm (Table 2) densities occurred in the absence of burning (NO BURN) and presence of HIGH residue level and were similar to densities in the BURN treatment with LOW residue level. Mean total and juvenile earthworm densities were lower and similar when burned (BURN) with high residue level (HIGH) and juvenile earthworms were lower in density when residue was unburned (NO BURN) and LOW. In contrast, in the NT, the highest total density compared to the other treatments was in the HIGH residue, BURN treatment (Table 1). Density was also lower in the NO BURN, HIGH residue compared to the NO BURN, LOW residue. For juveniles in the NT, the highest density was in the HIGH residue, BURN treatment which was not different than in LOW residue, NO BURN (Table 2). Juvenile densities were similar across the two LOW residue levels and the HIGH residue, NO BURN treatments. Juvenile earthworms accounted for more than half (56-74%) of the mean total earthworm densities (Tables 1 and 2).

**Table 1. Mean total earthworm densities (# $m^{-2}$ ± standard error) collected in March 2009 from non-irrigated plots in a wheat-soybean double-crop system subjected to a main effects of conventional tillage (CT) or no till (NT), split plot effects of burning (BURN) or leaving (NO BURN) wheat residue to decompose on the soil surface, and split-split plot effects of LOW or HIGH residue amount† at the Lon Mann Cotton Research Station in eastern Arkansas.**

| | CT | | | NT | |
|---|---|---|---|---|---|
| | High | Low | | High | Low |
| **Burn** | 271 (50)d‡ | 428 (79)bc | **Burn** | 497 (92)a | 281 (52)bc |
| **No Burn** | 508 (94)ab | 320 (59)cd | **No Burn** | 275 (51)c | 325 (60)b |

† For the first 3 years, 101 kg N $ha^{-1}$ was applied to the LOW residue plots and 202 kg N $ha^{-1}$ was applied to the HIGH residue plots. After the first 3 years, 0 kg N $ha^{-1}$ was applied to the LOW residue plots and 101 kg N $ha^{-1}$ was applied to the HIGH residue plots.

‡ Means followed by a similar letter within a tillage treatment are not statistically different ($P < 0.0001$). There are no significant differences between CT and NT.

The predominance of juveniles in many samples may be explained by the March sampling time. Spurgeon and Hopkin (1999) found juveniles were more abundant than adults in spring and summer; whereas adults outnumbered juveniles in fall and winter at a site in southwest England. A potential reason for the juveniles being more numerous than adults at the time of sampling in March is that *Ap. trapezoides* and *Diplocardia sylvicola* hatch in the winter and spring, and mature to adulthood later in the year; however, little previous research has been done on the reproductive cycling of either species in the southeastern United States (Spurgeon and Hopkin, 1999). It is expected that during the dry, hot summer, very few earthworms will be active in a non-irrigated system, so another possible explanation for the large densities at the March sampling is that samples were taken in the cool, wet spring (Spurgeon and Hopkin, 1999).

Only two species, one native and one exotic, were identified among the adult earthworms from the 24 plots. This seems to be relatively low number of species compared to similar studies performed in managed systems (Callaham et al., 2003; Callaham et al., 2006; Emmerling, 2001). All native earthworms were identified as *D. sylvicola*, and all exotic species were identified as *Ap. trapezoides*. Native earthworms accounted for 65–100% of adult earthworms collected across treatments. Furthermore, except for three samples in NO BURN treatments where native earthworms accounted for 19%, 54%, and 60% of the adult population, native earthworms accounted for 88-100% of adult earthworms collected in individual samples (data not shown). Adult earthworms consisted solely of *D. sylvicola* in the CT, LOW residue, BURN and the NT, LOW residue, BURN treatments (data not shown). The only treatment that had exotic earthworms in all three replicate samples was the CT, HIGH residue, NO BURN (data not shown).

Because of the infrequent detection of exotic species, statistical analysis of adult earthworms was conducted only on native earthworm densities. The three-way interaction among treatments (tillage × burn × residue level) had a significant effect on native earthworm density ($P < 0.0001$; Table 3). Similar to total and juvenile earthworm

**Table 2. Mean juvenile earthworm densities (# $m^{-2}$ ± standard error) collected in March 2009 from non-irrigated plots in a wheat-soybean double-crop system subjected to main effects of conventional tillage (CT) or no till (NT), split plot effects of burning (BURN) or leaving (NO BURN) wheat residue to decompose on the soil surface, and split-split plot effects of LOW or HIGH residue amount† at the Lon Mann Cotton Research Station in eastern Arkansas.**

| | CT | | | NT | |
|---|---|---|---|---|---|
| | High | Low | | High | Low |
| **Burn** | 181 (36)b‡ | 271 (54)a | **Burn** | 301 (59)a | 200 (40)b |
| **No Burn** | 371 (73)a | 176 (35)b | **No Burn** | 195 (39)b | 217 (43)ab |

† For the first 3 years, 101 kg N $ha^{-1}$ was applied to the LOW residue plots and 202 kg N $ha^{-1}$ was applied to the HIGH residue plots. After the first 3 years, 0 kg N $ha^{-1}$ was applied to the LOW residue plots and 101 kg N $ha^{-1}$ was applied to the HIGH residue plots.

‡ Means followed by a similar letter within a tillage treatment are not statistically different ($P < 0.0001$). There are no significant differences between CT and NT.

**Table 3. Mean native earthworm densities (# $m^{-2}$ ± standard error) collected in March 2009 from non-irrigated plots in a wheat-soybean double-crop system subjected to main effects of conventional tillage (CT) or no till (NT), split plot effects of burning (BURN) or leaving (NO BURN) wheat residue to decompose on the soil surface, and split-split plot effects of LOW or HIGH residue amount† at the Lon Mann Cotton Research Station in eastern Arkansas.**

| | CT | | | NT | |
|---|---|---|---|---|---|
| | High | Low | | High | Low |
| **Burn** | 84 (25)b‡ | 152 (45)a | **Burn** | 185 (55)a | 80 (24)b |
| **No Burn** | 86 (26)b | 106 (32)a | **No Burn** | 71 (21)b | 98 (29)a |

† For the first 3 years, 101 kg N $ha^{-1}$ was applied to the LOW residue plots and 202 kg N $ha^{-1}$ was applied to the HIGH residue plots. After the first 3 years, 0 kg N $ha^{-1}$ was applied to the LOW residue plots and 101 kg N $ha^{-1}$ was applied to the HIGH residue plots.

‡ Means followed by a similar letter within a tillage and burn treatment are not statistically different ($P < 0.0001$). There are no significant differences between CT and NT, and there are no significant differences between burn treatments.

density, the effect of residue level was different within tillage treatment, but unlike total and juvenile earthworm densities, the native earthworm densities in CT were similar and higher with LOW compared to HIGH residue level within a burn treatment regardless of BURN or NO BURN treatment. The effect of residue level within NT was also different for native earthworms than it was for total and juvenile earthworm densities. In NT, native earthworm densities were higher in BURN and HIGH. Lower abundances were obtained in NO BURN, HIGH residue level compared to the BURN, LOW residue treatment. There were no differences within NT between burn treatments for native earthworms.

Many studies indicate that earthworm populations are larger in NT than other tillage systems (Eriksen-Hamel et al., 2009; Ernst and Emmerling, 2009). Chan (2001) compared several studies that revealed earthworm densities in various NT systems ranged between 137 and 467 $m^{-2}$ and between 52 and 213 $m^{-2}$ in CT systems. Total earthworm densities in this study were similar between CT and NT with densities under CT greater than those reported in Chan (2001). Densities in NT were within range or greater than previously reported (Chan, 2001). Both *D. sylvicola* and *Ap. trapezoides* are endogeic species. Endogeic, or soil-dwelling, earthworms have been known to benefit under tillage, likely from increased nutrient availability resulting from decomposition of plowed-in organic matter (Chan, 2001).

In general, cultivation may provide a competitive advantage for exotic species. In the midwestern and southeastern United States, exotic species have been found in greater densities than native species in cultivated systems (Callaham et al., 2003; Callaham et al., 2006). It is often assumed that this is due to the exotic species' ability to tolerate disturbances, such as tillage or fertilization, to a greater extent than the native species (Callaham et al., 2006). Although species were not identified among juvenile earthworms due to the lack of clitellum—the location of which is vital to identifying earthworms—in this experiment, native adults outnumbered exotic earthworms.

Although residue management within a tillage treatment impacted earthworm densities differently, earthworms were not more abundant in NT compared to CT treatment combinations. Rather, the interaction between residue amount and burning impacted earthworm densities and relative abundances differently within tillage type. Prior to European settlement and subsequent introduction of exotic earthworm species, soils were burned frequently with aboveground biomass removal, thus native earthworms may be better adapted to temperature and resource availability changes that occur with aboveground burns than exotic earthworms (Callaham et al., 2003).

## SUMMARY AND CONCLUSIONS

Earthworms were collected in March 2009 in eastern Arkansas from non-irrigated plots in a wheat-soybean double-crop system subjected to CT or NT, BURN or NO BURN, and fertilization to produce LOW or HIGH wheat residue amounts. Earthworms were abundant with total densities ranging from 271–508 $m^{-2}$. Native adult earthworms (*D. sylvicola*) outnumbered an exotic species (*Ap. trapezoides*), and juveniles outnumbered adult earthworms in all treatments. Residue management practices of tillage, fertilization impacting residue amount, and burning interacted to impact the density of total, juvenile and native earthworms.

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# Matching missions: hunger relief programs and impact of food donation partners in Northwest Arkansas

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## ABSTRACT

In 2012 and 2013, Arkansas ranked first in the nation in food insecurity in both categories of "low food secure" (21.2%) and "very low food secure" (8.4%). The Cobblestone Project developed a hunger relief donation partner, The Farm, in order to help address food insecurity in Northwest Arkansas. In spring 2014, The Farm partnered with the University of Arkansas to 1) better understand the demographics and need of hunger relief organizations, 2) calculate the impact of donations to hunger relief organizations, and 3) assess satisfaction of donations from The Farm to hunger relief organizations. A series of surveys were targeted to hunger relief organizations that The Farm serves to meet these objectives. Statistical analyses of survey data provided the following results: 1) Demographics and needs of hunger relief organizations: there were no significant differences in demographics served (age and gender) among organizations that put different values on hunger relief in their mission statements. Additionally, there was no significant difference between the number of people served and the functional type (pantry, soup kitchen, in-house) of the organization. 2) The impact of donations: during the 2014 harvest, 10,863 kg of food were donated by The Farm impacting a total of 12,598 recipients. 3) Satisfaction regarding the quality, quantity and diversity of the commodities donated: there is a difference in usefulness of produce that is easily prepared with known recipes and for large amounts of people. This survey showed bell peppers, cabbage, potatoes, zucchini, tomatoes, and lettuce to be considered most beneficial.

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## MEET THE STUDENT-AUTHOR

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I am the daughter of Michael and Nancy West of Gravette, Arkansas, and have graduated with a degree in Agricultural Business with a focus in Agricultural Economics. Active in Student Government, I was a member of Fresh H.O.G.S., Senator for Dale Bumpers College, served as the Chair of Senate and Vice-President. I have served as a college ambassador for the Dale Bumpers College, Vice-President for Agricultural Business Club, Jr. Panhellenic Delegate for Kappa Kappa Gamma, Director of Awards for the Honors Student Board and am a member of the AgriBusiness/Agricultural Economics Quiz Bowl Team. For two years, I worked for Dr. Goodwin as a research assistant. After my freshman year, I studied abroad in Belize.

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## INTRODUCTION

In 2012 and 2013, Arkansas ranked first in the nation in food insecurity in both categories of "low food secure" (21.2%) and "very low food secure" (8.4%) (Lilley, 2013; Coleman-Jensen et al., 2014). In some counties in the Eastern Delta (Lee, St. Francis, Desha, and Crittenden), 25% of households reported having been food insecure at one point in 2013 (Gundersen et al., 2012).

Northwest Arkansas (NWA), defined as Benton, Washington, Madison and Carroll counties, also experiences food insecurity. In Benton county, 13.7% of households were food insecure at one point in 2011 (Gundersen et al., 2012). Washington (16.8%), Madison (15%), and Carroll (14.7%) counties were all above the national average (Gundersen et al., 2012). Furthermore, in real 2010 dollars, per capita income has fallen from $22,508 to $20,840 (The Central Arkansas Library System, 2015; USCB, 2014). As the number of people earning an income above the poverty level declines, the need for nonprofit food aid increases. The goal of this study is to assess efforts of one non-profit agency to alleviate hunger in NWA.

The consequences of hunger are great. Children who experience food insecurity are more likely to develop chronic conditions such as asthma or anemia, experience oral health problems or conditions that require hospitalization, have stunted growth, and be unable to fully engage in daily life (Nord, 2009). These children may develop physical and intellectual impairments that will stay with them for the rest of their lives. Additionally, these children cannot learn as quickly, are less likely to have high academic achievements, and will be less competitive in obtaining jobs. Eventually, this disability leads to a cycle of food insecurity (Cook and Jeng, 2009).

While many Arkansans benefit from federal food aid programs, not all Arkansans who are food insecure are eligible for these programs. To catch these remaining food insecure households and to supplement those who are already enrolled in federal aid programs, Arkansas and NWA in particular have many organizations, many of which are non-profits, that strive to end hunger locally (Fayetteville COC, 2014). Nonprofits experience challenges along with the successes in relieving hunger. Programs that distribute food (either meals or raw produce) directly address the need, but because they generally have high implementation costs, they are often viewed as inefficient (Hidrobo et al., 2012). Nonprofits often struggle to pay the heavy overhead that is necessary to run a successful organization (Gregory and Howard, 2009). Often they skimp on overhead (including paying individuals to conduct impact reports), that leads to a lack of communication between funders and organizations, which can leave nonprofits underfunded and challenged in fulfilling their missions (Gregory and Howard, 2009). Nonprofits typi-

cally include soup kitchens, pantries, or in-house meal servings. Studies suggest that these methods of alleviating hunger are more likely to lead to waste than voucher or cash programs (Hidrobo et al., 2012; Gentilini, 2007).

Because both sectors of hunger relief (governmental and nonprofit) in the U.S. have experienced their challenges and successes, impact assessments have an important role. Performance measurements are essential to determine management strategies, and increase relative understanding of effectiveness (Cunningham and Ricks, 2004; Bryson, 2011). Performance measurements increase donors' confidence levels and the organizations' abilities to obtain grant funding. Many studies have focused on the use of performance measurements for non-profits (e.g., Forbes, 1998; Garcia et al., 2013; Kaplan, 2003; Sharp and Brock, 2010; Zimmerman and Stevens, 2006 ). These studies suggest that traditional financial assessment alone may not truly measure performance, and both quantitative and qualitative performance measurements should be used.

Founded in 2008, the Cobblestone Project is a nonprofit organization that serves those in NWA who are living in poverty. The Cobblestone Project developed a hunger relief donation partner, The Farm, that has provided tens of thousands of kilograms of food to hunger relief programs in NWA (J. Watts, pers. comm.) including soup kitchens, prepared meal programs, and food pantries (Cobblestone Project, 2013; J. Watts pers. comm.). The purpose of this study is to better understand the demographics and needs of the hunger relief organizations to which The Farm donates produce and to explore ways that The Farm can positively impact the ability of hunger relief organizations to meet their own goals of reducing hunger in NWA.

## MATERIALS AND METHODS

Three types of surveys (an introductory survey, harvest season surveys and a final survey) were developed for 17 hunger relief organizations in NWA with whom The Farm collaborated. The first survey had 11 questions that focused on general characteristics of each organization. A second survey comprised of 8 questions was sent to hunger relief organizations each time they received a donation from The Farm from May 2014 to October 2014. This survey was used to assess the hunger relief organization's impact and ability to use a given donation. The third survey had eight questions that gauged overall satisfaction with donations from The Farm during the 2014 harvest. Upon receiving the University of Arkansas Internal Review Board approval (number 14-04-686), the surveys were built into the Qualtrics electronic survey software (Qualtrics, Provo, Utah) and distributed to organizations' representatives.

Once data were collected, statistical tests were conducted in Statistical Analysis System v. 9.4 (SAS software, Cary, N.C.) using Fisher's exact tests, student's *t* test, and analysis of variance to look for significant differences among organizations who rated hunger relief as of primary (PG) or secondary (SG) importance to their missions and among different functional types of organizations: pantry, soup kitchen and in-house.

## RESULTS AND DISCUSSION

**Introductory Survey Results**

The survey population consisted of 17 organizations that The Farm identified as potential donation recipients. Of those, 14 (82%) completed the introductory survey (Table 1). Participants included four soup pantries, four churches, four shelters, and two elementary schools. Five of the 14 (36%) organizations ranked the importance of hunger relief as part of the organization's mission as a low priority (ranking it three or lower on a scale of one to five). These organizations will be called "secondary goal organizations" (SG). Nine organizations, known as "primary goal organizations" (PG), ranked hunger relief as a high priority for their organizations (ranking it a 4 or 5). Additionally, organizations were divided into three functional type categories. Soup kitchens are those organizations that serve meals at their own facilities for non-residential client use, pantries are those organizations who give away food to be prepared by the recipient elsewhere, and in-house organizations are those who take in clients for a longer time than a single meal service.

**Table 1. Number of organizations by functional types and hunger relief importance.**

| | Functional Type of Organization | | | |
|---|---|---|---|---|
| **Hunger Relief Importance** | **Soup Kitchens** | **Pantries** | **In-House** | **Total** |
| PG[a] | 3 | 5 | 1 | 9 |
| SG[b] | 1 | 0 | 4 | 5 |
| Total | 4 | 5 | 5 | 14 |

[a] PG = organizations that consider hunger relief as a primary goal in their mission.
[b] SG = organizations that consider hunger relief as a secondary goal in their mission.

Fisher's exact tests were conducted to determine if certain characteristics differed between PG and SG organizations. These characteristics included quantity and age of people served, how the organization serves their recipients, and who they believe considers efficiency important in their organization. Results of the testing are summarized in Table 2.

No significant differences existed between PG and SG organizations for most categories of individuals served. However, significant differences did exist ($P$ = 0.0291) between the two types of organizations for men ages 65+: a statistically greater percentage of PG organizations served men ages 65+ compared to the SG organizations. As expected, a higher percentage of PG organizations served at least 600 people annually compared to SG organizations. However, statistical testes revealed no significant ($P$ = 0.5671) difference in these results.

Respondents were asked whether they served food in a central location, distributed food to individuals for consumption at home, or both. They were also asked how they prepared food for consumption: 1) raw food, 2) canned food and/or 3) a prepared meal. There were no significant differences between PG and SG organizations regarding where, or type of food, served.

Finally these respondents were asked who, among four groups, would be interested in their impact numbers: 1) donors, 2) their own workers, 3) benefactors, 4) members of their boards. No significant differences were found in the answers provided by PG and SG organizations. All organizations believed that donors would find impact numbers compelling.

**Second Survey Results**

During the 2014 harvest, 10,886 kilograms of food were donated by The Farm to 13 organizations impacting a total of 12,598 recipients. Of those 13 organizations, 8 completed surveys after each donation. This survey focused on the impact of the donation, the number of people served per donation and the donation's help in meeting the organization's weekly food needs. Student's $t$-tests were

**Table 2. Testing for significant differences between organizations where hunger relief is highly important to their mission (primary goal organizations) and organizations where hunger relief is not highly important to their mission (secondary goal organizations).**

| Characteristic | Primary Goal Organizations | | Secondary Goal Organizations | | |
|---|---|---|---|---|---|
| | Yes (%) | No (%) | Yes (%) | No (%) | *P* value |
| Serve Boys 18 Years Old and Younger | 100.0 | 0.0 | 83.3 | 16.6 | 0.4615 |
| Serve Girls 18 Years and Younger | 100.0 | 0.0 | 83.3 | 16.6 | 0.4615 |
| Serve Males 18-64 | 85.7 | 14.2 | 33.3 | 66.6 | 0.1026 |
| Serve Females 18-64 | 85.7 | 14.2 | 83.3 | 16.6 | 1.0000 |
| Serve Males Over 64 | 85.7 | 14.2 | 16.6 | 83.3 | 0.0291 |
| Serve Females Over 64 | 85.7 | 14.2 | 50.0 | 50.0 | 0.2657 |
| Serve More Than 600 Annually | 66.6 | 33.3 | 33.3 | 66.6 | 0.5671 |
| Serve At Central Location | 85.7 | 14.2 | 100.0 | 0.0 | 1.0000 |
| Send Food Home To Be Served | 57.1 | 42.8 | 33.3 | 66.6 | 0.5921 |
| Serve Fresh Foods | 71.4 | 28.5 | 66.6 | 33.3 | 1.0000 |
| Serve Canned Foods | 85.7 | 14.2 | 100.0 | 0.0 | 1.0000 |
| Serve Prepared Meals | 85.7 | 14.2 | 83.3 | 16.6 | 1.0000 |
| Donors Consider Efficiency | 83.3 | 16.6 | 100.0 | 0.0 | 1.0000 |
| Workers Consider Efficiency | 33.3 | 66.6 | 60.0 | 40.0 | 0.5671 |
| Benefactors Consider Efficiency | 0.0 | 100.0 | 40.0 | 60.0 | 0.1818 |
| Board Members Consider Efficiency | 33.3 | 66.6 | 60.0 | 40.0 | 0.5671 |

conducted to determine if the kilograms received from The Farm and the number of people that organizations were able to serve with this produce differed between PG and SG organizations. No statistical difference existed (Table 3) between the kilograms PG and SG received from The Farm during the 2014 Harvest ($P = 0.5719$). Additionally, no statistical difference existed (Table 4) between the number of people PG and SG organizations were able to serve with donations ($P = 0.2089$).

Analysis of variance tests examined whether the number of kilograms received differed by pantry, soup kitchen or packed for in-house/resident consumption and people served. No statistical differences ($P = 0.9329$) existed in kilograms received across functional type of organization or as an interaction with number of people served ($P = 0.5535$) (Table 5). Statistical difference (at the $P < 0.1000$ level) did exist between the kilograms received and the number of people served ($P = 0.0597$).

**Final Survey Results**

Nine organizations completed the final survey that asked questions concerning organizations' use of the food donations, satisfaction with the donations and donation processes, usefulness of donations, and likelihood that the organization would work with The Farm in the future. Three organizations reported that they usually prepared meals with donations, three reported repackaging their donations, and three reported doing both.

On a scale of 1-7 (very dissatisfied to very satisfied), seven organizations were satisfied or very satisfied with The Farm staff, donation timeliness, food quality, food quantity, and food type. Organizations rated bell peppers, cabbage, potatoes, and zucchini as most beneficial while beets, Brussel sprouts, chives, rosemary, and Swiss chard received no votes (Table 6). Seven organizations (78%) reported they were "very likely" and two (22%) reported that they were "likely" to partner with The Farm again.

**Recommendations for The Farm**

Based on the results of the surveys and statistical testing, the following recommendations are offered for the farm:

Because survey results showed that NWA hunger relief organizations have different missions, The Farm could target organizations that strive to increase the quantity of food consumed by recipients knowing that this is where their impact might be most effective.

Because statistical tests showed that impact is not related to importance of hunger relief to the partner organization (i.e., PG vs SG), The Farm can continue to donate to a diverse set of organizations and maintain effectiveness.

While all farm donations seem to result in a positive impact, the largest impacts are in organizations with the largest numbers of people to serve. To ensure all organizations can use all food provided, The Farm could consider making smaller donations more frequently to organizations that serve smaller amounts of people.

The Farm could plan their annual production based on the commodities of greatest use by the partnering organizations.

**Recommendations for Future Studies**

The following recommendations are made to improve future studies. Surveys were not an effective means to reach all organizations. To improve response rates in future studies, face-to-face contact with organizations may be necessary.

**Table 3. Kilograms (kg) received by organization vs. importance of hunger relief by organization.**

| Characteristic | Value |
|---|---|
| PG Organizations (mean kg received) | 284.2 |
| SG Organizations (mean kg received) | 223.4 |
| \|t\| value | 0.6 |
| *P* value | 0.5719 |

n = 13; data from the Cobblestone Project Social Impact Report 14.

**Table 4. People served vs. importance of hunger relief by organization.**

| Characteristic | Value |
|---|---|
| PG Organizations (mean people served) | 1731.6 |
| SG Organizations (mean people served) | 793.8 |
| \|t\| value | 1.43 |
| *P* value | 0.2089 |

n = 8; data from the second survey.

**Table 5. Analysis of variance tests.**

| Characteristic | F Value | *P* Value |
|---|---|---|
| Received vs. Functional Type of Organization (in kg) | 0.07 | 0.9329 |
| Received vs. People Served (in kg)[a] | 4.68 | 0.0597 |
| People Served vs. Functional Type of Organization[a] | 0.65 | 0.5535 |

[a] In these tests, n = 8, other test n = 13.

**Table 6. Food items considered most useful by hunger relief organizations.**

| Food Item | Number of Votes |
|---|---|
| Bell Peppers | 8 |
| Lettuce | 5 |
| Tomatoes | 5 |
| Cabbage | 4 |
| Potatoes | 4 |
| Zucchini | 4 |
| Banana Peppers | 3 |
| Broccoli | 3 |
| Onions | 3 |
| Squash | 3 |
| Cucumbers | 2 |
| Eggs | 2 |
| Acorn Squash | 1 |
| Arugula | 1 |
| Basil | 1 |
| Collard Greens | 1 |
| Eggplant | 1 |
| Kale | 1 |
| Radishes | 1 |
| Turnip Greens | 1 |
| Turnips | 1 |
| Beets | 0 |
| Brussels Sprouts | 0 |
| Chives | 0 |
| Rosemary | 0 |
| Swiss Chard | 0 |

Second, additional efforts may be needed to clarify the meaning of some questions and answer choices provided on the survey to ensure that all respondents can interpret questions similarly.

Finally, this study was based on a small number of organizations. This small sample can limit the robustness of the statistical testing as well as the ability to generalize these results across all hunger relief organizations in NWA.

## SUMMARY AND CONCLUSIONS

This partnership between the University of Arkansas and Cobblestone Project's The Farm set out to 1) better understand the demographics and need of hunger relief organizations, 2) calculate the impact of donations to hunger relief organizations, and 3) assess satisfaction of donations from The Farm to hunger relief organizations. A series of surveys were targeted to hunger relief organizations that The Farm serves to meet these objectives. Statistical analyses of survey data provided the following results: 1) there were no significant differences in demographics served (age and gender) among organizations that put different values on hunger relief in their mission statements. Additionally, there was no significant difference between the number of people served and the functional type (pantry, soup kitchen, in-house) of the organization. 2) During the 2014 harvest, 10,863 kg of food were donated by The Farm impacting a total of 12,598 recipients. 3) There is a difference in usefulness of produce that is easily prepared with known recipes and for large amounts of people. This survey showed bell peppers, cabbage, potatoes, zucchini, tomatoes, and lettuce to be considered most beneficial.

This study was a case study and the surveys used in this study can be extended to a larger sample in order to truly determine impacts of food donations in NWA. As all organizations surveyed agreed that impact reports, such as the one generated here, can be useful in informing their boards and soliciting donors, studies such as these could be continued to assess and improve the impact of food aid partners in Northwest Arkansas.

## ACKNOWLEDGMENTS

This research was supported in part from research grants received from the Arkansas Department of Higher Education Student Undergraduate Research Fellowship (Surf) as well as the Dale Bumpers College of Agricultural, Food and Life Sciences Honors Program. We would like to thank the Cobblestone Project's The Farm and the following food aid partners for assisting in the development of or participating in this study: 7 Hills Homeless Center, Bread of Life, Central United Methodist Church, Full Circle Food Pantry, Havenwood Elementary, LifeSource International, NWA Women's Shelter, Owl Creek School, Restoration Village, St. Paul's Episcopal Church, Samaritan Center, Saving Grace, Second Street Pantry, Wiggins United Methodist, and Youth Bridge.

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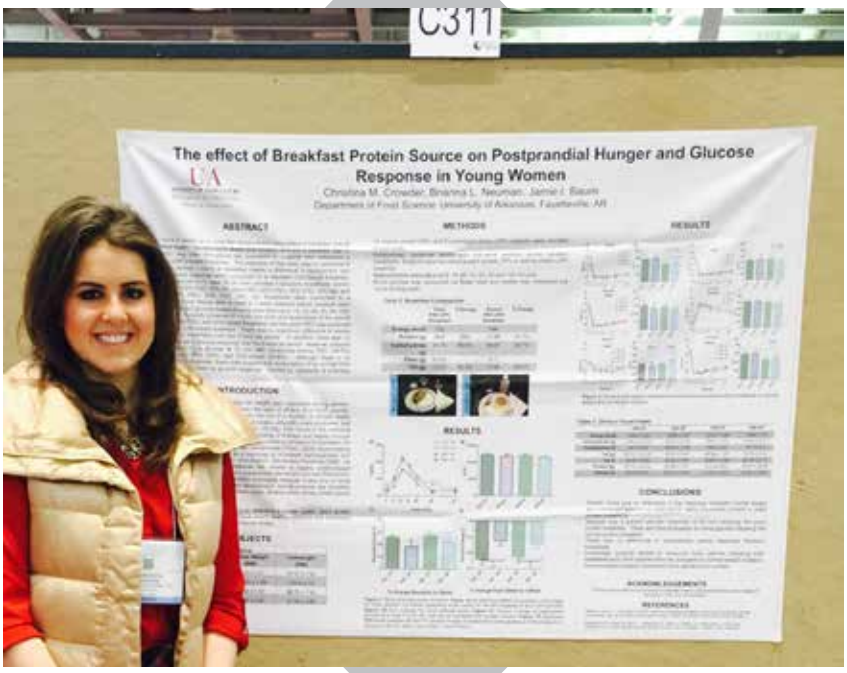
# Bumpers College Students in Action

**Amy West. (Agricultural Economics and Agribusiness).** Amy poses in front of the U.S. Capitol in Washington, D.C., where she worked through the Spitze Public Policy Legislative Internship during the summer of 2013 after her sophomre year. This internship provides $5000 funding for one Bumpers College student who is working with agricultural policy in a legislative or congressional office.

**Megan Lankford (Horticulture).** Pictured at the Botanical Gardens of the Ozarks (BGSO). Megan landed her dream job before graduation as Lead Gardener at BGSO. She began working there to fulfill her 3 month internship requirement in her sophomore year and stayed on part time throughout school leading to the offer to go full time after graduating. She received an American Society for Horticultural Science Scholars Scholarship, one of only two recipients in the U.S. of this award for 2014. Megan also received the Outstanding Graduating Senior of the Horticulture Department award.

**Christina Crowder (Food, Human Nutrition, and Hospitality).** Christina poses in front of a garden in Beauvais, France, where she completed an international program at LaSalle Polytechnique University. Christina studied sustainable culinary nutrition by connecting nutrition, sustainability and health through experimental learning in the university's culinary platform and while traveling France. Christina took this trip the summer right after she completed her senior year coursework. She received a Bumpers College International Programs Office scholarship, Honors College Airfare Study Abroad Grant, and funds from the Food Science Department.

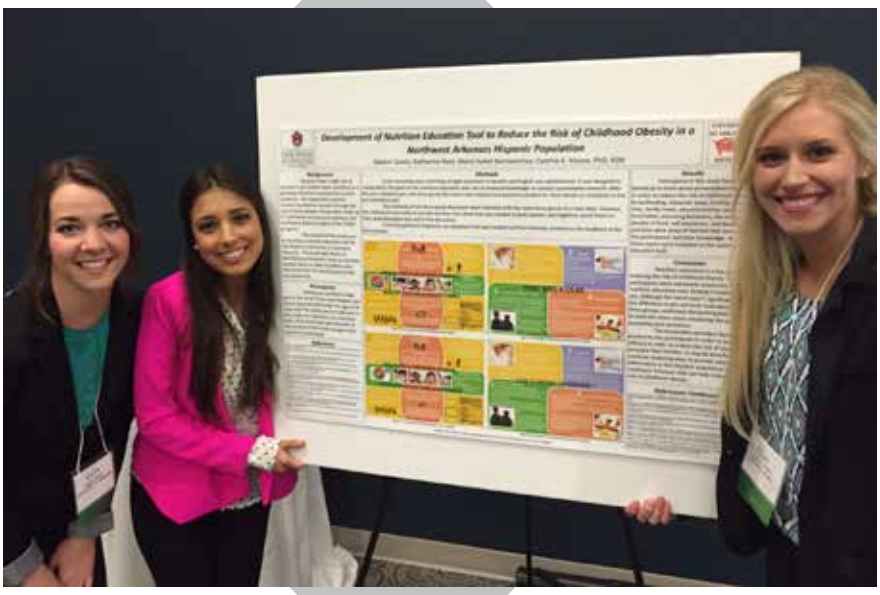
**Christina was named the 2015 Outstanding Dietetic Student in the State by the Arkansas Academy of Nutrition and Dietetics! The Bumpers College's School of Human Environmental Sciences has produced the last three state winners.**




**Christina Crowder**. Pictured at the Experimental Biology Conference in Boston in March 2015 presenting a poster from the article in this issue. The same poster went on to win 3rd place in the Food Science research poster competition and 2nd place in the Ozark Food Processors Association competition (graduates and undergraduates).

**Bonifacio Lopez Torres.** (**Food, Human Nutrition, and Hospitality).** Pictured at the city of Heilbronn, Germany (left) and at the The Memorial to the Murdered Jews of Europe in Berlin (right) during his one semester study abroad exchange trip funded in part by the Silas Hunt Distinguished Scholarship. Lopez Torres says this experience expanded his knowledge and guided him to narrow down his research project, seeing how cities like Madrid, Paris, Antwerp, Berlin and Hamburg are cities that attract so many tourists. This trip encouraged him to do his project on the promotion of tourism because he wanted to know more of the process that it took for destinations to keep a positive growth and continuous benefits for their cities.

**Sarah Mayfield.** (**Food Science).** Pictured in her lab. Mayfield won the Dale Bumpers College of Agricultural, Food and Life Sciences Honors Student Board Outstanding Thesis competition. Mayfield traveled to Belgium, world-renowned for its chocolate, to develop CLA-enriched chocolate bars and chocolate spread in the University of Ghent's Cacaolab, where she worked with professors Ashok Patel and Koen Dewettinck. A SURF grant, an Honors College International Research Grant, and funds from Bumpers College and the University of Ghent supported her research.



**Kate Ross, Maria Isabel Barrenechea, and Mallori Sando.** (**Food, Human Nutrition and Hospitality).** Pictured at the peer-reviewed research poster session of the Arkansas Academy of Nutrition and Dietetics in Little Rock in April, 2015.

**Kate Ross (left) and Mallori Sando.** (**Food, Human Nutrition and Hospitality).** Pictured in the Dietetics class of Dr. Cynthia Moore taking body mass measaurements.

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