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Discovery Editors

DISCOVERY

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

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Viability of 3-D-printed fashion
(inset: 3-D-printed tile)

UofA DIVISION OF AGRICULTURE RESEARCH & EXTENSION
University of Arkansas System

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

DISCOVERY

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Cover: (from left to right) Kaitlyn Walker makes adjustments as *Laura Corral* models the finished top from their project, "Exploring the abilities of 3-D printing and its viability for consumption in the fashion industry." Photo by Fred Miller.

DISCOVERY

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

Vol. 18 **Fall 2017**

Undergraduate Research Articles *continued*

Letter from the Dean

Students Address Real-World Issues While Demonstrating Research and Problem-Solving Skills

Lona Robertson

The Dale Bumpers College of Agricultural, Food and Life Sciences is focused on improving the quality of life for Arkansans by preparing students for successful careers, conducting impactful research, and sharing knowledge. The *Discovery* undergraduate research journal provides an opportunity to highlight the work of our talented students and the work that they have completed inside and outside of the classroom. Many of our outstanding faculty work with these students to produce the work you will find within.

We encourage undergraduate research by awarding undergraduate research grants. Our students compete for research and travel grants awarded by the University of Arkansas Honors College and the Arkansas Department of Higher Education SURF grants program. Projects may be designed to meet the requiremnts for an honors project in the Bumpers College Honors Program. One of our goals is to prepare students to be responsible leaders with strong communication skills and problem-solving abilities. Inside this issue you will discover research studies from across the college that highlight and exemplify those qualities.

Congratulations to the student authors, and a sincere THANK YOU to the faculty mentors and editors who make this year's issue of the journal possible. We are pleased and proud to present their results and findings in a citable publication as a service to them and to all our readers.

Lona Robertson, Professor and Interim Dean
Dale Bumpers College of Agricultural, Food and Life Sciences

A Message from the Faculty Editor

Mary Savin

Welcome to the 18th issue of *Discovery*, the journal that provides a venue for undergraduate students to disseminate their accomplishments in research and creative projects. This is my eighth year as faculty editor, and the projects that our students complete get more interesting each year, while the manuscripts they write continue to showcase their talents. This year's diversity of creative projects and research should make all Bumpers students, faculty, staff, and family proud.

This issue of *Discovery* contains 12 articles written by undergraduate student authors representing four departments and three programs in the School of Human Environmental Sciences working with 25 mentors from Bumpers College and across the University of Arkansas.

I invite everyone to read and reflect upon these projects and contributions, where you will find articles on

- Creative projects simultaneously advancing innovation and sustainability in the fashion industry from use of 3-D printing to guidance on how to construct cosplay costumes ra-ther than waste materials;
- Investigations benefiting people's health including learning about chemicals in peanuts with properties to help prevent cancer, and how people's continued desire for low fat content beef may be related to ability to choose beef based on visual cues rather than preference for characteristics of cooked meat;
- How the strategy of love-bombing, or use of excessive communication at the beginning of a romantic relationship for power and control, relates to those with narcissistic tendencies and low self-esteem;
- Analyses benefitting localized communities, including 1) savings resulting from serving portioned compared to unrationed meals and snacks in a daycare setting, 2) evaluation of crop diversification strategies to reduce risk and increase food security in Mozambique, 3) information to help local beekeepers market products in Arkansas, and 4) the feasibility of Arkansas hemp production;
- Evaluation of genetic markers in cattle for association with meaningful physical traits and determination of the benefits of incorporating genetic information in breed selection for pasture production systems, and finally a method evaluation so that researchers can use the best approaches to advance cutting-edge science in animal health.

Please join me in wishing the best for all Bumpers College students as they complete their undergraduate degrees at the University of Arkansas and embark on their careers to become leaders, innovators, policy makers, and entrepreneurs in their professional careers.

Mary Savin, *Discovery* Faculty Editor
Professor of Microbial Ecology, Department of Crop, Soil, and Environmental Sciences

Undergraduate Research Articles

The bovine rumen microbiome revealed by different fractions of rumen contents

Ashlee Breakstone and Jiangchao Zhao†*

Abstract

The bovine rumen microbiota is very important in terms of animal functionality and digestion. The fermentative capability of the rumen provides means for the digestion of complex plant material that is indigestible by humans. The rumen microbiota is made up of billions of microorganisms, primarily bacteria, that digest and ferment feed into volatile fatty acids and bacterial protein for the animal's energy and protein needs, respectively. Changes to the rumen microbiota can have a direct measure on animal growth, health, and performance. The possibility of productivity boosts in the cattle industry make the rumen microbiome a hot topic in the field of livestock research. A consistent and accurate method for the fractionation of rumen contents would improve the ability for researchers to detect differences found in rumen microbiomes among different animals and treatments. The objective of this study was to determine the view that five different sampling methods of rumen contents would have on the rumen microbiome. Steers fed hay and fresh pasture wheat were used, which also highlights differences found between diets. Next generation sequencing was used to sequence the V4 region of bacterial 16sRNA. Results were analyzed via Mothur, an open source command-line used to analyze sequencing data in microbial communities, and visualized using R, a command-line software used for statistical analysis and graphical display. The results of this study provided no significant differences between fractionation methods; however, noteworthy differences were observed between the two diets. Due to the lack of differences between methods, the best method was chosen based on time, efficiency, and simplicity. The results of this study allow research scientists to pick the method of choice without sacrificing the accuracy of results.

* Ashlee Breakstone is a May 2017 honors program graduate with a major in Animal Science.
† Jiangchao Zhao is the honors faculty mentor and an Assistant Professor in the Department of Animal Science.

Meet the Student-Author

Ashlee Breakstone

I am from St. Louis, Missouri and graduated from Fort Zumwalt West High School in 2013. I graduated from the University of Arkansas in May 2017 with a major in Animal Science with a focus in microbiological research. My last two years at the University have been dedicated to my honors research project. I have also had the opportunity to be a part of numerous clubs such as Pre-Veterinary club and Block&Bridle club. For the past year, I have served as the President of the Arkansas Union Advisory Committee where I was able to improve policies and events in the Arkansas Union. I have also served as an Honors College Ambassador for the 2016–2017 academic year, which has given me access to numerous volunteer opportunities on and off campus. After graduation, I will enter a Master's Program for Molecular and Cell Biology at the University of Texas at Dallas. I hope for a long future in research and academia.

I would like to thank Dr. Jiangchao Zhao for serving as my honors mentor for this project and Robert Story and Charles Rosenkrans for serving as committee members. I would also like to acknowledge Jeff Pummill, Fanli Kong, and Robert Story for their help and assistance in the completion of this project.

Introduction

Within the livestock industry, ruminant species, such as cattle, make up a considerable component and present valuable resources to the United States. The economic value and substantial food source cattle provide are extensive. According to beefnutrition.org, a 3-oz. serving of lean beef provides more than 10% of the Daily Value of 10 essential nutrients (Cattlemen's Beef Board and National Cattlemen's Beef Association, 2017). The nutrients and high-quality protein found in beef could be crucial to the numerous nutritional issues Americans face (Cattlemen's Beef Board and National Cattlemen's Beef Association, 2017). Economically, the United States prospers from the beef and livestock industry. As of 2014, approximately $88.25 billion in farm gate receipts for cattle and calves were reported (National Cattlemen's Beef Association, 2016). In 2012, the livestock industry produced about $346 billion in total economic output and provided 1.8 million jobs (Dillivan and Davis, 2014). The production of cattle, regardless of end-product, is increasing with time. Researchers have begun to ask themselves whether the performance and production of cattle can improve. Due to advancements in technology and research, the knowledge needed to enhance the cattle industry has become more available.

The digestive system of a ruminant animal is highly complex in that it is made up of four separate stomach compartments: the rumen, reticulum, omasum, and abomasum. Of these four compartments, the rumen is possibly the most important and certainly the largest comprising the entire left side of the abdominal cavity and having the capacity to hold 40-60 gallons of material (Ishler et al., 1996). Around 150 billion microorganisms per teaspoon can be found in the rumen, ranging from prokaryotic species (bacteria and archaea) to eukaryotic species (protists and fungi) (Ishler et al., 1996; McCann et al., 2014; Weimer, 2015). The microorganisms found inside the rumen are a part of a mutually beneficial, host-microbe relationship (McCann et al., 2014). The microorganisms are provided essential nutrients needed for survival and consequently break down complex nutrients for the host that would otherwise be indigestible. These capabilities make the rumen the most important site for microbial activity and fermentation (Weimer, 2015).

Carbohydrates, both structural (fiber) and non-structural (sugars and starches), and proteins undergo microbial fermentation in the rumen. Volatile fatty acids (VFAs) are the primary end products resulting from carbohydrate fermentation. Volatile fatty acids play a crucial role in host energy demand, accounting for 50% to 70% of the energy production in cattle (Regents of the University of Minnesota, 2017). Another important function of the rumen is the capability to produce microbial protein from non-protein nitrogen sources and feed proteins. Microbial protein produced by microorganisms can be used for most

of the animal's protein needs, while the remainder is digested and absorbed in the abomasum and small intestine, respectively. The rumen and its working constituents (microorganisms) are necessary for digestion; therefore, loss of this function would lead to host productivity failure. Comparatively, improving rumen function may lead to significant improvements in digestive and fermentative performances; therefore, increasing animal growth and production.

The rumen microbiota is made up of the millions of microorganisms harbored within the rumen, while the microbiome is made of the genes these cells harbor (Ursell et al., 2012). Bacteria are by far the most abundant and diverse, accounting for 95% of total microbiota (Brulc et al., 2009). The prevalence of bacteria and its consequent role in feed degradation and fermentation make it the highlight of most studies involving the rumen microbiome (Firkins and Yu, 2015). Past research methods involving the microbiome have used culture-dependent methods, such as isolation and cultivation of species. This is a very limited approach due to the immense number of bacteria that are not cultivable (Tajima et al., 1999). More recent microbiome research uses culture-independent methods which involve direct DNA and RNA sequencing and analysis. These novel approaches make it possible to uncover more information on the diversity and roles that bacteria and other microorganisms play in the rumen ecosystem.

The bacteria in the rumen are highly responsive to changes in diet, host genetics, and physiology, as well as geographical and environmental factors (Wu et al., 2012). The bacterial community can be affected in numerous ways regarding membership, composition (abundance), and diversity. The alpha diversity, the microbiome within a specific environment, and the beta diversity, the relationships of microbiomes between two or more different environments, can be affected and measured. The observed and measured differences in microbial ecology can have a direct and quantitative impact on animal function and health. Ultimately, the rumen microbiota controls the balance of fermentation products, such as VFAs and microbial protein, which determines the efficiency of nutrient fermentation and utilization; hence, the rumen microbiota is essential to the animal's well-being and productivity (Hernandez-Sanabria et al., 2012; Jami and Mizrahi, 2012; Jewell et al., 2015).

In the rumen, there are three interrelated environments associated with the microbial population. The liquid phase makes up about 25% of the microbial mass and consists of the free-living microbial groups in the rumen fluid. The largest portion, making up about 70% of the microbial mass, is the solid phase including all microbial groups attached or affiliated with food particles in the rumen. The microbes attached to the rumen epithelial cells and protozoa make up the last 5% of the microbial mass found inside the rumen (Ishler et al., 1996). Considering the microbial population's ability to modify according to several elements (diet, geographic location, genetics, etc.) and the effects these have on the animal, it is necessary to understand the ways in which the contrasting rumen fractions and fractionation methods might alter the view of the rumen microbiome. The research directed towards the different phases of the rumen contents is still new; past studies have determined that a substantial difference between the liquid and solid portions of the rumen exists and these differences could possibly reflect specialized functions related to digestion of feed (Pitta et al., 2010). Further investigation into the different rumen fractions is needed to provide additional insight into the microbiological functions that might be present.

The research and manipulation of the rumen microbiome has a strong influence on the livestock industry leading to possible changes in cattle growth, performance, and health. The significance of the rumen microbiome makes it a high priority in the field of research. Although fundamental variation in the rumen exists, a consistent sampling technique will improve the ability to detect microbiome differences among animals or treatments. Through the development of novel approaches and comparisons between standard methods, the efficiency and accuracy of sampling the bovine rumen may improve. The objective of this study is to determine the effect, if any, that five different sampling methods have on the view of the rumen microbiome. The outcome of this study will provide a possible method(s) that produces the most stable and consistent view of the rumen microbiome.

Materials and Methods

The samples used for this study were obtained from 8 black angus steers involved in a coinciding study involving the comparison between hay and fresh pasture wheat diets. On week two of the study, rumen samples from four steers fed on wheat and four steers on hay were extracted using a separate, sterile oral stomach tube (5/8 inch outside diameter × 3/8 inch inside diameter × 10 ft, Valley Vet Supply, Marysville, Kansas). The steers used in this study were provided by the University of Arkansas System Division of Agriculture's Batesville Station. This portion of the study was performed and provided by Don Hubbell, Tom Hess, and Jiangchao Zhao.

Various methods of rumen sampling were used in this study to obtain five different fractions of rumen contents. Prior to each method, the contents were pulled from -80 °C and thawed overnight at 4 °C. Each sample was briefly spun under high speeds (vortexed) directly before each procedure to effectively mix the contents. The first fraction,

representing the whole digesta (meaning all of the ingested food and material found within the rumen), was collected via pulling a direct 100-µl sample of rumen contents. Also, representing the whole digesta, the next sample was obtained by homogenization of contents in a paddle blender (Stomacher 400, Seward Ltd., Worthing, West Sussex, U.K.) (2 min, normal speed). Following homogenization, a 100-µl sample of blended contents was pulled from the stomacher bag. The third fraction, representing the whole digesta, was collected using a centrifugal method. The contents were centrifuged in a bead-beating tube and the following supernatant, or liquid lying above the solid residue, was discarded, leaving the remaining solid-like contents for further sampling. The last two fractions, depicting the solid and liquid portions, were attained using a filtration method. The rumen contents were tightly squeezed through four layers of sterile cheesecloth. A 100-µl sample of filtered liquid was used for the liquid portion and the remaining solids were used for the solid fraction. The solid end-products had weights ranging from 200 to 300 mg. Each sample was transferred to -80 °C until use for further DNA extraction.

A physical bead-beating disruption method (where contents are put in a small tube with tiny micro-beads to disrupt cellls and release DNA) was used for microbial cell lysis (disintegration or rupture of the cell) and total DNA extraction. The extractions were performed using the MO BIO PowerLyzer PowerSoil protocol and DNA isolation kit (MO BIO Laboratories (a Qiagen company), Carlsbad, California), with few minor adjustments. All extracted DNA was stored at -80 °C after quantification was performed using a NanoDrop One Spectrophotometer (Thermo Fisher Scientific, Madison, Wisconsin). After quantification, the V4 region of 16SRNA was amplified and sequenced using the Illumina MiSeq System (Illumina, Inc., San Diego, California).

The sequencing reads from the bacterial DNA were aligned and analyzed using mothur v. 1.39.1 software package and followed the standard operating procedures of the MiSeq platform contributed by Pat Schloss (Kozich et al., 2013; Schloss et al., 2009). The diversity and composition of bacterial communities was determined at an operational taxonomic unit (OTU) level with a 97% similarity cutoff. The Shannon and Observed OTU (sobs) indices were utilized to measure community diversity and richness, respectively (Chao and Shen, 2003). The Bray-Curtis and Jaccard distance metrics were calculated to estimate the differences in community structure and membership for beta diversity (Bray and Curtis, 1957). The mantel test was used to determine the statistical correlation and significance between sampling methods. These distances were visualized by principle coordinate analysis (PCoA) and plotted using R (R version 3.3.2).

Results and Discussion

The results were characterized by sequencing the bacterial 16S V4 hyper-variable region of the rumen microbiota. In total, 40 samples were described from 8 steers (4 hay, 4 wheat) with 5 different sample treatments per steer. A total of 532,735 high-quality sequencing reads were obtained with an average of 13,318 reads per sample ranging from 8662 to 19,931. The sequences were classified into 9147 OTUs. The coverage ranged from 93% to 98% with an average of 96%.

The results from this study will aid in future endeavors towards research in the bovine rumen microbiome. Although some minor differences were found, the substantiality of differences was inconsequential. In past studies, a large difference has been found between different fractions of rumen contents. The research done by Pitta et al. (2010) found that the genera *Prevotella* was dominant in all samples, but the liquid fraction of samples contained a greater dominance of *Prevotella* when compared to the solid and whole fractions. Similarly, upon examination of the top 20 OTUs per sample treatment, the solid fraction of this study was slightly lacking in *Prevotella* in comparison to the other samples which is also consistent with results found by Fouts et al. (2012) (data not shown). Despite this minor observation, there were no significant differences in genus and family levels when comparing sampling methods.

The two most abundant phyla found within all rumen microbiomes was *Firmicutes* and *Bacteroidetes* which is consistent with most past studies confirming that these two phyla are a part of the core rumen microbiome regardless of diet, age, fraction, etc. (data not shown) (de Menezes et al., 2011). Significant differences in the relative abundance of each was found between diets with phylum *Firmicutes* showing a significant dominance in the hay fed steers (data not shown). These results may indicate that diet has a much greater effect on community membership than the sampling approach.

The Shannon measure of diversity takes into account both community richness, or number of observed species, and community evenness, or abundance of specific species, whereas the observed OTU index is solely the community richness. The measured diversity in opposing phases of the rumen contents has been conflicting. In studies performed by Kong et al. (2010) and Cho et al. (2006), it was found that the solid fraction contained a higher measure of diversity and a greater number of known bacteria (species richness). On the contrary, a study by de Menezes et al. (2011) determined that the bacterial diversity was higher in the liquid fraction. McCann et al. (2014) analyzed the rumen content fractions of steers fed separate diets of hay and wheat and

found that the liquid fraction of the hay diet contained the greatest number of bacteria compared to the lowest number in the whole fraction of the wheat diet. In this study, results across diets showed that the Shannon measure of diversity and the community richness (observed OTU) were significantly different ($P < 0.05$) (Fig.

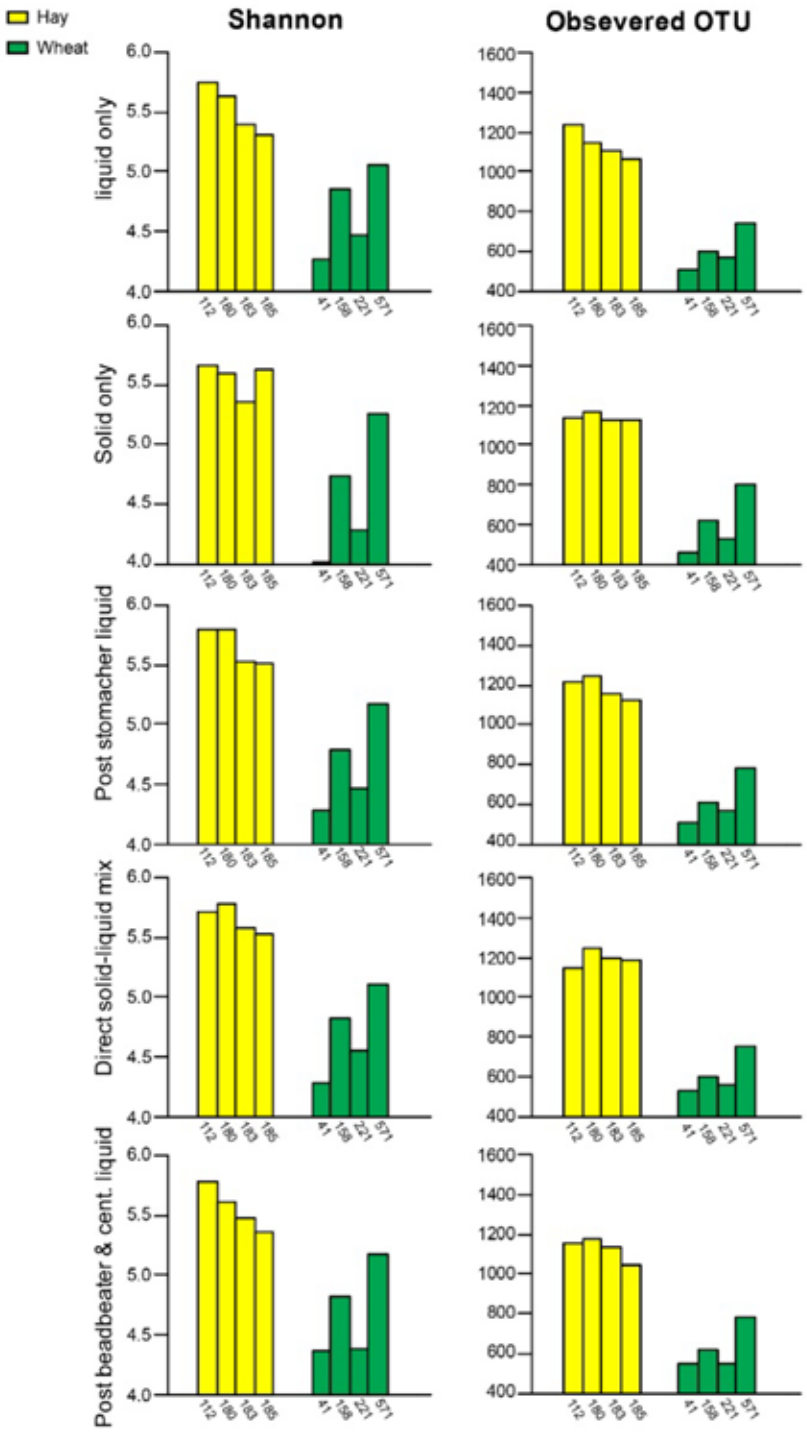

Fig. 1. The Shannon and Observed operational taxonomic unit (OTU) indices showing the alpha diversity (species richness and evenness) and species richness, respectively found in each diet and sample. Operational taxonomic units are individual and distinct organisms found in the sequences. The *x*-axis portrays the 8 steers with each number representing a specific animal and the two distinct colors portraying hay- and wheat-fed animals.

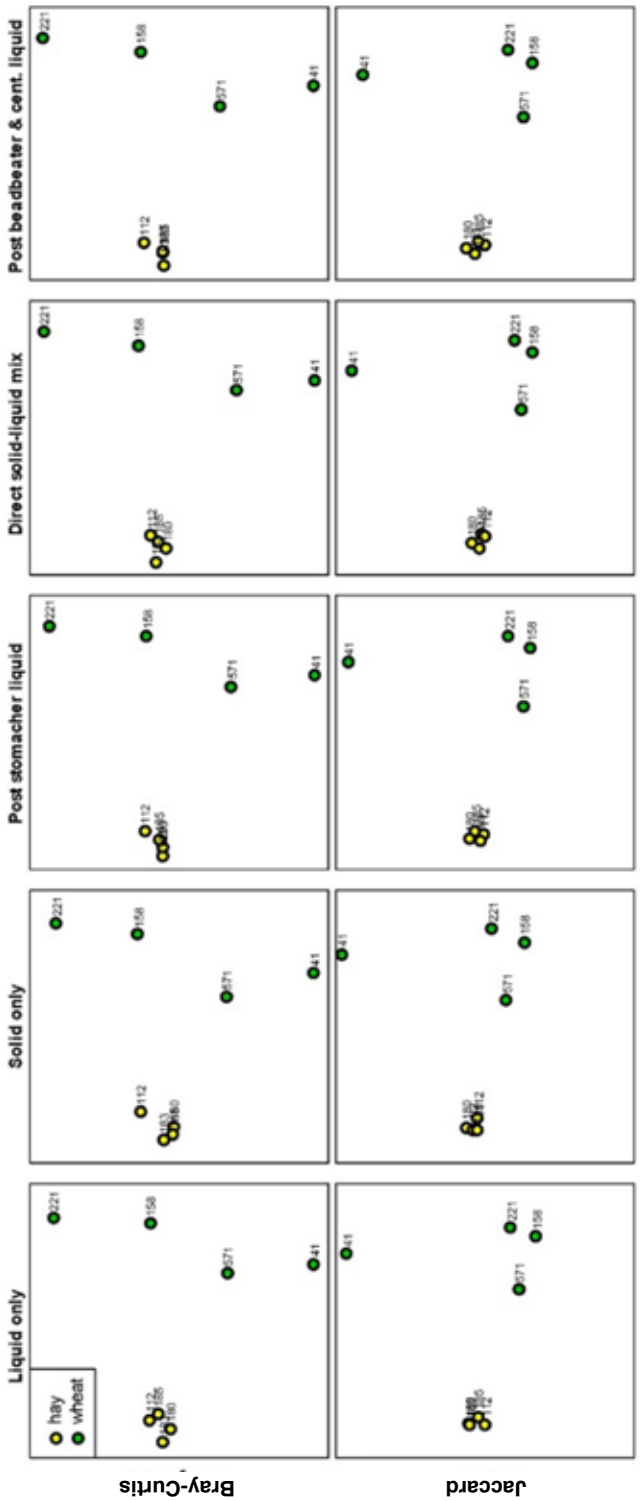

Fig. 2. Bray-Curtis and Jaccard distance matrices representing the beta diversity found between diets and samples. The Bray-Curtis coefficient considers community membership and structure, whereas the Jaccard coefficient only considers the community membership. Each numbered point represents a specific animal and the colors separate the hay- and wheat-fed animals. Across methods, the matrices are nearly identical reinforcing the inconsequential effects that the method has on the rumen microbiome.

1). Steers on hay diets had greater levels of diversity and richness when compared to steers on wheat diets, which is congruent with the results found by Pitta et al. (2010). When sample treatments were compared, there were no significant differences, keeping results neutral amid conflicting past results.

Distinct patterns in bacterial community structure and membership (beta diversity) were found between hay and wheat diets (Fig. 2). The wheat-fed steers had a much higher variability in comparison to the hay-fed steers. Comparison between methods showed insignificant differences between each treatment which is reflected by similar movements on the ordination plots. Using the mantel test, correlation statistics showed that each sample method in hay diets had a high correlation value at 0.8 and $P < 0.05$. Furthermore, the correlation measures found between methods in the hay diets were more variable, with the lowest correlation found between the solid-only and liquid-only fractions, however these results were insignificant ($P > 0.05$). In conclusion, the sampling methods did not produce any significant differences in rumen bacterial community structure or membership.

Conclusions

No consequential distinctions were made among the five sampling methods chosen to characterize the rumen microbiome. Due to the lack of differences found among fractionation methods, the direct method is the preferred choice. This method is the most user-friendly and time efficient, making it possible for researchers across multiple contexts, each with different time limitations, equipment, or financial barriers to achieve equivalent results. However, the importance of this study indicates that any of the above-mentioned fractionation methods can be used, depending on user preference, without the certainty of the results being compromised. One limitation may have been in the method of rumen collection, via the stomach tube, which is considered the liquid portion of rumen contents by some researchers. Future research utilizing rumen cannulation (withdrawal of rumen contents by directly inserting a tube to the cow's abdomen through to the rumen) and the comparison of sampling methods is needed to thoroughly understand the results of this study. This step towards universalizing sampling approaches used in the study of the rumen microbiome is important for researchers everywhere. This study and future considerations into the methods of rumen fractionation makes it possible for scientists with limitations in equipment, money, or time to use the rumen sampling method of choice, without sacrificing accurate results.

Acknowledgements

I would like to thank and acknowledge The Bumpers College of Agriculture, Food and Life Sciences for awarding me with the Bumpers College Undergraduate Research and Creative Project Grant. Support also provided by the University of Arkansas System Division of Agriculture.

Literature Cited

Bray, J.R. and J.T. Curtis. 1957. An Ordination of the Upland Forest Communities of Southern Wisconsin. Ecological Monographs. 27(4):325-349.

Brulc, J.M., D.A. Antonopoulos, M.E. Miller, M.K. Wilson, A.C. Yannarell, E.A. Dinsdale, R.E. Edwards, E.D. Frank, J.B. Emerson, P. Wacklin, P.M. Coutinho, and B.A. White. 2009. Gene-centric metagenomics of the fiber-adherent bovine rumen microbiome reveals forage specific glycoside hydrolases. Proc Natl Acad Sci USA. 106(6):1948-1953.

Cattlemen's Beef Board and National Cattlemen's Beef Association. 2017. Beef: Big Nutrient Power in a Small Package. BEEFnutrition.org. Accessed 23 January 2017. Available at: http://www.beefnutrition.org/beefnutrients.aspx

Chao, A. and T.-J. Shen. 2003. Nonparametric estimation of Shannon's index of diversity when there are unseen species in sample. Environ. Ecol. Stats. 10(4):429-443.

Cho, S.J., K.M. Cho, E.C. Shin, W.J. Lim, S.Y. Hong, B.R. Choi, R.C. Byoung, M.K. Jung, M.L. Sun, H.K. Yong, H. Kim, and H.D. Yun. 2006. 16S rDNA Analysis of Bacterial Diversity in Three Fractions of Cow Rumen. J. Microbiol. Biotech. 16(1):92-101.

de Menezes, A., E. Lewis, M. O'Donovan, B. O'Neill, N. Clipson, and E. Doyle. 2011. Microbiome analysis of dairy cows fed pasture or total mixed ration diets. Federation of European Microbiological Sciences. 78:256-265.

Dillivan, K. and J. Davis. 2014. Economic Benefits of the Livestock Industry. iGrow. Accessed 23 January 2017. Available at: http://igrow.org/livestock/profit-tips/economic-benefits-of-the-livestock-industry/

Firkins, J.L. and Z. Yu. 2015. Ruminant Nutrition Symposium: How to use data on the rumen microbiome to improve our understanding of ruminant nutrition. J. Anim. Sci. 93(4):1450-1470.

Fouts, D.E., S. Szpakowski, J. Purushe, M. Torralba, R.C. Waterman, M.D. MacNeil, L.J. Alexander, and K.E. Nelson. 2012. Next generation sequencing to define prokaryotic and fungal diversity in the bovine rumen. PLoS One. 7(11):e48289.

Hernandez-Sanabria, E., L.A. Goonewardene, Z. Wang, O.N. Durunna, S.S. Moore, and L.L. Guan. 2012. Impact of feed efficiency and diet on adaptive variations in the bacterial community in the rumen fluid of cattle. Appl. Environ. Microbiol. 78(4):1203-1214.

Ishler, V.A., A.J. Heinrichs, and G. Bánné Varga. 1996. From feed to milk: understanding rumen function. PennState Extension. Acessed 5 February 2017. Available at: http://extension.psu.edu/animals/dairy/nutrition/nutrition-and-feeding/rumen-function/from-feed-to-milk-understanding-rumen-function

Jami, E. and I. Mizrahi. 2012. Composition and similarity of bovine rumen microbiota across individual animals. PLoS One. 7(3): e33306.

Jewell, K.A., C.A. McCormick, C.L. Odt, P.J. Weimer, and G. Suen. 2015. Ruminal Bacterial Community Composition in Dairy Cows Is Dynamic over the Course of Two Lactations and Correlates with Feed Efficiency. Appl. Environ. Microbiol. 81(14):4697-4710.

Kong, Y.R. Teather, and R. Forster. 2010. Composition, spatial distribution, and diversity of the bacterial communities in the rumen of cows fed different forages. FEMS Microbiol. Ecol. 74(3):612-622.

Kozich, J.J., S.L. Westcott, N.T. Baxter, S.K. Highlander, and P.D. Schloss. 2013. Development of a dual-index sequencing strategy and curation pipeline for analyzing amplicon sequence data on the MiSeq Illumina sequencing platform. Appl. Environ. Microbiol. 79(17):5112-5120.

McCann, J.C., T.A. Wickersham, and J.J. Loor. 2014. High-throughput Methods Redefine the Rumen Microbiome and Its Relationship with Nutrition and Metabolism. Bioinform. Biol. Insights. 8:109-125.

National Cattlemen's Beef Association. 2016. Beef Industry Statistics. BEEF USA. Accessed 23 January 2017. Available at: http://www.beefusa.org/beefindustrystatistics.aspx

Pitta, D.W., E. Pinchak, S.E. Dowd, J. Osterstock, V. Gontcharova, E. Youn, K. Dorton, I. Yoon, B.R. Min, J.D. Fulford, T.A. Wickersham, and D.P. Malinowski. 2010. Rumen bacterial diversity dynamics associated with changing from bermudagrass hay to grazed winter wheat diets. Microbial Ecol. 59(3):511-522.

Regents of the University of Minnesota. 2017. Feeding the Dairy Herd: Ruminant Anatomy and Physiology. University of Minnesota Extension. Accessed 12 January 2017. Available at: https://www.extension.umn.edu/agriculture/dairy/feed-and-nutrition/feeding-the-dairy-herd/ruminant-anatomy-and-physiology.html

Schloss, P.D., S.L. Westcott, T. Ryabin, J.R. Hall, M. Hartmann, E.B. Hollister, R.A. Lesniewski, B.B. Oakley, D.H. Parks, C.J. Robinson, J.W. Sahl, and C.F. Weber. 2009. Introducing mothur: open-source, platform-independent, community-supported software for describing and comparing microbial communities. Appl. Environ. Microbiol. 75(23):7537-7541.

Tajima, K., R.I. Aminov, T. Nagamine, K. Ogata, M. Nakamura, H. Matsui, Y. and Benno. 1999. Rumen bacterial diversity as determined by sequence analysis of 16S rDNA libraries. FEMS Microbiol. Ecol. 29(2):159-169.

Ursell, L.K., J.L. Metcalf, L.W. Parfrey, and R. Knight. 2012. Defining the human microbiome. Nutr. Rev. 70(1):S38-S44.

Weimer, P.J. 2015. Redundancy, resilience, and host specificity of the ruminal microbiota: implications for engineering improved ruminal fermentations. Frontiers Microbiol. 6:296.

Wu, S., R.L. Baldwin, W. Li, C. Li, E.E. Connor, and W. Robert. 2012. The bacterial community composition of the bovine rumen detected using pyrosequencing of 16S rRNA genes. Metagenomics. 1:ID235571

Risk mitigation through diversified farm production strategies: the case in Northern Mozambique

Olivia C. Caillouet[*]*, Lawton L. Nalley*[†]*, and Amy L. Farmer*[§]

Abstract

Mozambique, like many other parts of the low-income world, faces perennial challenges with food security. With a rapidly growing population and arable land on the decline, sustainable agriculture is vital to managing the already depleted natural resources of Sub-Saharan Africa more effectively while increasing food security. Food security issues for subsistence farmers in most low-income countries are a product of endogenous (crop yields) and exogenous (currency fluctuations as many agricultural inputs are imported) factors. In Mozambique the value of the local currency, meticals, has decreased by approximately 50% since January 2015 compared to the U.S. dollar. While this makes exporting products out of Mozambique more attractive in a relative sense, it negatively effects those industries which rely on imported inputs such as animal feed and inorganic fertilizer. In response to this exogenous currency crisis, research was conducted in Nampula, Mozambique during the summer of 2016 on a method for implementing crop diversification to reduce the risk that accompanies the devaluation of the metical. This research was undertaken on a poultry operation which is heavily dependent on imported maize and soya. Similar to the market structure of the poultry industry in the United States, all birds are grown by individual out growers who typically also have small plots of land to farm. Objectives for the project included 1) perform on-site crop production evaluations, 2) determine profitability for various row crops, and 3) simulate alternative production practices to increase crop profitability. Of the crops grown (tomatoes, maize, and cabbage), maize required the least labor, lowest initial investment, and the highest probability of breaking even. This research concluded that if poultry producers in Mozambique who rely on imported feed grew maize simultaneously it would reduce the dependency on imported maize and reduce income variability associated with exogenous currency fluctuations. Implementing a program such as this could increase revenue streams as well as reduce variability, thereby enhancing regional food security.

[*] Olivia C. Caillouet is a December 2016 Honors program graduate with a major in Horticulture, Landscape, and Turf Sciences and minor in Foundations of Sustainability.
[†] Lawton L. Nalley, a faculty mentor, Associate Professor of Agricultural Economics and Agribusiness.
[§] Amy L. Farmer, a faculty mentor, University Professor in the Walton College of Business Department of Economics.

Meet the Student-Author

Olivia Caillouet

I am from Little Rock, Arkansas, and graduated with honors from Little Rock Central High in 2012. I graduated in December 2016 from the Dale Bumpers College of Agricultural, Food and Life Sciences with a degree in Horticulture and minor in Sustainability. This research was presented at the National American Society for Horticultural Science (ASHS) undergraduate oral paper competition in Atlanta, Georgia, August 2016 and at the International Society for Horticultural Science (ISHS) Conference in Montevideo, Uruguay November 2016.

During my time at the University of Arkansas, I have served as the Horticulture Club treasurer and vice president; worked as the Bentonville Farmer's Market Assistant Manager; completed an internship on a certified organic citrus farm in Big Sur, California; and was a summer intern at a farm in Adjuntas, Puerto Rico. I have also completed research at farms in Arkansas and Mozambique. I plan to pursue a Master's Degree in Agricultural and Extension Education, then embark upon my career focused on education outreach.

I would like to thank Dr. Lanier Nalley for his help and support throughout this research process. Dr. Amy Farmer was a crucial component to the success of this project, and without her it would not have been possible. I would also like to thank Dr. Dustan Clark for his insight while in Mozambique. Last, I would like to thank Dr. Wayne Mackay and the Department of Sustainability for allowing this project to serve as an interdisciplinary learning experience.

Introduction

Challenges for Mozambique

The Food and Agriculture Organization of the United Nations (FAO, 2007) described Mozambique's agriculture as strongly bipolar, split between 3.2 million small-scale farmers, producing 95% of agricultural gross domestic product (GDP), and about 400 commercial farmers producing the remaining 5%. The population of Mozambique is approximately 28 million (World Bank, 2016) with a reported poverty rate in the northern state of Nampula, where this study took place, between 50% and 70% (JICA, 2010). The National Profile of Working Conditions in Mozambique (ILO, 2009) reported that 40% of the employed population was involved in some part of the agriculture industry. Furthermore, employment in the agriculture sector was found to offer the lowest wages of all jobs accessed.

Poverty in Mozambique is also influenced by evolving climatic events. The 2015 and 2016 cropping seasons were some of the most drastic drought years recorded in sub-Saharan Africa. The Famine Early Warning Systems Network (FEWSN, 2016) reported that southern Africa was in the second year of drought related to the El Niño years of 2015 and 2016 and the drought was expected to increase as the 2016 year continued. Drought impacts coupled with the devaluation of the local currency, meticals (mets), has increased the risk for farmers in Northern Mozambique who produce goods that rely on rain and imported inputs, such as maize, soya, and poultry. According to CoinMill (2016), as of August 2016 the metical was at an exchange rate of 67 mets to $1, and the metical was predicted to continue to lose value.

With almost half of the working population in the agriculture sector, there is a need to increase production efficiency and profitability of crops to increase farm revenue and decrease farm revenue variance. Reducing yield variance can help both producers and consumers as consistent yields also provide consistent consumer prices. The Poverty Reduction Action Plan (PRAP, 2011) stated the solution to addressing poverty in Mozambique included:

1. increasing economic productivity through family farming,
2. promoting general employment, and
3. increasing human and social development.

There is a need for sustainable practices for feeding and employing the people of Northern Mozambique to promote economic growth and development. Sustainability is essential in this part of Mozambique; with the discovery of natural resources such as coal and natural gas, there has

been a recent influx of foreign direct investment (FDI) to extract said resources. On the surface, this FDI looks attractive as regional GDP increases but looking closer one finds signs of Dutch Disease where local economies are focusing only on extraction of resources and abandoning investment in traditional sectors of the economy (Corden, 1984). Moreover, while coal and natural gas can boost GDP, there is little taxation on these foreign firms and even less reinvestment (schooling, hospitals, etc.) into the local Mozambican communities. Problems such as this plague Sub-Saharan Africa. Thus, sustainable agricultural practices that do not rely on foreign investment and in fact protect against fluctuation (in the form of local currency fluctuations) were investigated.

Sustainability in Farming Production Practices

Mozambique has consistently struggled with macro-economic issues such as currency devaluation and continues to struggle with poor soils (due to lack of fertilizer), lack of rainfall (due to frequent droughts), and lack of agricultural inputs (due to currency devaluations). As such, sustainable agricultural programs are of utmost importance to combat the growing food insecurity issues in the face of climate change. Sustainability in agricultural systems incorporates concepts of resilience (capacity for systems to buffer shocks and stresses) and persistence (a system's ability to continue for extended periods of time) while taking into consideration social, economic, and environmental outcomes (Pretty, 2007). Furthermore, Smith (2013) explained that reduced income variability can be achieved by growing multiple crops which includes, but is not limited to, choosing crops with different growing seasons or maturity dates, mixing livestock and plant crops, and raising different types of livestock.

This research was conducted at New Horizons poultry farm where employees help diversify their risk by growing other crops, as poultry is inherently risky. That is, if a disease is to infect one bird there is a high likelihood that it infects all birds. These employees are termed "out growers" which are family operations that grow poultry to maturity then sell the birds to New Horizons in exchange for chick supply, poultry feed and support building grow houses. These poultry out growers also raise crops on the side to ensure their food security even if their poultry profits are marginalized by disease. Furthermore, New Horizons is pursuing contracts with out growers to produce maize on their farms instead of traditional crops such as cassava, beans, and sorghum because poultry feed mainly consists of maize and soya. The idea with out growers producing maize is that they would have a guaranteed market (New Horizons) and a guaranteed price to lock into, if they so choose. This would decrease revenue volatility as producers would not be subject to a fluctuating domestic market price, New Horizons would have a guaranteed supply of maize at a locked-in price that would not be subject to foreign exchange rates. This would appear to be mutually beneficial, but only under the context that out growers could produce enough maize to cover their input costs. Also, yield variability may pose profitability issues given the current drought in Sub-Saharan Africa and the fact that maize requires a relatively large amount of water.

Many low-income producers often prefer income stability over income maximization (Nalley and Barkley, 2010) and, as such, this study provides poultry producers in Mozambique an insurance tool through crop diversification that can smooth revenue from destabilizing exogenous factors such as currency devaluation. Implementing a program such as this aims to both increase total income as well as reduce income variability. Our results indicated that if small-scale poultry producers could simultaneously raise maize on small plots they could earn additional income and stabilize domestic prices of maize, which could increase food security as well as producer livelihoods.

The idea of vertical integration, poultry out growers selling maize to poultry feed mills in Mozambique, has the opportunity for a mutually beneficial realtionship. Poultry feed mills could reduce risk from volatile currency fluctuations which can drastically effect the price of imported maize. Poultry out growers could increase their revenue stream and simultaneously reduce variance by diversifying their income and locking in a price for maize before the growing season with a local feed mill. This research has provided a foundation for further study on the relationship between row crops (horticulture and agricultural row crops) and poultry production practices that take place in Northern Mozambique. The ability to research other row crops beyond maize could further diversify poultry producers cropping systems and could open up the ability to improve soil fertility through strategic crop rotations. Conservation crop rotation is a systematic sequence of crops grown in combination with grasses and legumes, which has been found to help maintain cropland sustainability (USDA, 1996). Nampula experiences high pest pressures in combination with poor, sandy soils that highlighted the need to incorporate crop rotations. Fewer problems with weeds, insects, and fungi have been linked to crop rotations, thus the need for fungicides, pesticides, or insecticides that are expensive and difficult to obtain could be reduced (USDA, 1996).

The research seeks to improve the economic sustainability of small-scale farm systems through reduced income variability and increased yields. Furthermore, this research aims to determine profitability of various row crops (tomatoes, maize, and cabbage) and to inform Mozambicans on practices to increase economic returns and reduce volatility.

Materials and Methods

This study was conducted in collaboration with New Horizons poultry farm in Nampula, Mozambique (15°04' 23.1"S 39°11'40.0"E) (Google, 2016). While New Horizons focuses on poultry production, its goal is to ensure a consistent supply of poultry. As such, New Horizons encourages out growers to have a crop farm as well as raise poultry.

To stabilize income for out growers and market prices for New Horizons, New Horizon out growers producing alternative crops were evaluated at Ebenezer Agriculture Apprentice Program (EAAP), an organization under the management of New Horizons Farm, aimed at teaching youth in the community practical farming techniques. Crops were evaluated by analyzing past data sets for:

1. yearly cost of crop production,
2. yearly crop yields, and
3. yearly market price of crops.

When data were not available, the estimated ranges were obtained for the three variables listed above through discussion with the farm manager as well as locals. The data were then entered into the structural framework for profitability to determine profitability of crops for producers (Fig. 1). This information was entered into a statistical program @Risk® (Palisade Corp., Ithaca, N.Y.), via a Monte Carlo simulation, where each crop was simulated 10,000 times to determine the outcome for profitability. For this study, risk is not solely defined as the probability of breaking even, but rather profit smoothing through diversification of agricultural production.

Tomatoes

Tomatoes have the potential to be profitable, but also pose several marketing and production problems. First, tomatoes require daily watering which has to be done by hand in Northern Mozambique as irrigation equipment is expensive. Second, given that tomatoes are a fresh product with no preservation methods (canning is not practiced in Northern Mozambique), price can be high one day (if you are the first to market) and low (almost free) the next as everyone in a community harvests and sells simultaneously. Our tomato data collection began with past yields from the 2015 season. There were 16 apprentices that worked field plots in 2015 and 2016 which provided spatial and temporal variation.

Tomato plots are typically watered by hand so drought conditions can be mitigated through hand irrigation. Plot sizes varied and were calculated in meters (m). Five apprentices managed (30 m × 15 m) plots and 11 apprentices managed (15 m × 15 m) plots in 2015. The yields from each plot in 2015 were gathered by weight, kilograms (kg). The 2016 growing season had the same production inputs as 2015, which included labor, seeds, fertilizer, fungicide, and insecticide (Table 1). The 2016 field plots were all (10 m × 10 m). The yields and production costs from 2015 were calibrated in @Risk® to equal that of a 10 m × 10 m plot. This kept uniformity in data sets and allowed for comparisons between years for grower percent profitability. The last step for tomato data collection was to determine the range for 2016 market price of tomatoes (Table 1). This was done by verbal communication with the farm manager. The 2015 yield data are represented by "A", on Fig. 2, while 2016 yields with a 50% increase in yields compared

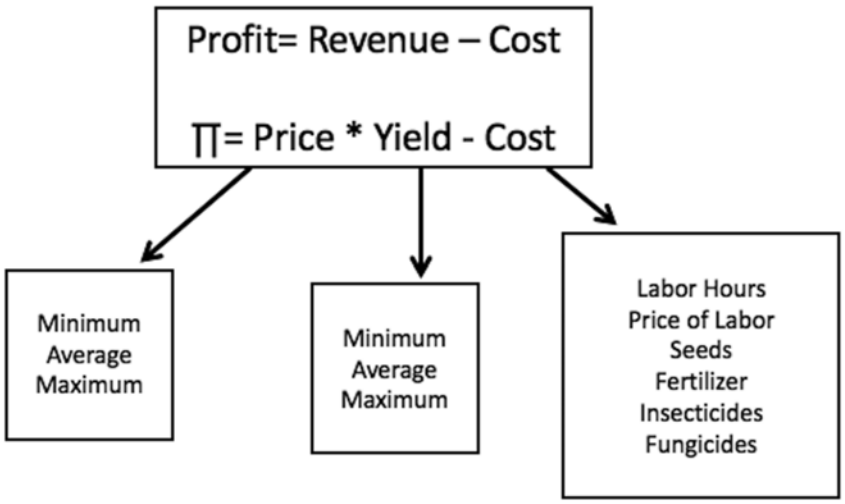

Fig. 1. Structural framework for profitability (Lawton Nalley, pers. comm. 2016). ∏= Profit.

to 2015 are "B". A 50% yield increase was determined for 2016 based on communication with the EAAP Farm Manager and the expectation of how increased apprentice education would also increase fruit production.

Maize

The cost of maize production included labor, seed, and urea fertilizer (Table 2). Maize production differed from other crops evaluated because yields and price of crops were based on number of cobs per plot during the first harvest (harvest 1) as well as dry maize sales collected in the second harvest (harvest 2) (Table 3). The range of cobs per plot was determined by the number of stalks per plot multiplied by either 1 cob per stalk (minimum) or 2 cobs per stalk (maximum) and then those values were used for the average. The yields were collected from 13 field plots (50 m × 50 m), which were all grown with the same production practices. The 2016 yield data are "A" on Fig. 3, while the future 2017 yields with a 30% decrease in market price are "B". All other factors remained the same for maize production in the structural framework equation (Fig. 1). Furthermore, the market price was reduced for the future

Table 1. Total cost range for all inputs for 17-week tomato production cycle of 10 m × 10 m plot and market prices, Nampula, Mozambique, 2016.

Range	Labor (mets[a])	Seeds (mets)	AN[b] fertilizer (mets)	N-P-K[c] fertilizer (mets)	Spray fertilizer (mets)	Fungicide (mets)	Insecticide (mets)	Total cost (mets)	Market price (mets/ kg)
Minimum	7650	900	278	325	452	105	144	9854	25
Average	9563	1125	464	541	452	105	144	12,394	40–60
Maximum	11,475	1350	928	1083	452	105	144	15,537	90–100

[a] Metical currency.
[b] Ammonium nitrate fertilizer.
[c] Nitrogen-Phosphorus-Potassium fertilizer.

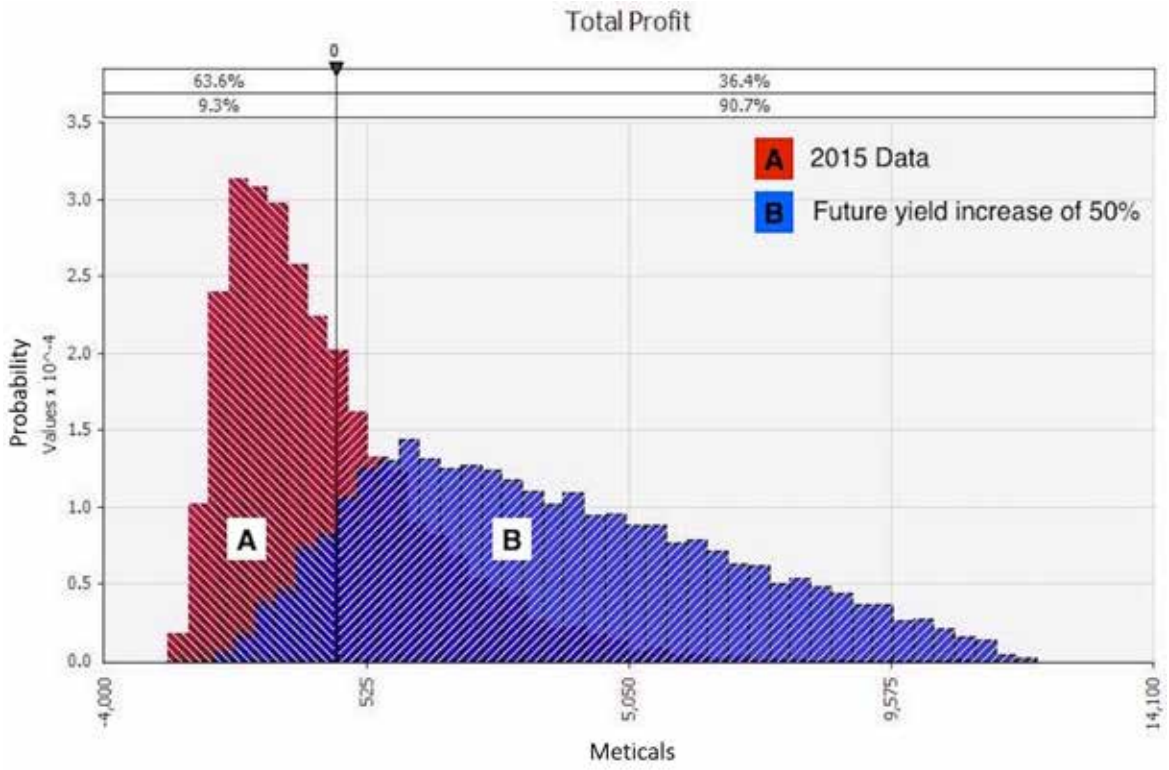

Fig. 2. Past and future profitability for tomatoes, Nampula, Mozambique, 2016. The percentages at the top of the figure represent the "A" data as having a 63.6% profit loss probability and 36.4% profit probability. The "B" data has a 9.3% profit loss probability and 90.7% profit probability. The vertical bar represents the point at or below where growers do not make a profit.

Table 2. Total cost range of maize production for 20-week maize production cycle of 50 m × 50 m plot, Nampula, Mozambique, 2016.

Range	Labor cost (mets[a])	Seed cost (mets)	Urea cost (mets)	Total cost (mets)
Minimum	4050	1080	7000	12,130
Average	6750	1080	7000	14,830
Maximum	9450	1080	7000	17,530

[a] Metical currency.

Table 3. Maize yields per 50-m × 50-m plot and total market price for yield, Nampula, Mozambique, 2016.

Range	Harvest 1 (Cobs[a])	Harvest 2 (kg[b])	Corn on the cob (mets[c]/ cob[d])	Dry maize (mets/ kg)	Total market price (mets)
Minimum	5346	98.5	3	5	16,530.5
Average	8019	450.5	3	15	38,833.5
Maximum	10,692	883	3	30	58,566

[a] Corn on the cob yields that were harvested March 2016.
[b] Kilograms of harvest 20 May 2016.
[c] Metical currency.
[d] Corn on the cob was sold in bags (100 cobs per 300 meticals).

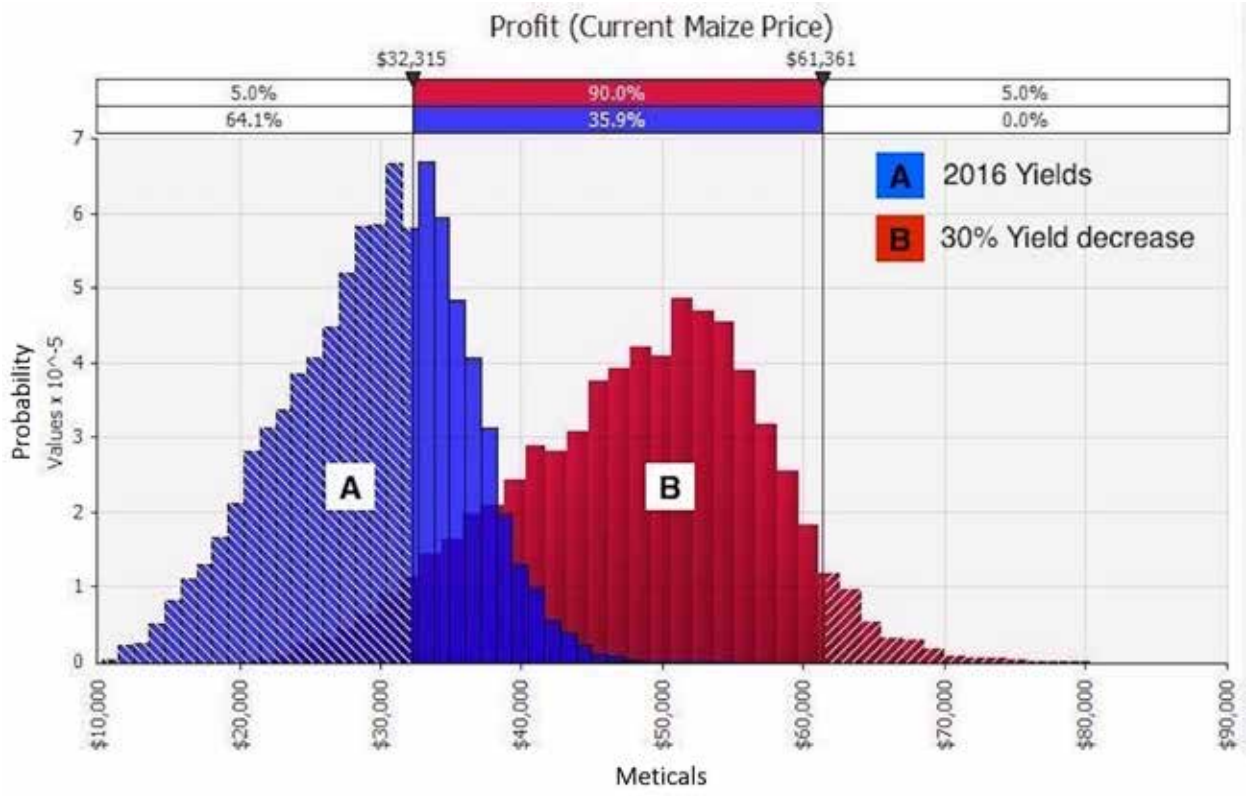

Fig. 3. Current maize yields and maize with 30% price decrease, Nampula, Mozambique, 2016. The percentages at the top of the figure represent "A" data as having a 64.1% probability of making 10,000-32,315 meticals (mets) and 0% probability of making 61,361-80,000 mets. The "B" data has a 5% probability of making 10,000-32,315 mets and 5% probability of making 61,361-80,000 mets. There is 35.9% probability that "A" will return between 32,315-61,361 mets, while "B" has 90% probability between 32,315-61,361 mets.

because it was not expected that the current maize price impacted by drought and limited supply would remain the same.

Cabbage

Cabbage plots were planted around the middle of March 2016 and were estimated to be harvested 13 June 2016, which totaled 13 weeks of production. Total cost of production included labor, seeds, fertilizer, and insecticide (Table 4). This was the first year for cabbage to be grown at EAAP and, as such no past data were available. However, estimated price ranges for cabbage at Nampula markets was verbally collected from locals. In addition, based on observations in the field, the range for crop yields was determined. Costs were determined for hand watering practices versus the use of drip irrigation, which reduced the cost of labor, to determine if investing in irrigation supplies had minimal risk.

Results and Discussion

Tomatoes

The results for tomatoes used the data collected during the statistical analysis through @Risk®. The 2015 data are represented by the letter "A" and the estimated 2016 yields are shown by "B" (Fig. 2). The black vertical line on Figs. 3 and 5 represents the breakeven point where below (to the left of) producers lose money. The 2015 data set on Fig. 2 are high in probability (*y* axis) which represents that growers were more likely not to make a profit than 2016 yields. We estimated that in 2015, growers lost money 64% of the time and lost an average of -182 mets per 10 m × 10 m plot (Fig. 2). It is worth noting that 2015 yields were said to have been low. In addition, the local market was flooded by another tomato producer. The term "flooded" refers to oversupply, which can decrease demand and the market price of crops.

The 2016 yields are a simulation that predicts what profitability could look like for growers if 1) the market were not flooded, and 2) yields per plot were increased by 50% (min., avg., and max.). Agricultural teachers at the EAAP indicated they thought their students were capable of increasing their tomato yields by 50% with more training. Although Fig. 2 shows a larger variance in profitability, the risk is upside not downside risk. That is, with the chance of yielding more (but keeping the floor constant) the overall risk variance increases but only positive risk (to the right on the figure) which indicates making more money. If tomato yields could be increased by 50% moving into the future and the market were to not be flooded, growers could go from making a profit 36% of the time to 91% of the time. Furthermore, average profits would increase from -182 mets to 3696 mets per plot. These results inform growers that in the past tomatoes have not been a crop with high profitability, but if several changes were made to the production cycle, tomatoes could be a viable crop to grow in the future (Fig. 2).

Maize

Maize production was found to require the least inputs as well as the lowest up-front investment for the cropping cycle, both attributes that are attractive to low-income farmers. However, Bundy (1998) states that maize uses substantial amounts of nitrogen (N), phosphate (P_2O_5), and potash (K_2O). Furthermore, the nutrients taken up by the plant must be supplied by the soil reserves or by adding nutrients and a deficiency of any nutrients may reduce yields (Bundy, 1998).

Using the information that was collected as described in the materials and methods section, the results for 2016 yields and future crop profitability, with 30% market price decrease, were determined in @Risk®. Due to the ability to rely on rain-fed irrigation, the cost of production is lessened because of the reduction in labor needed for hand watering. While maize has profitability benefits when compared to tomato and cabbage, it is not expected that these benefits will sustain if maize is grown continuously. Roth (1996) states that crop rotations contribute enhancements in yields, soil physical properties related to plant growth and is essential to the control of crop-disease problems.

Table 4. Total cost for all inputs for 13-week cabbage production cycle of 10 m × 10 m plot and market prices, Nampula, Mozambique, 2016.

Range	Labor (mets[a])	Seeds (mets)	N-P-K[b] fertilizer (mets)	Spray fertilizer (mets)	Insecticide (mets)	Total cost (mets)	Market price (mets/ 1 cabbage)
Minimum	4388	900	302	452	144	6186	20
Average	6581	1125	806	452	144	9108	40
Maximum	8775	1350	1915	452	144	12,636	60

[a] Metical currency.

[b] Nitrogen-Phosphorus-Potassium fertilizer.

The letter "A" represents 2016 yields where growers were found to make a profit 100% of the time (Fig. 3). Profits for 2016 came with an average of approximately 48,190 mets per plot. These results may be misleading as in 2015 and into 2016 there was a drought across the entire continent of Africa which increased the demand for maize as well as the market price. It is not anticipated that the 2016 price for maize will remain at this level as the drought subsides and producers react to market prices. So, a simulation was conducted in @Risk® where the price for maize was decreased by 30%, to mimic a larger regional maize supply, while all other factors of production remained the same.

The data set with the letter "B" on Fig. 3 represents the future profitability of growers with the price of maize decreased by 30%. It was estimated that growers still made a profit 100% of the time. However, growers would go from making an estimated 48,190 mets per plot to 29,460 mets per plot. These results ensured that given past data yields and future anticipations for 30% price decrease, maize is a crop that is in high demand with limited risk for growers (Fig. 3). Again, it should be noted that being profitable 100% of the time is not feasible, these data suggest this under two important assumptions. First, all maize farmers have gone to a technical school to learn how to grow maize. This includes access to fertilizer, disease diagnosis, etc. Second, there is ample rainfall/water supply to make a crop. When working with New Horizons the first assumption (schooling) will be provided, but the second assumption is not dependable and our results would most likely change if we had a more robust dataset.

Cabbage

During 2016 was the first year that EAAP grew cabbage. Therefore, the profitability analysis was completed without past yield data sets. Using @Risk®, the percentage of time growers would make a profit was determined with and without the use of drip irrigation. It is important to determine if cabbage could be more profitable with drip irrigation prior to making the financial investment to obtain the necessary equipment. This analysis took into consideration the ranges for cost of production, estimated yields as well as market price per head of cabbage. The "A" data set on Fig. 4 represents the outcome if growers were to continue hand watering without the use of an irrigation system. With the practice of hand watering growers lost money 37% of the time and had an average income of 724 mets

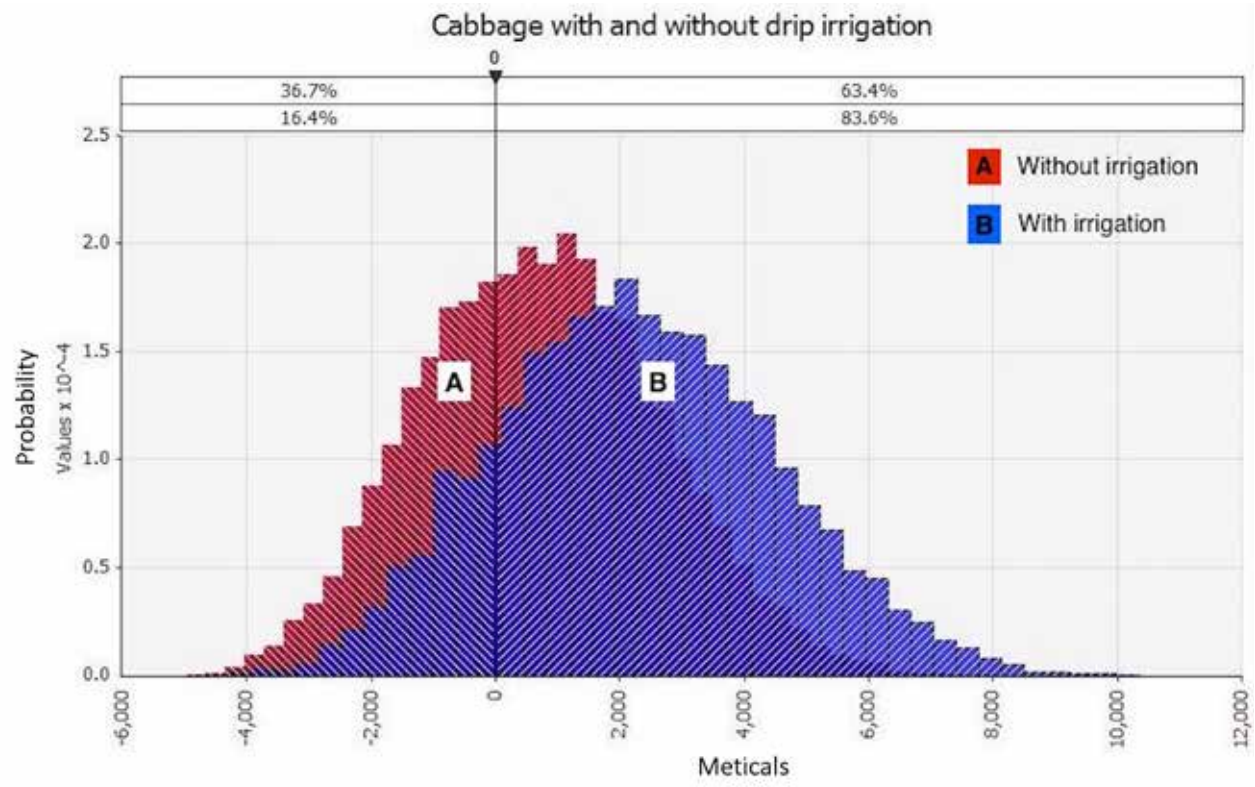

Fig. 4. Predicted cabbage yields with and without drip irrigation, Nampula, Mozambique, 2016. The percentages at the top of the figure represent the "A" data as having a 36.7% profit loss probability and 63.4% profit probability. The "B" data has a 16.4% profit loss probability and 83.6% profit probability. The vertical bar represents the point at or below where growers do not make a profit.

per plot. While the average profit of 724 mets is greater than zero, it is misleading because without irrigation, over one-third of the growers were losing money.

The "B" data set on Fig. 4 represents the outcome if growers were to implement a form of drip irrigation. Drip irrigation is a specific type of irrigation system that is either above or below ground and is a more resource-conservative form of applying water to the base of plants. The use of this technique would avail the opportunity to grow crops during the dry season when hand watering is not an option. The demand for the crop would be greater in the dry season, while the market price of the crop would have also increased. Growers could go from making a profit 63% of the time without irrigation, to 84% with irrigation. This increase in the percentage of crops making a profit is related to shifting the timing of production which increased demand, market price, and reduced cost of labor. Drip irrigation decreased the amount of time spent by workers to water plants by hand and thus reduced the total cost of inputs.

For this analysis the cost of the drip irrigation was not taken into consideration, because it was seen as a "sunk cost". The term "sunk cost" refers to the concept that over time the cost of the irrigation would be negligible. This simulation represented that if growers were to implement the horticultural technique of irrigation, it would increase the percentage that growers would make a profit. These results confirmed that risk could be reduced with a shift in production practices (Fig. 4).

Conclusions

These areas for future research would further enable poultry growers in Mozambique to increase farm productivity through row crop diversification, provide jobs, and address human and social development issues outlined by PRAP. The results of this study are important on several levels. First, it appears that maize can be the most profitable to small-scale producers out of the three crops evaluated in Northern Mozambique. Second, via the @Risk® simulation, it also appears that maize production provided a stable source of income (high percentage of breaking even) which is important for food security, stable food prices, and producer livelihoods. Last, maize production by small-scale producers can benefit the up-and-coming poultry industry in Mozambique which has provided much needed inexpensive protein, in the form of eggs and meat, via reduced maize price through a mechanism not subject to foreign currency fluctuations.

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Literature Cited

Bundy, L.G. 1998. Corn fertilization. University of Wisconsin Extension. Accessed 27 June 2017. Available at: http:www.soils.wisc.edu/extension/pubs/A3340.pdf

CoinMill. 2016. Metical to U.S. dollar value. Accessed 10 October 2016. Available at: http:www.coinmill.com/MZN_USD.html

Corden, W.M. 1984. Booming sector and Dutch disease economics: Survey and consolidation. Oxford Economic Papers. 36(3):359-380.

FAO. 2007. Food and Agriculture Organization of the United Nations. Accessed 10 October 2016. Available at: http:www.fao.org/reliefoperations

FEWSN. 2016. Famine Early Warning Systems Network. Accessed 17 October 2016. Available at: http:www.fews.net

Google. 2016. Google maps. Accessed 26 April 2017. Available at: http:www.google.com/maps/place/15%C2%B004'23.1%22S+39%C2%B011'40.0%22E/@-15.0730781,39.1922557,17z/data=!3m1!4b1!4m5!3m4!1s0x0:0x0!8m2!3d-15.0730833!4d39.1944444

ILO. 2009. International Labor Organization. National profile of working conditions in Mozambique. Accessed 17 October 2016. Available at: http:www.ilo.org/wcmsp5/groups/public/@ed_protect/@protrav/@travail/documents/publication/wcms_119345.pdf

JICA. 2010. Japan International Cooperation Agency. Republic of Mozambique study for poverty profile (Africa) final report. Accessed 12 October 2016. Available at: http:www.jica.go.jp/activities/issues/poverty/profile/pdf/moz_02.pdf

Nalley, L. and A. Barkley. 2010. Using portfolio theory to enhance wheat yield stability in low-income nations: An application in Yaqui Valley of northwestern Mexico. J. Agric. Resource Econ. 35(2):334–347.

PRAP. 2011. Poverty Reduction Action Plan. Republic of Mozambique: Poverty reduction strategy paper. Int. Monetary Fund. Accessed 11 October 2016. Available at:

http:www.imf.org/external/pubs/ft/scr/2011/cr11132.pdf

Pretty, J. 2007. Agriculture sustainability: Concepts, principles and evidence. Philosophical transactions of the Royal Society. 363:447-465.

Roth, G. 1996. Crop rotations and conservation tillage. Pennsylvania State University Cooperative Extension. Accessed 27 June 2017. Available at: http:www.extension.psu.edu/plants/crops/soil-management/conservation-tillage/crop-rotations-and-conservation-tillage/extension_publication_file

Smith, N. 2013. Southern agricultural production risk issue. Risk education publication series. Accessed 13 October 2016. Available at: http:www.uaex.edu/publications/pdf/srme04fs.pdf

USDA. 1996. United States Department of Agriculture. Conservation crop rotation effects on soil quality. Accessed 29 June 2017. Available at: http:www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053269.pdf

World Bank. 2016. Accessed 13 October 2016. Available at: http:www.worldbank.org/en/country/mozambique

Exploring the abilities of 3-D printing and its viability for consumption in the fashion industry

Laura C. Corral[*]*, Kaitlyn J. Walker*[†]*, and Stephanie K. Hubert*[§]

Abstract

The fashion industry encounters its most general difficulties regarding cost of samples, lead time, sustainability, and fit. An emerging technology that could solve these issues is 3-D printing, which utilizes computer-aided technology and a variety of filaments to construct an object. Though 3-D printing technology offers the ability for rapid prototyping, a condensed supply chain by way of creating samples domestically rather than internationally, and a sustainable additive manufacturing process that results in manufacturing with zero excess material, there is question as to whether consumers are ready for 3-D printed clothing to enter their wardrobes. The purpose of this study was to construct a 3-D-printed garment and measure consumer response to the application of this technology to ready-to-wear clothing. Wearability was achieved with the 3-D-printed garment, meaning it mirrors a traditional ready-to-wear garment. The survey instrument measured three factors: perception of 3-D printing, fashion interest, and opinions of the 3-D-printed project garment. Data were analyzed using a *t*-test for male versus female responses and descriptive statistical methods were utilized to report means and compare responses on the three factors from each age group and ethnicity. Overall the responses for all three factors were positive. The results of this research indicate that a major transformation in ready-to-wear style is feasible and beneficial to the apparel industry because of 3-D printing.

[*] Laura C. Corral is an honors program May 2017 graduate with majors in Apparel Merchandising & Product Development and German, and a minor in International Business.

[†] Kaitlyn J. Walker is an honors program May 2017 graduate with a major in Apparel Merchandising & Product Development and a minor in Marketing.

[§] Stephanie K. Hubert, the faculty mentor, is an Instructor in the Apparel Merchandising & Product Development program within the School of Human Environmental Sciences.

Meet the Student-Authors

Laura Corral

I was born in Cincinnati, Ohio and moved around quite a bit after that, but have been settled in Fayetteville, Arkansas for the past 14 years. I graduated from Fayetteville High School in 2013. I began my education at the University of Arkansas by taking advanced German classes on campus my senior year of high school. Since then, I have pursued a double major in Apparel Merchandising and Product Development (AMPD) and German, and a minor in International Business. I have been awarded Bumpers Honors College and Honors College grants to fund my research and to help bring 3D printers to the AMPD program. Through this research, I was able to travel to San Francisco to meet fashion technology leaders and learn about the direction in which fashion is going. I am interested in pursuing sustainable fashion in a global market and am thankful for the mentorship of Ms. Stephanie Hubert in encouraging me to pursue a sustainability-linked research topic. I would like to recognize Dr. Mahendran Balasubramanian in contributing to the statistical analysis in my research. I would also like to thank my honors thesis committee for their assistance in this research: Dr. Kathy Smith, Mr. Lance Cheramie, and Dr. Laurie Apple. This research could not have been completed without their guidance and without the support from the Dale Bumpers College and the University of Arkansas.

Kaitlyn Walker

I am from Plano, Texas and graduated with honors from Plano Senior High School in 2013. I chose the University of Arkansas for its well-rounded Apparel Merchandising and Product Development program, studying all facets of the apparel and retail industries along with my Marketing minor. My ultimate dream is to be self-employed and sell my own designs. I graduated with honors in May 2017 and look forward to beginning my career in fashion design or product development. During my time at the U of A, I was a member of Phi Upsilon Omicron honor society, an appointed officer for Kappa Delta sorority, a member of the Association of Apparel Merchandising and Product Development, and participated in the Walmart Mentor Circle through the AMPD program.

I am thankful to Dr. Leslie Edgar for allowing me to join the Bumpers College Honors Program as a junior. During my senior year I was excited to take part in this creative study on 3D printing for a fashion application. This project taught me about design exploration in a rising technology that could have a great impact on my industry and my interests in innovative design and sustainability. I would like to thank my mentor, Stephanie Hubert, for encouraging me to join the Honors Program and bring this exciting field of study to our department and for her hands-on approach in assisting my project partner and me throughout this research. I would also like to recognize Dr. Mahendran Balasubramanian for the considerable time and energy he volunteered to the data collection and interpretation portion of this project. I would like to thank my honors thesis committee for their support and encouragement of this project: Dr. Kathy Smith, Lance Cheramie, and Dr. Laurie Apple. Lastly, a big thank you to my student research partner Laura Corral.

Introduction

With the ever-evolving state of today's technology, designers and retailers in the apparel industry are seeking out new technological methods to revolutionize and individualize their brand as well as meet consumer needs and preferences. An emerging technology is 3-D printing, which utilizes computer-aided technology, filaments, and heated extruders to create an object from a computerized vector drawing. The technology of 3-D printing has been referred to as the "third industrial revolution" because of its potential to dramatically shorten the supply chain, utilize sustainable additive manufacturing techniques, and maximize customization possibilities through inexpensive rapid prototyping (Markillie, 2012; Istook, 2000; The United States Congress, 2014).

Designers have already begun exploring the capabilities of 3-D printing for jewelry, footwear, and clothing (Vanderploeg et al., 2016). A pioneer in this area is Iris van Herpen, who has utilized 3-D printing in her haute couture collections since 2010 (Howarth, 2013). While her collections show the artistic and avant-garde expressions of 3-D printing for fashion, designer Danit Peleg has completed collections created solely from household 3-D printers (Peleg, n.d.). Peleg's more wearable garments reflect the possibility that this medium for clothing production could supplant traditional fabric garments and reduce waste. However, there is question as to whether or not consumers are ready for 3-D-printed clothing to enter their wardrobes. Research in this area of consumer preference toward 3-D printing for fashion has not been conducted. This study aims to test the authors' prediction that consumers will have a positive perception of 3-D printing being integrated into ready-to-wear clothing.

Materials and Methods

To create a 3-D-printed textile for garment assembly, several repeatable square tiles were designed using the 3-D building freeware 123D-Design (Fig. 1). To test each tile's strength and repeatability, prototyping was conducted on the Raise 3-D N2 and N2 Plus 3-D printers, first in polylactic acid (PLA) and then in thermoplastic polyurethane (TPU). The PLA was useful for quick prototyping as a low-cost hard plastic filament, and TPU was chosen as the final print material due to its flexibility and rubber-like properties. The final tile was then repeated at a half-step pattern to create a single sheet of textile, and 13 sheets in total were printed measuring 206.375 mm long by 206.375 mm wide by 0.9 mm high (Fig. 2). These sheets were then combined using JB Weld Plastic Bonding Glue to create a full piece of 'fabric', which allowed for cutting out the flat pattern pieces (Fig. 3). The pattern pieces were then assembled into a top using the welding glue, and TPU filament was used to

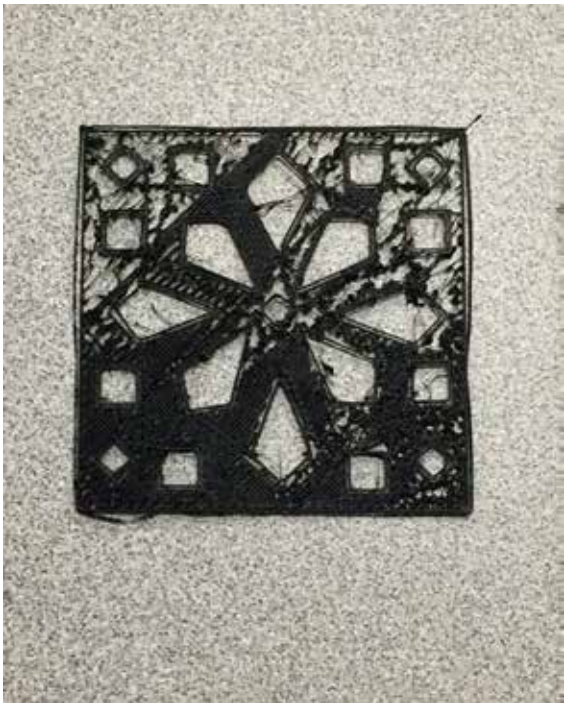


Fig. 1. Final tile designed by the authors, printed in thermoplastic polyurethane (TPU) filament.

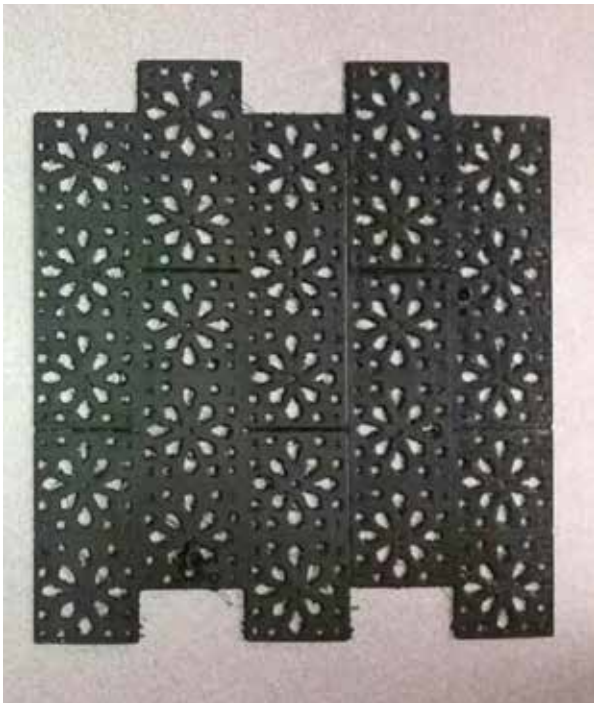


Fig. 2. Sheet of 3-D printed textile in thermoplastic polyurethane (TPU) filament.

lace up the side seams, which served as the closure for the garment. No traditional stitches were used in creating the garment.

To test the viability of 3-D-printed clothing in the apparel marketplace, a 36-question 5-point Likert scale survey was created to measure consumer response to the project garment and was administered on the University of Arkansas campus (with two days in the Student Union and one day in an introductory apparel course). The 3-D-printed garment was displayed on a mannequin for the subjects to examine as they completed the survey.

The survey data were tested for sample adequacy and significance before conducting a factor analysis. The number of respondents was 116 (sample size, N = 116) and the number of survey questions was 36. To test for sample adequacy and significance of the variables, the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity were used, respectively. The KMO results showed the sampling adequacy as 0.718, which satisfied the criterion of being greater than 0.7 and therefore met sample adequacy. In addition, the Bartlett's test of sphericity was reported at <0.001, which is less than the alpha of 0.05, thereby meeting significance. All tests were performed using SPSS 23.0 (SPSS Inc., Chicago, Ill.).

A factor analysis was run to divide the 36 survey questions into groups to assist with the data analysis. The factor analysis divided the questions into three groups: prior exposure to 3-D printing, innovative fashion interest, and opinions of the aesthetics of the 3-D-printed project garment. Each factor was then tested for reliability using Cronbach's Alpha test and a total of 25 out of 36 questions were retained within the factors to ensure the strength of each group of questions. Data were entered into MS-Excel spreadsheets and divided into the three factors, and a mean score was calculated for each respondent based on their response to each item within the factors. The data were then organized based on gender, and a *t*-test with unequal variances was conducted to test whether there was a significant difference in responses between male and female respondents for each factor. In conducting the *t*-test, a *P*-value of 0.05 or less was used to indicate a significant difference in gender response. Additional descriptive statistics were utilized from the data means to illustrate the range in responses received from various ethnic and age groups. These demographic questions sought to understand what ethnic groups and age ranges were participating in the survey. The ethnic groups reported were American Indian (0.86%), Asian (3.45%), Black (14.66%), Hispanic

Fig. 3. The authors assemble 3-D printed top with welding glue.

(11.21%), White (62.93%), and Other (6.03%). Age ranges reported were 18–20 (52.59%), 21–25 (35.34%), 26–30 (6.03%), 31–35 (3.45%), 36–40 (0.86%), 41–50 (0%), and 51+ (1.72%). These ranges were chosen based on the authors' general understanding of the youthful demographic makeup of the University of Arkansas campus.

Results and Discussion

3-D Printed Top

The final 3-D-printed garment achieved the project goal of wearability (Fig. 4). The design allows it to look very similar to a traditional fabric top made of lace, and some respondents even likened the TPU to leather when given the opportunity to leave additional comments on the survey. Additionally, the flexibility of the TPU allowed for the garment to have slight drape and it fit the body well with dart shaping.

The intent of this research was to create a wearable garment from a 3-D printer, so from the beginning the goal was to supplant the typical garment construction process with 3-D printing processes. Using the 3-D printing method, there are benefits offered by the technology of which the authors did not take full advantage: reduced waste and more inventive construction techniques. It seems that for the potential of 3-D printing to truly be recognized, the whole process of designing the garment from textile to construction must be overhauled. In addition, though TPU provided several tactile benefits during construction of the garment, this material has many limitations when compared to the fabrics customers recognize today. Most notably, the finished garment in TPU still has a mostly rigid and plastic tactile property, although on average the survey respondents found the texture to be smooth and the garment likely somewhat comfortable to wear. Further research is needed to explore alternative materials for creating wearable garments. The usability of these materials depends on the design of the garment and the ability of the 3-D printer to work with them, as not all printers can print with all materials. As 3-D printing technology improves, print materials could be designed to match current fabric and fiber properties more closely.

There are also some important considerations that the apparel industry should take in adopting 3-D technologies. For one, 3-D printing offers a sustainable solution to waste in the apparel industry by being an additive manufacturing process. Designers and manufacturers should research the abilities of 3-D printing to create a garment with zero waste; whereas this study applied subtractive manufacturing clothing production techniques in cutting out pattern pieces from a larger textile and, therefore, created waste from the scrap pieces of material. In addition, 3-D printing also offers the opportunity for a dramatically decreased lead time. Studying the effects of a condensed supply chain with minimal to no sample lead time will provide the industry more insight into how 3-D printing could affect jobs

Fig. 4. Final 3-D printed top.

and logistics. Lastly, further research is warranted into the possibility of mass customization through the adoption of 3-D printers for manufacturing and home use, and how that can revolutionize the way consumers shop at retailers.

Survey

The authors' prediction that consumers will have a positive perception of 3-D printing being integrated into ready-to-wear clothing was supported by the data. Based on the overall average for all the three variables, the subjects showed:

1. High interest in and a positive perception of 3-D printing,
2. High interest in innovative fashion, and
3. A positive opinion on the aesthetics of the garment created by the authors.

The sample size for this project allowed for a *t*-test assuming unequal variances on the gender demographic. The results of the *t*-test between male (31% of sample) and female (69% of sample) respondents showed a significant difference (*P*-value = 0.003) in the responses for the second factor: innovative fashion interest. On a scale of 1–5, female average response was 3.68 and male average response was 3.16. A total average for innovative fashion interest was 3.52, signifying that there is fashion interest in the sample. Since the data from this study show that women reported a higher interest in innovative fashions than did men, the authors suggest further integration of 3-D printing into women's apparel first as this segment may be more willing to try new technologies and innovations in their clothing, according to the results from the survey data. In comparing means, there was not a significant difference in response between the ethnic groups nor between age ranges. This could be due to the homogenous nature of the age demographic data reported: 87.93% of the respondents were in the 18–25 age range. No meaningful data can be reported based on those demographics. Averages for each factor are shown in Fig. 5.

Conclusions

The results present evidence that 3-D printing can be used to create a wearable garment and consumers, on average and overall, are interested in its potential and would like to see further application of this technology in fashion. Because the results of this study show 3-D printing to be a technology that consumers are ready to start seeing regularly, future research should be conducted to measure consumer preference and design wearable garments. Future research, however, should gather a larger pool of responses by having a longer survey time and diversify survey response by expanding the sample population outside of a university campus. Additionally, with the large positive impact that this technology could have on sustainability, dramatically decreased lead times, and mass customization, future research should explore the total effects and integrations of utilizing new 3-D processes to test fully the viability of the apparel industry adopting this technology on a wider scale.

Acknowledgments

This project was funded by grants from the University of Arkansas Honors College and Dale Bumpers College

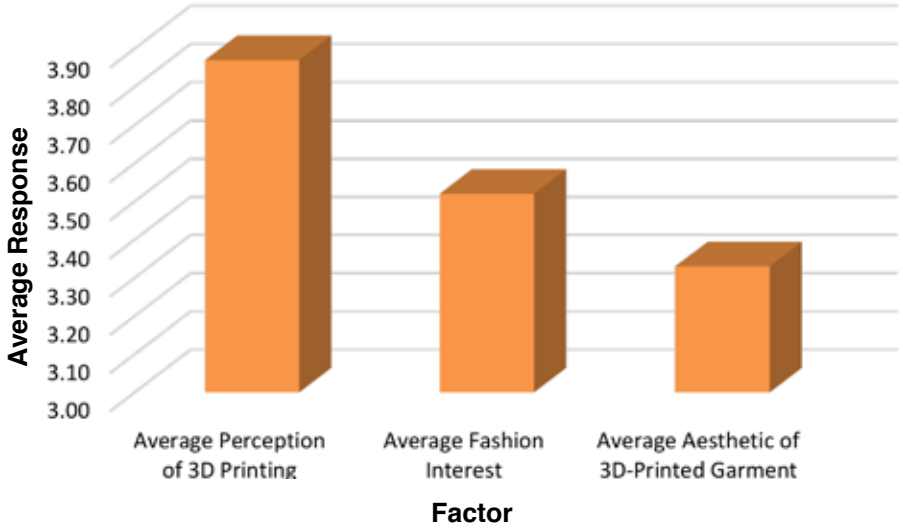


Fig. 5. Graph depicting average survey responses based on 5-point Likert scale (n = 116).

of Agricultural, Food, and Life Sciences Honors program. Support also provided by the University of Arkansas System Division of Agriculture.

Literature Cited

Howarth, D. 2013, April 24. Iris van Herpen print shift interview. Accessed March 2016. Available at: https://www.dezeen.com/2013/04/24/iris-van-herpen-interview/

Istook, B. 2000. 3-D printing: The new industrial revolution. J. Textile Apparel, Technol. Mngmnt. 1(1). Accessed April 2016. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.125.598&rep=rep1&type=pdf

Markillie, P. 2012, April 21. A third industrial revolution. The Economist. Accessed March 2017. Available at: http://www.economist.com/node/21552901

Peleg, D. n.d. About Danit Peleg. Danit Peleg 3D Printed Fashion. Accessed February 2017. Available at: http://danitpeleg.com/about-danit-peleg/

The United States Congress. 2014. The Rise of 3D Printing: Opportunities for Entrepreneurs: Hearing before the Committee on Small Business, House of Representatives, 113th Cong. 1. Accessed April 2016. Available at: https://www.gpo.gov/fdsys/pkg/CHRG-113hhrg87278/pdf/CHRG-113hhrg87278.pdf

Vanderploeg, A., S. Lee, and M. Mamp. 2016. The application of 3D printing technology in the fashion industry. Int. J. Fash. Des. Technol. Educ. Accessed April 2016. Available at: http://www.academia.edu/28069917/The_application_of_3D_printing_technology_in_the_fashion_industry

Cost-benefit analysis of a genetic marker on cow-calf operations differentiated by pasture and breed

Josh C. Crystal*, Michael P. Popp†, Nathan P. Kemper§, and Charles F. Rosenkrans Jr.‡

Abstract

Genetic sequencing in beef cattle (*Bos taurus* L.) is expected to aid producers with selecting breeding stock. Using data from experimental trials conducted with Angus, Brahman, and their reciprocal cross, the single nucleotide polymorphism (SNP) P450 C994G marker expression was investigated for use in selecting genetics suited to grazing endophyte-infected tall fescue (*Festuca arundinacea Schreb.* L.) compared to bermudagrass (*Cynodon dactylon* L.) pasture. The study is unique in the sense that actual cow-calf breeding failure rates (open cows were not culled) were tracked from 1991 to 1997 on herds that were bred to calf in spring and were either exposed to fungal endophyte-infected (*Acremonium coenophialum* L.) tall fescue grazing and hay or not. The study used the Forage and Cattle Analysis and Planning (FORCAP) decision support software to assess economic performance driven by birth weight, weaning weight, and breeding failure rate differences across treatment. Results suggest that for reciprocal cross herds primarily grazing bermudagrass pastures, the P450 C994C genotype (*CC*) was most favorable; whereas, the P450 G994C genotype (*GC*) was more profitable with tall fescue. Adding genetic market information when selecting a production strategy led to approximately $15/head in added profitability. In comparison to the prorated cost of $2.40/head over the life of a dam, the collection, interpretation, and management of genetic information under the conditions observed in this study may be worthwhile.

* Josh C. Crystal is an May 2017 honors program graduate from the Department of Agricultural Economics and Agribusiness.
† Michael P. Popp, the faculty mentor, is a Professor in the Department of Agricultural Economics and Agribusiness.
§ Nathan P. Kemper is an instructor in the Department of Agricultural Economics and Agribusiness.
‡ Charles F. Rosenkrans, Jr. is a Professor in the Department of Animal Science.

Meet the Student-Author

Josh Crystal

I was born and raised in a very small town near Tulsa, Oklahoma, and graduated from Liberty High School in 2013. Growing up, my family raised whitetail deer, which initiated my interest in agriculture. I first made my way to Arkansas on a golf scholarship at John Brown University in Siloam Springs. After two years, I decided to transfer to the University of Arkansas to return to my farming roots and pursue an agricultural career. During this time, I completed an internship with J.B. Hunt, while also working at Lowe's and for a local veteran. I graduated with honors from Dale Bumpers College of Agriculture with a B.S. in Agricultural Business in May 2017. This fall, I will be pursuing a Master of Business Administration degree through John Brown University's graduate program in Little Rock, Arkansas.

I would like to thank my mentor, Dr. M. Popp, for his relentless effort and guidance while I completed my thesis. I would also like to thank Dr. Rosenkrans and Dr. Kemper for their valuable input and serving on my committee. Most importantly, I give all the glory to God, for without Him, nothing is possible.

Introduction

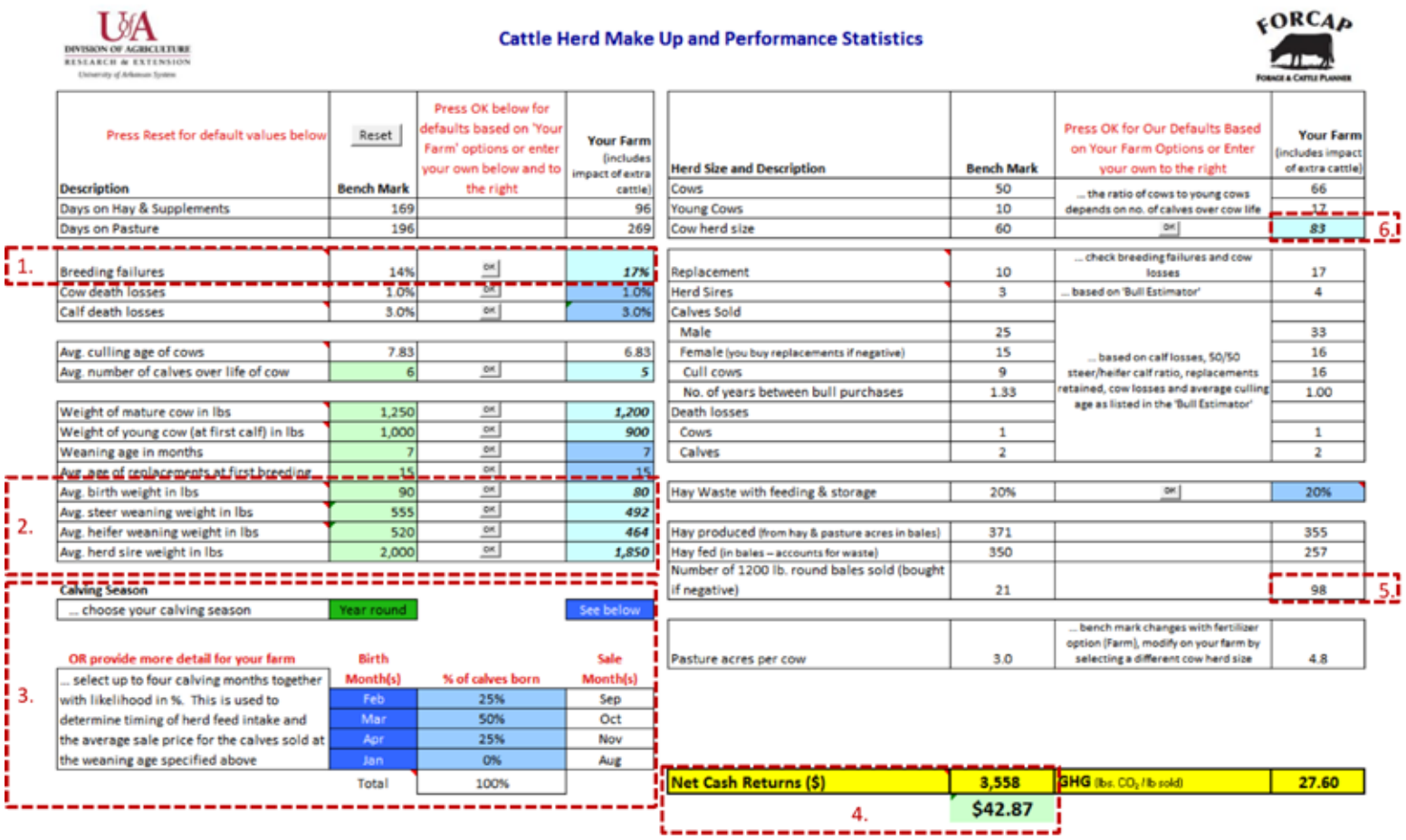
The economics of beef cattle production at the cow-calf level is very much dependent on proper breeding stock selection. Ranchers crossing cattle of different breeds to exploit hybrid vigor, typically select for calving ease with low birth weight and high weaning weight for added revenue potential. However, genetic selection for lower breeding failure rate to enhance herd profitability is more difficult; hence, using genetic markers may be needed. By documenting genetic markers that make up different phenotypes of cattle as expressed by their expected progeny difference (EPD)—which distinguishes cattle of a certain breed to a relative moving average annual baseline standard either within or across breeds for a host of performance statistics (Kuehn and Thallman, 2016a,b)— farmers can make informed choices involving the genetic makeup of their herd. Keeton et al. (2014) used decision support software called the Forage and Cattle Analysis and Planning (FORCAP; Popp et al., 2013) as a tool to evaluate breeds on the basis of EPDs. Choosing genetic marker information, however, is expected to be a more precise method of developing consistent herd and feedlot performance (Brown et al., 2010; Looper et al., 2010; Rosenkrans et al., 2010; Sales et al., 2011a,b; Thompson et al., 2014). Whether such decisions are potentially profitable at the cow-calf level, has not been analyzed to a great extent to date especially when dealing with fescue toxicosis occurring in endophyte-infected tall fescue (E^+) pastures (Caldwell et al., 2013; Smith et al., 2012; Johnson et al., 2015).

The objective of this project was to assess whether genetic marker inofrmation would benefit cow-calf operations when they compare the relative profitability of: i) E^+ vs. bermudagrass (*BG*) pasture management strategies; ii) the interaction of pasture management with breed selection of purebred Angus, purebred Brahman or their reciprocal cross to measure the effect of breed selection on pasture utilization; and iii) the interaction of pasture management × breed × genetic marker information.

Materials and Methods

As described in Brown et al. (1997), purebred Angus, purebred Brahman and their reciprocal cross dams were bred to Hereford sires with data on spring calves available from 1991 to 1997 under central Arkansas growing conditions. Animals were placed on either E^+ or *BG* pastures and fed hay of similar type. To eliminate sire effects, herd sires were rotated across treatments in 13-d intervals throughout the 75-d breeding period. Lifetime breeding failure rates (BFR) are defined as:

$$\text{BFR} = 1 - \frac{\text{\# of calves born}}{\text{\# of times the cow was bred}} \qquad \textit{Eq. 1}$$



Cattle Herd Make Up and Performance Statistics

Press Reset for default values below	Reset	Press OK below for defaults based on 'Your Farm' options or enter your own below and to the right	Your Farm (includes impact of extra cattle)
Description	**Bench Mark**		
Days on Hay & Supplements	169		96
Days on Pasture	196		269
1. Breeding failures	14%	OK	*17%*
Cow death losses	1.0%	OK	1.0%
Calf death losses	3.0%	OK	3.0%
Avg. culling age of cows	7.83		6.83
Avg. number of calves over life of cow	6	OK	*5*
Weight of mature cow in lbs	1,250	OK	*1,200*
Weight of young cow (at first calf) in lbs	1,000	OK	*900*
Weaning age in months	7	OK	7
Avg. age of replacements at first breeding	15	OK	15
2. Avg. birth weight in lbs	90	OK	*80*
Avg. steer weaning weight in lbs	555	OK	*492*
Avg. heifer weaning weight in lbs	520	OK	*464*
Avg. herd sire weight in lbs	2,000	OK	*1,850*

Calving Season		
... choose your calving season	Year round	See below

3. OR provide more detail for your farm ... select up to four calving months together with likelihood in %. This is used to determine timing of herd feed intake and the average sale price for the calves sold at the weaning age specified above	Birth Month(s)	% of calves born	Sale Month(s)
	Feb	25%	Sep
	Mar	50%	Oct
	Apr	25%	Nov
	Jan	0%	Aug
	Total	100%	

Herd Size and Description	Bench Mark	Press OK for Our Defaults Based on Your Farm Options or Enter your own to the right	Your Farm (includes impact of extra cattle)
Cows	50	... the ratio of cows to young cows depends on no. of calves over cow life	66
Young Cows	10		17
Cow herd size	60	OK	*83* 6.
Replacement	10	... check breeding failures and cow losses	17
Herd Sires	3	... based on 'Bull Estimator'	4
Calves Sold			
Male	25	... based on calf losses, 50/50 steer/heifer calf ratio, replacements retained, cow losses and average culling age as listed in the 'Bull Estimator'	33
Female (you buy replacements if negative)	15		16
Cull cows	9		16
No. of years between bull purchases	1.33		1.00
Death losses			
Cows	1		1
Calves	2		2
Hay Waste with feeding & storage	20%	OK	20%
Hay produced (from hay & pasture acres in bales)	371		355
Hay fed (in bales – accounts for waste)	350		257
Number of 1200 lb. round bales sold (bought if negative)	21		98 5.
Pasture acres per cow	3.0	... bench mark changes with fertilizer option (Farm), modify on your farm by selecting a different cow herd size	4.8
Net Cash Returns ($)	3,558	**GHG** (lbs. CO_2 / lb sold)	27.60
4.	$42.87		

Note: Ignore the bench mark farm information and focus on the Your Farm information that is tailored to a particular cow deemed representative of the herd continuously grazing on 400 acres of pasture and hay supplies met using 125 acres of hay land. Adjusted for each cow were, (1) breeding failure rate (*BFR* defined in Eq. 1) to estimate herd performance if all cows had a specific genetic marker of the experimental cow, (2) birth (*BW*)and weaning weights (*WW205*) observed after 7 months on pasture, (3) modal calving month for the cow to reflect potential for seasonal price fluctuation, (4) estimated farm level net cash returns defined as cattle and excess hay (5) revenue less cash expenses for feed, fertilizer, veterinary and medicine, fuel, twine, repair and maintenance, and operating interest that are divided by number of cows (6) exposed to the herd sires. Results shown pertain to an operation using *E*$^+$ pastures and associated average *BFR, BW,* and *WW205* as reported in Table 3 for the most commonly observed March calving month. The average reported in Table 3 does not match given effects of averaging over changes in calving month, *BW* and *WW205,* and rounding to nearest calf sales with *BFR*. Unit conversions: 1 ha = 2.4711 acres, 1 lb = 0.4536 kg.

Fig. 1. Sample cattle input interface in the Forage and Cattle Analysis and Planning (FORCAP) program.

In addition to BFR, birth weights, sex of calves and 205-d weaning weight data, calving month, and genetic marker information on the dam were available to perform economic analysis in FORCAP (Fig. 1) to estimate net cash returns per cow (*NR*) holding other operating parameters constant (as summarized in Table 1). As such, *NR* are the revenue from the sale of cattle and excess hay less cash expenses for feed; fertilizer; veterinary and medicine; fuel; repair and maintenance; twine; and operating interest as a measure of relative profitability across individual animals. Further, it is assumed that the performance of a cow could be replicated for a cow with the same genetic marker, breed, and pasture management and thus extrapolated to herd performance of 83 continuously grazing cows, which is a herd size deemed adequate for a farmer to consider obtaining genetic marker information using 125 acres of hay and 400 acres of pasture. Ten-year averages were used for prices of cattle and fertilizer to remove potential distortion of profitability due to cyclically high or low prices. Seasonality in prices was captured by modifying the calving month and using weaning weight-dependent sales prices for the attendant sale months (USDA-AMS, 2017) for cattle of different weight (Table 1). Cattle prices were deflated to 2016 dollars using U.S. All Beef Cattle prices (USDA-NASS, 2017a); whereas a fertilizer price index was used on fertilizer price (USDA-NASS, 2017b). Finally cost of production estimates for fuel, twine, and other inputs were obtained from local sources and reflect cost conditions faced by beef producers in 2016.

Calculated estimates of cow profitability were then regressed against explanatory factors involving genetic marker information, breed, pasture forage, *BFR*, birth, and weaning weight variables and select interactions to assess their relative economic impact:

$$NR = a_0 + a_1 \cdot E^+ + a_2 \cdot ANGUS + a_3 \cdot BRAHMAN + a_4 \cdot BFR + a_5 \cdot BW + a_6 \cdot WW205 + a_7 \cdot GC + a_8 \cdot GG + a_9 \cdot E^+ \times ANGUS + a_{10} \cdot BFR \times E^+ + a_{11} \cdot BFR \times ANGUS + a_{12} \cdot BFR \times BRAHMAN + a_{13} \cdot BFR \times GC + a_{14} \cdot BFR \times GG \quad \text{Eq. 2}$$

where E^+ is a binary 0/1 variable to observe fescue toxicosis effects ($E^+ = 1$) or alternatively using *BG* without toxins ($E^+ = 0$), *ANGUS* or *BRAHMAN* are similar binary variables indicating breed, *GC* and *GG* indicate the presence or absence of P450 G994C (*GC*) or P450 G994G (*GG*) marker expressions, *BW* and *WW205* are the average birthweight and adjusted 205-d weaning weights of calves born over the life of the cow, respectively. The baseline cow is a reciprocal cross with a P450 C994C (*CC*) marker expression on *BG* pasture and hay as those observations were most frequent. Both *BW* and *WW205* were added as they are key statistics in bull EPDs.

Differences in regression estimates of *NR* across pasture forage, breed, and genetic marker were compared rather than the calculated average of FORCAP-based *NR* as some pasture × breed × marker combinations had very few observations. For example, estimated profitability of the *BG* pasture system with reciprocal cross cattle and the *CC* marker was:

$$NR_{BG,Cross,CC} = a_0 + a_4 \cdot \overline{BFR}_{BG,Cross,CC} + a_5 \cdot \overline{\mathrm{BW}}_{BG,Cross,CC} + a_6 \cdot \overline{\mathrm{WW205}}_{BG,Cross,CC} \quad \text{Eq. 3}$$

where the *a*'s are coefficient estimates from Eq. 2 and $\overline{BFR}$, $\overline{BW}$, and $\overline{WW205}$ are averages from observations pertaining to *BG* pastures for reciprocal cross cattle with the *CC* marker. Changing to E^+ pastures for cattle of the same breed and marker, the applicable additional coefficients, a_1 and a_{10} were used with averages for *BFR*, *BW*, and *WW205* for cattle on E^+. To allow comparisons of *NR* across pasture and pasture × breed, equality of means tests were performed using Welch's F-test.

To have a cow tested for genetic markers, a hair sample can be collected at nearly no cost or a blood sample is estimated to cost $3/head. An additional cost of $8/head is needed for testing. Adding administrative overhead of $1/head, a $12/head cost was prorated over the life of the cow (5 y on average in this study). Profitability gains with breeding stock selection based on breed × pasture × genetic markers compared to breed and breed × pasture selection, thus, needed to exceed $2.40/head for a cow-calf operator to entertain collecting this information.

Results and Discussion

Sales et al. (2011b) focused on the genetic sequence labeled as P450 C994G to determine resistance to E^+ effects on reproductive performance and weight gain in offspring. Economically, drawbacks of E^+ in cattle performance are offset by drought tolerance and persistence of E^+ compared to other non-toxic, cool season grasses which affect feeding and pasture maintenance costs. To combat fescue toxicosis, producers can, for example, seed their pastures to *BG*—free of toxin and heat tolerant—at the cost of added hay feeding when cool season fescue would normally offer grazing opportunities for pasture-fed beef cattle.

This tradeoff is demonstrated at observed average cattle performance statistics for the E^+ and *BG* systems by the wide dark bars in Fig. 2. Using FORCAP, an E^+ system requires 96 d of hay feeding in comparison to 187 d for *BG* pastures in study conditions described above. Hence, using *BG* leads to more hay feeding but also no E^+.

To shed further light on individual cow performance data, regression results for Eq. 2 are shown in Table 2 with the frequency distribution of observations by treatment

Table 1. Prices and costs used by Forage and Cattle Analysis and Planning (FORCAP) decision support software.

Item and Description	Unit	Price	Item and Description	Unit	Price
Livestock			Feed		
4 - 500 lb. steers[†]	$/cwt	170.62	Hay delivered/sold FOB – 5 ft x 5 ft (1,200 lbs)	$/bale	60.00
5 - 600 lb. steers	$/cwt	153.48	Salt & minerals (50-lb bag)	$/bag	20.00
6 - 700 lb. steers	$/cwt	142.41	Fertilizer		
7 - 800 lb. steers	$/cwt	136.83	Lime	$/ton	33.10
3 - 400 lb. heifers	$/cwt	146.13	Ammonium nitrate (34-0-0)	$/ton	338.64
4 - 500 lb. heifers	$/cwt	135.48	Poultry litter (3-2-3)	$/ton	18.74
5 - 600 lb. heifers	$/cwt	129.15	Application cost per acre	$/acre	4.61
6 - 700 lb. heifers	$/cwt	125.76	Fuel Use & Other Miscellaneous		
Cull cow[‡]	$/cwt	64.35	Amortized pasture/hay maintenance & establishment[¶]	$/acre	14.00
Purchase price of breeding bull	$/head	2000			
Cull bull[§]	$/cwt	80.77	Fuel use for mowing, raking, and staging	gal/acre	4.50
Beef check off, ins. & yardage	$/head	1.00	Fuel use per day for feeding	gal/83 cows/day	1.19
Sales commission (% of sales)	%	3.50	Fuel use per day for checking cattle	gal	1.00
Veterinary Services Charges			Fuel cost	$/gal	1.70
Prolapse	$/head	75	Twine	$/bale	1.00
Caesarian section	$/head	225	Cost for farm vehicle ($/head/month)	$	1.00
Sick treatment (avg. drug charge)	$/head	15	Capital recovery rate[#]	%	5.00
Bull soundness	$/head	30	Operating interest[††]	%	4.75

Notes: Unit conversions needed 1 ha = 2.4711 acres, 1 gal = 3.78 L, 1 ton = 2000 lb, 1 lb = 0.4536 kg, 1 cwt = 100 lbs = 45.36kg

[†] State average, medium and large frame No. 1 prices (USDA-AMS, 2017). A ten-year average was used for sale months that were split across several marketing months with a specific calving distribution and depended on weaning age. Shown are the sale prices for cattle when selecting a user-specified calving season with 25% of calves born in February and April, and 50% born in March. Prices were deflated using average US beef cattle prices. Further, calf prices are linearly interpolated across weight categories to adjust for specific sale weight.

[‡] 75-80% Lean Breaking Utility.

[§] Yield Grade 1-2, 1000 to 2100 lbs.

[¶] Based on 10-year life of stand and standard seedbed preparation and weed control expenses.

[#] Capital recovery rate is used for estimating ownership charges on equipment and buildings and is also used for the opportunity cost of investment in breeding stock.

[††] Charged on half the cash operating expenses incurred per year to reflect likely operating credit line expense.

shown in Table 3. Coefficients were of the expected sign and adjusted R^2 suggested that misspecification was not an issue. Further, coefficient estimates were statistically significant and justified estimation of profitability by pasture × breed × marker combination. Table 3 summarizes calculated FORCAP profitability differences by pasture and pasture × breed, as well as estimated profitability differences by pasture × breed × marker.

As shown in Table 3 and Fig. 3, when comparing E^+ to *BG* forage systems with the average weights and average *BFR*, E^+ forage systems outperform the *BG* system. Given the presence of fescue toxicosis, this is puzzling unless considering the E^+ forage systems' advantage of lesser hay feeding in comparison to *BG* (Fig. 2). If a producer were thus interested in managing fescue toxicosis using the *BG* system and paid no attention to breed or genetic markers, his or her choice would be to pursue an E^+ system even though the ANOVA equality of means test showed no statistically significant differences ($P = 0.31$).

If the producer now adds breed selection to his or her repertoire of decision-making, then the optimal solution is to have E^+ forage with reciprocal cross cattle (Fig. 3B) with

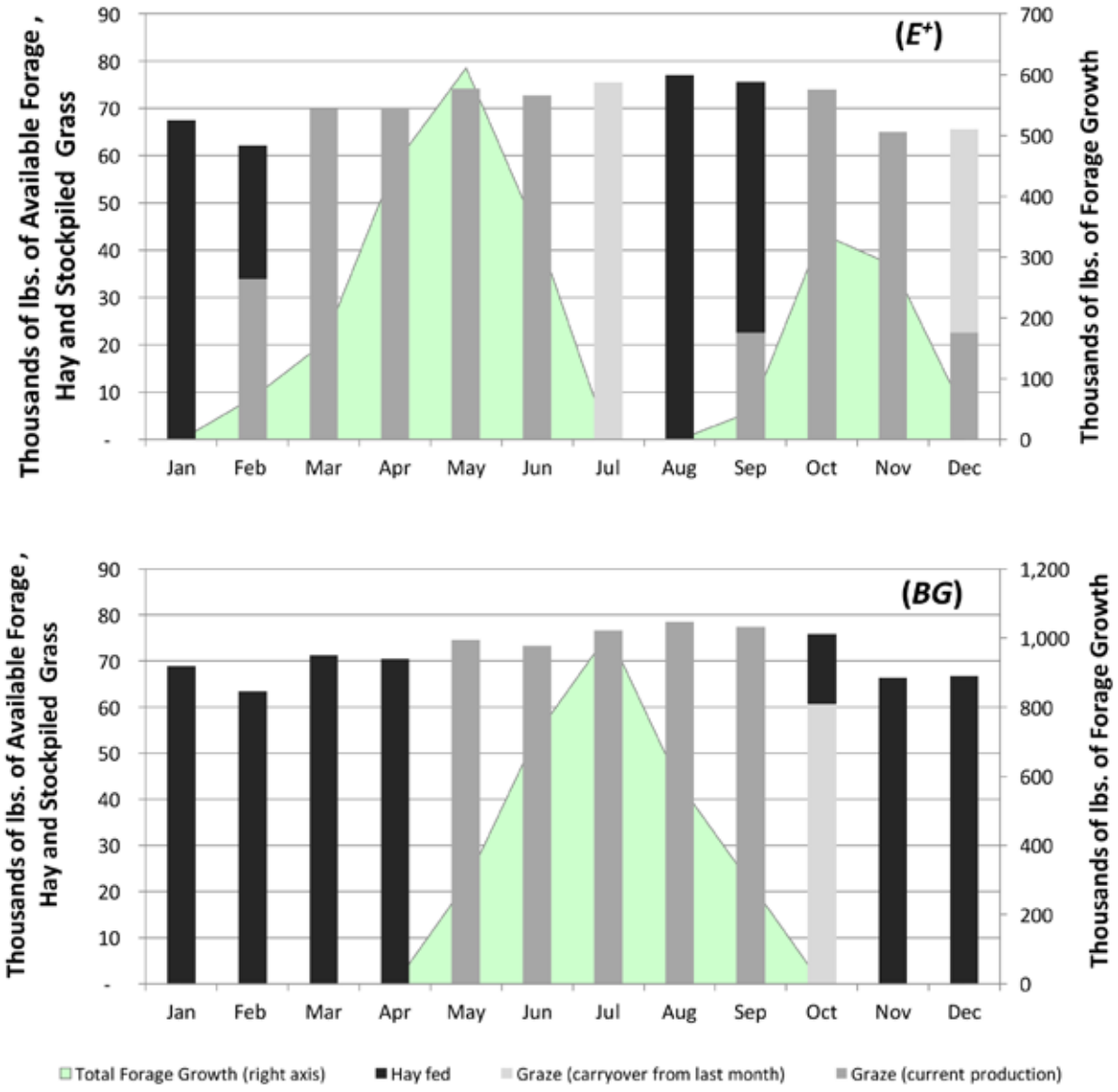


Fig. 2. Forage Balance for Fescue (E^+) vs. Bermudagrass (*BG*) Pasture Systems as modeled in the Forage and Cattle Analysis and Planning program (FORCAP). Note: Height of bars represents total herd intake requirements. Unit conversion: 1000 lb = 453.6 kg.

hybrid vigor. Angus tend to have lower *BFR* while Brahman deliver higher *WW205* with the reciprocal crosses excelling on both fronts regardless of pasture forage (Table 3). Note that on *BG* systems, weaning weights are higher in the absence of fescue toxicosis. This adds costly hay feeding, and higher weight calves also lead to lower price per 100 lb (cwt) (Table 1). A *BG* × *BRAHMAN* strategy in particular, showed negative cash returns not only because of hay feeding but also high *BFR*. Adding breed information compared to only using pasture system information led to higher returns. Reciprocal cross cattle on E^+ had the highest *NR* at $169.64/head.

Adding genetic marker information on E^+, the optimal solution was to have the *GC* genotype in reciprocal crossed cattle resulting in an estimated *NR* of $184.99/head (Table 3). Negligible *BFR* in conjunction with highest *WW205* when compared to the *GG* genotype that had the same *BFR* showed that lighter *WW205* led to lower cattle revenue. Both the *GG* and *GC* genotypes showed lower *BFR* than the *CC* genotype leading to greater estimated *NR*. Similar to pasture × breed-based results above, the *BG* system was inferior to the E^+ system as higher *WW205* across all markers were not sufficient to offset costs associated with elevated *BFR* with *BG* compared to E^+. Cows with the *CC* genotype performed best on *BG* pastures. This suggested the P450 C994G marker indeed is associated with cattle ability to deal with E^+.

Noteworthy, and not taken into consideration, is the future fate of calves in feedlots starting at lower *WW205* due to their exposure to E^+ pastures. Nonetheless, adding marker information allowed the producer to gain approximately $15 per head per year ($184.99/head with E^+, *Cross*, *GC* vs. $169.64/head on E^+, *Cross*) which is approximately six times the cost of obtaining the added informa-

Table 2. Multivariate regression statistics for forage production, breed, and marker effects.

Variable		Coefficient (Std. Error)	T-Statistic
Constant	a_0	119.79 (43.14)*** †	2.78
E^+ ‡	a_1	3.39 (9.61)	0.35
ANGUS	a_2	-57.65 (13.00)***	-4.44
BRAHMAN	a_3	2.49 (11.37)	0.22
BFR	a_4	-808.88 (44.41)***	-18.21
BW	a_5	1.11 (0.43)**	2.58
WW205	a_6	-0.06 (0.08)	-0.80
GC	a_7	4.25 (8.46)	0.50
GG	a_8	-5.53 (12.03)	-0.46
E^+ × *ANGUS*	a_9	50.10 (13.77)***	-3.64
BFR × E^+	a_{10}	-156.72 (29.40)**	5.33
BFR × *ANGUS*	a_{11}	144.77 (50.70)***	2.86
BFR × *BRAHMAN*	a_{12}	-53.04 (47.67)**	-1.11
BFR × *GC*	a_{13}	35.06 (32.05)	1.09
BFR × *GG*	a_{14}	105.98 (53.25)*	1.99
R^2		97.65%	
Adj. R^2		97.19%	
# of obs.		86	

Notes:

† * < 0.1, ** <0.05, and *** <0.001 level of significance.

‡ Dependent variable is individual cow profitability in $/head as estimated in Forage and Cattle Analysis and Planning (FORCAP). E^+ is a binary (0/1) variable and represents the presence of endophyte-infected tall fescue as feed source on pasture and from hay. *ANGUS*, *BRAHMAN*, *GC*, and *GG* are also binary variables indicating presence = 1 or absence = 0 of breed and genetic marker *P450 GC* and *P450 GG*, respectively. *BFR*, *BW*, and *WW205* are cow specific average 1991–1997 performance statistics related to breeding failure rate, average birth and weaning weight, respectively. The baseline scenario reflects a bermudagrass (BG) pasture system devoid of fescue toxicosis using reciprocal cross cattle with the *P450 CC* genetic marker expression.

tion. The results are therefore similar to Thompson et al.'s (2014) findings and add to information already reported by Looper et al. (2010) and Sales et al. (2011 a,b).

For future research, a mixed pasture system consisting of both *BG* and E^+ pastures would make an interesting third alternative as that pasture forage species mix is common in many pastures. Further, had genetic marker information been collected on the calves, weaning weight differences could have been analyzed for their effect. Finally, had calves been tracked through the feedlot stage, an overall economic performance to slaughter would have been possible and may favor the *BG* system.

Conclusions

For cow-calf operations using breeds of Angus and Brahman grazing on E^+ or *BG* pastures, the results suggested that the genetic marker analyzed would allow producers to enhance their operation's profitability in comparison to a strategy selection based only on forage type and breed.

Table 3. Observed and predicted profitability in $/head by pasture, breed, and marker effects.

	# of obs.	FORCAP Profitability[†]	Avg. of Explanatory Variables[‡]			Est. Profitability[§]
Description		**($/head)**	***BW***	***BFR***	***WW205***	**($/head)**
E^+[¶]	37	$54.56	79.7	16.5%	477.5	na[§]
BG	49	$19.54	79.8	17.8%	546.4	na
E^+ × *ANGUS*	10	-$6.71	79.2	18.9%	386.3	na
E^+ × *CROSS*	15	$169.64	81.8	2.2%	522.8	na
E^+ × *BRAHMAN*	12	-$38.24	77.5	32.5%	496.9	na
BG × *ANGUS*	14	$49.83	83.2	12.1%	488.4	na
BG × *CROSS*	19	$119.57	78.1	6.8%	571.6	na
BG × *BRAHMAN*	16	-$125.73	78.9	35.9%	567.3	na
E^+ × *ANGUS* × *CC*	3	$61.87	75.0	4.7%	377.0	$52.46
E^+ × *ANGUS* × *GC*	5	-$61.04	81.8	30.0%	395.0	-$54.81
E^+ × *ANGUS* × *GG*	2	$26.27	79.0	12.5%	378.5	$24.81
E^+ × *CROSS* × *CC*	7	$157.64	83.6	4.7%	529.4	$153.52
E^+ × *CROSS* × *GC*	6	$187.82	80.3	0.0%	528.5	$184.99
E^+ × *CROSS* × *GG*	2	$157.05	80.0	0.0%	482.5	$177.62
E^+ × *BRAHMAN* × *CC*	7	$11.20	76.3	24.1%	499.1	$10.23
E^+ × *BRAHMAN* × *GC*	4	-$126.74	81.5	47.0%	485.5	-$123.61
E^+ × *BRAHMAN* × *GG*	1	-$30.29	70.0	33.0%	527.0	-$31.43
BG × *ANGUS* × *CC*	4	-$1.97	83.0	18.8%	480.0	$1.06
BG × *ANGUS* × *GC*	9	$63.44	82.6	10.4%	488.7	$63.11
BG × *ANGUS* × *GG*	1	$134.50	90.0	0.0%	519.0	$125.48
BG × *CROSS* × *CC*	10	$135.96	79.1	4.0%	562.5	$141.58
BG × *CROSS* × *GC*	6	$85.66	75.7	11.7%	576.8	$83.24
BG × *CROSS* × *GG*	3	$132.72	79.7	6.7%	591.7	$120.44
BG × *BRAHMAN* × *CC*	11	-$122.04	80.3	34.7%	577.1	-$122.45
BG × *BRAHMAN* × *GC*	3	-$134.26	75.7	38.0%	560.7	-$137.24
BG × *BRAHMAN* × *GG*	2	-$133.22	76.0	39.5%	523.5	-$128.79

Notes: Unit conversion needed 1 lb = 0.4536 kg.

[†] Calculated net cash returns per head (*NR*) from Forage and Cattle Analysis and Planning (FORCAP) using observed averages for *BW, WW205,* calving month and pasture forage (E^+ or *BG*).

[‡] Birth weight (*BW* in lbs/head), breeding failure rate (*BFR* as defined in Eq. 1), and weaning weight (*WW205* in lbs/head averaged across male and female calves per cow) are reported for subsamples meeting the pasture system, breed, and genetic marker characteristics shown in the left most column.

[§] Profitability estimates using Eq. 2 coefficients. These estimates are not appropriate (na) for *NR* that vary only by pasture or pasture x breed.

[¶] E^+ and *BG* represent the presence of endophyte-infected tall Fescue and bermudagrass, respectively as the sole feed source on pasture and from hay. *ANGUS*, *BRAHMAN*, *CROSS*, *GC*, and *GG* are variables indicating breed, reciprocal cross, and presence of genetic markers *P450CC*, *P450 GC,* and *P450 GG*, respectively.

Literature Cited

Brown, M.A., A.H. Brown Jr., W.G. Jackson, and J.R. Miesner. 1997. Genotype × Environment Interactions in Angus, Brahman, and Reciprocal Cross Cows and Their Calves Grazing Common Bermudagrass and Endophyte-Infected Tall Fescue Pastures. J. Anim. Sci. 75(4):920-925. Available at: http://0-search.proquest.com.library.uark.edu/docview/218121899?accountid=8361

Brown Jr., A., S. Reiter, M. Brown, Z. Johnson, I. Nabhan, M. Lamb, A. Starnes, and C. Rosenkrans Jr. 2010. Effects of Heat Shock Protein-70 Gene and Forage System on Milk Yield and Composition of Beef Cattle. Prof. Anim. Sci. 26(4):398-403. Available at: http://dx.doi.org/10.15232/S1080-7446(15)30621-5

Caldwell, J., K. Coffey, J. Jennings, D. Philipp, A. Young, J. Tucker, D. Hubbell, T. Hess, M. Looper, C. West, M. Savin, M. Popp, D. Kreider, D. Hallford, and C. Rosenkrans Jr. 2013. Performance by Spring and Fall-Calving Cows Grazing with Full, Limited, or No Access to Toxic Neotyphodium Coenophialum-Infected Tall Fescue. J. Anim. Sci. 91(1):465-476. http://dx.doi.org/10.2527/jas.2011-4603

Johnson, J.S., J.K. Bryant, B. Scharf, D.K. Kishore, E.A. Coate, P.A. Eichen, D.H. Keisler, and D.E. Spiers. (2015) Regional differences in the fescue toxicosis response of *Bos taurus* cattle. Int. J. Biometeorol. 59:385-396. http://dx.doi.org/10.1007/s00484-014-0850-4

Keeton, D., M. Popp and A. Smith. 2014. Economic and Environmental Repercussions of Changing Bull Genetics. J. Am. Soc. Farm Manage. Rural Appraisers, 77:124-144.

Kuehn, L.A. and R.M. Thallman. 2016a. Across-Breed EPD Tables for the Year 2016 Adjusted to Breed Differences for Birth Year of 2014. As presented at the

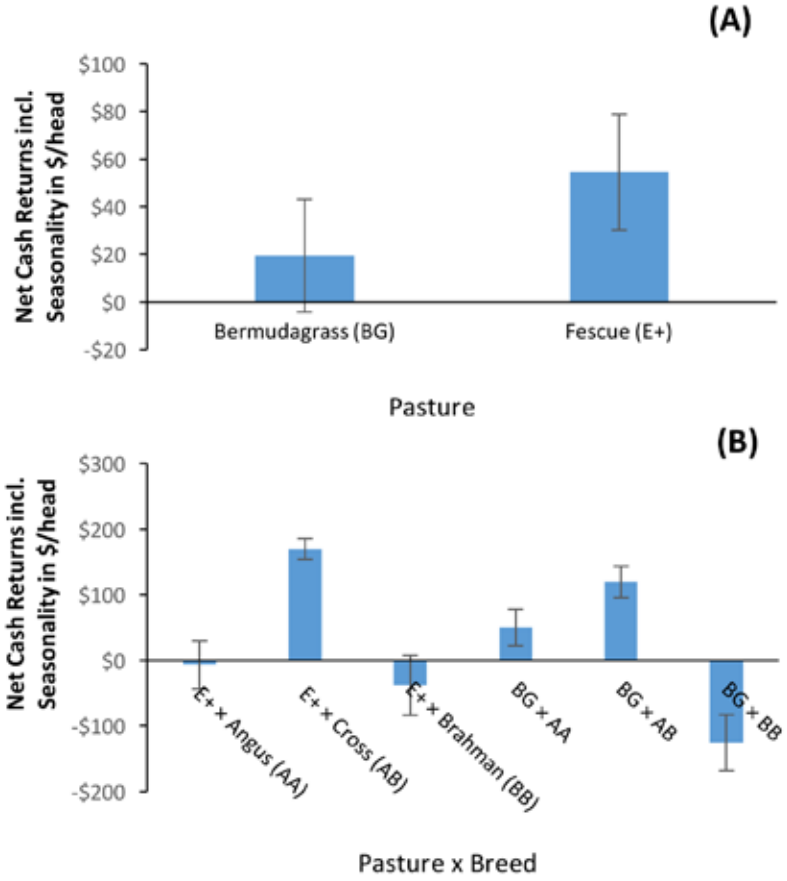


Fig. 3. Comparison of mean net cash returns in $/head as calculated in the Forage and Cattle Analysis and Planning program (FORCAP) including seasonality of sale prices by pasture-based information (A) and pasture- × breed-based information (B) where pasture was either tall fescue or bermudagrass, cattle breed was either Angus, Brahman or their reciprocal cross, Booneville, Ark., 1991-97. Standard errors are not adjusted for birthweight, breeding failure rate, and weaning weight. Pasture differences were not significant ($P = 0.31$) whereas pasture × breed means were significantly different ($P < 0.0001$).

2014 Beef Improvement Federation Conference. Available at http://www.bifconference.com/bif2016/documents/2016-ABEPD-press-release.pdf

Kuehn, L.A. and R.M. Thallman. 2016b. Mean EPDs reported by different breeds. In: Proceedings of the Beef Improvement Federation 48th Annual Research Symposium & Meeting. p. 122-126.

Looper, M., S. Black, S. Reiter, R. Okimoto, Z. Johnson, M. Brown, and C. Rosenkrans Jr. 2010. Identification of polymorphisms in the enhancer region of the bovine prolactin gene and association with profitability traits of beef cattle. Prof. Anim. Sci. 26(1):103-108. http://0-search.proquest.com.library.uark.edu/docview/230411596? accountid=8361

Popp, M., A. Smith and D. Keeton. 2013. Forage and Cattle Planner (FORCAP). University of Arkansas, Department of Agricultural Economics and Agribusiness. Accessed 27 Jan 2017. Available at: http://agribusiness.uark.edu/decision-support-software.php#forcap

Rosenkrans Jr., C., A. Banks, S. Reiter, M. Looper. 2010. Calving traits of crossbred Brahman cows are associated with Heat Shock Protein 70 genetic polymorphisms. Anim. Reprod. Sci. 119(3-4):178-182. http://dx.doi.org/10.1016/j.anireprosci.2010.02.005

Sales, M.K. Murphy, S. Reiter, A. Brown Jr., M. Brown, M. Looper, and C. Rosenkrans Jr. 2011a. Effects of forage type, body condition and single-nucleotide polymorphisms in the bovine cytochrome P450 regulatory region on cow productivity. J. Anim. Physiol. Animal Nutr. 97(1):91-96. http://dx.doi.org/10.1111/j.1439-0396. 2011.01246.x

Sales, M., M. Larson, S. Reiter, A. Brown Jr., M. Brown, M. Looper, K. Coffey, and C. Rosenkrans Jr. 2011b. Effects of bovine cytochrome P450 single-nucleotide polymorphism, forage type and body condition on production traits in cattle. J. Anim. Physiol. Animal Nutr. 96(4):545-553. http://dx.doi.org/10.1111/j.1439-0396.2011.01176.x

Smith, S.A., J.D. Caldwell, M. Popp, K.P. Coffey, J.A. Jennings, M.C. Savin, and C.F. Rosenkrans, Jr. 2012. Tall Fescue Toxicosis Mitigation Strategies: Comparisons of Cow-Calf Returns in Spring- and Fall-Calving Herds. J. Agr. Appl. Econ. 44(4):577-592. Available at: http://ageconsearch.umn.edu/bitstream/137129/2/jaae542.pdf

Thompson, N.M., E.A. De Vuyst, B.W. Brorsen, and J.L. Lusk. 2014. Value of genetic information for management and selection of feedlot cattle. J. Agr. Res. Econ. 39(1):139-155. Available at: http://0-search.proquest.com.library.uark.edu/docview/1526511508? accountid=836

USDA-AMS. 2017. United States Department of Agriculture-Agricultural Marketing Service. 2017. Arkansas Weighted Average Prices for Feeder Cattle, Cull Cow and Bull prices. Per e-mail from Little Rock, Ark. office.

USDA-NASS. United States Department of Agriculture-National Agricultural Statistics Service. 2017a. U.S. Beef Cattle Prices [Database.] Washington, D.C. Accessed 27 Jan 2017. Available at: https://www.nass.usda.gov/Charts_and_Maps/graphics/data/priceca.txt

USDA-NASS. United States Department of Agriculture - National Agricultural Statistics Service. 2017b. Quick Stats: Fertilizer Totals—Index for price paid, 2011. [Database.] Washington, D.C. Accessed 27 Jan 2017. Available at: https://quickstats.nass.usda.gov/results/12922365-06BD-36BD-AE5E-AAB63A064677

Genetic polymorphisms of the glucocorticoid receptor and interleukin-8 receptor genes and their relationship to production traits and hair coat scores in crossbred cattle

Avery B. Deaton[*], *Laura Meyer*[†], *Jeremy Powell*[§], *and Charles F. Rosenkrans, Jr*[‡],

Abstract

Little is understood about how the diversity of genes, specifically the glucocorticoid receptor (GR) and interleukin-8 receptor (CXCR2), are related to reproductive health and how this affects physical traits in cattle. Glucocorticoid receptors have been positively associated with higher milk yields, lactose content, feed intake, and feed conversion rates. Interleukin-8 genes are part of the innate immune response and help with many aspects of female reproductive health, such as protecting the embryo from the maternal immune system during pregnancy. The objective of this research was to identify polymorphisms in the GR and CXCR2 genes and to associate genotypes between the abovementioned polymorphisms and production traits in crossbred cattle. The hypothesis was that polymorphisms will exist for GR and CXCR2 genes and will be linked to production traits. Blood samples were collected from 94 crossbred cattle over a period of 3 years (2012, 2013, 2014) and the DNA was extracted, amplified, and sent to GeneSeek in Lincoln, Nebraska, to be analyzed and genotyped for single nucleotide polymorphisms (SNP). Phenotypic data, including cow pre-breeding body condition score (BCS) and weight, Julian calving date, calf birth weight, cow weaning BCS and weight, calf weaning weight, calf adjusted 205-day weight, cow efficiency, and hair coat scores (HCS) were collected from the 94 crossbred cattle and analyzed alongside the genotypic results. Significant relationships were determined using *t*-tests. Single nucleotide polymorphisms were found for the GR and CXCR2 genes and the polymorphisms were significantly related to production traits in cattle. Scientists and breeders could manipulate these genes to produce cattle that are more efficient and possess more desirable production traits.

* Avery Deaton is a May 2017 honors program graduate with a major in Animal Science and Pre-Professional Science concentration.
† Laura Meyer is a Research Manager for James Koltes and graduated with a master's degree in Animal Science.
§ Jeremy Powell is a thesis committee member and a professor in the Department of Animal Science.
‡ Charles F. Rosenkrans, Jr. is the faculty mentor and a professor in the Department of Animal Science.

Meet the Student-Author

Avery Deaton

I grew up in Maumelle, Arkansas and graduated from Arkansas Baptist High School in 2014. I will have graduated magna cum laude from the University of Arkansas in May 2017 with a major in Animal Science and a Pre-Professional Science concentration. During my undergraduate career, I was an active member of the Pre-Vet club, Block and Bridle, and several honors societies. I was an intern at Shackleford Road Veterinary Clinic in Little Rock, Arkansas during the summer of 2016 and gained a lot of veterinary experience. I applied to veterinary school the summer of 2016 and have been accepted at several universities. I will attend the veterinary school of my choosing in August of 2017 and pursue a career in large and small animal medicine. I want to thank my mentor Charles Rosenkrans for all his help while writing my thesis. His continued guidance throughout the whole process made my research possible. I would also like to thank my committee members, Jeremy Powell and Lauren Thomas, for their support of my thesis.

Introduction

Glucocorticoids

Steroid hormones can be classified as anabolic, which result in increased lean body mass, and catabolic, which facilitate metabolism. Glucocorticoids, specifically cortisol and corticosterone, are the primary catabolic steroid hormones which assist with homeostasis in the body by mobilization of glucose and increase glucose synthesis through gluconeogenesis in the liver. In response to stress, the hypothalamic-pituitary-adrenal (HPA) axis is activated and glucocorticoids are synthesized and released by the adrenal cortex which triggers the fight-or-flight response. Specifically, when an animal becomes stressed, the hypothalamus releases corticotropin-releasing hormone which triggers the anterior pituitary to secrete adrenocorticotropin hormone (ACTH) into the bloodstream. Circulating ACTH acts on the adrenal cortex, which then releases glucocorticoids, which circulate throughout the body. Intracellular glucocorticoid receptors (GR) are located in the cytoplasm and nucleus which are members of the nuclear receptor subfamily of ligand-dependent transcription factors. The GR remains inactive until glucocorticoids bind to it. The GR then transports the glucocorticoid to the nucleus through the use of nuclear pores. Once bound to the DNA, the GR acts as a transcription factor and can either induce or repress certain target genes (Oakley and Cidlowski, 2013).

In an experiment with Brown Swiss cows, a polymorphism of the glucocorticoid receptor DNA-binding factor 1 (GRLF1) was identified and positively associated with milk yields and lactose percentages. Two single nucleotide polymorphisms (SNP) had previously been found that were associated with feed intake and feed conversion rates in cattle (Cecchinato et al., 2014). In a study done on meat quality traits in male Nellore cattle, GR polymorphisms were found to be associated with various traits, including: glucocorticoid sensitivity, bone mineral density, body mass index, abdominal obesity, cholesterol, and lower concentrations of plasma cortisol (Poleti et al., 2014). This supported the prediction that the GR is related to energy production in cattle (Cecchinato et al., 2014).

Interleukin 8

Chemokines are a family of small (8-10 kDa) chemotactic cytokines that help coordinate the movement of cells. They are grouped into four families based on their amino acid sequences: α, β, γ, and δ (Tizard, 2013). The β, or CXC, chemokines are further classified into two subgroups, ELR- and ELR+. These subgroups are based on the presence of the amino acid sequence glutamic acid-leucine-arginine, or ELR (Umasuthan et al., 2014). Interleukin-8 (IL-8) is a β chemokine that attracts and activates neutrophils for inflammatory and immune responses. It is produced by macrophages, and is often denoted as CXCL8 due to its structure and function as a ligand (Tiz-

ard, 2013). It is ELR+ and typically found in or associated with liver, acute lung injury, and atherosclerotic lesions (Olson and Ley, 2002). The most common receptor for IL-8 is CXCR2, which binds all ELR+ CXC chemokines (Olson and Ley, 2002). Recruitment of myeloid cells is facilitated by CXCR2 for inflammation sites in the liver, lungs, and atherosclerotic lesions (Olson and Ley, 2002). Different genotypes for CXCR2 have been linked to impaired neutrophil migration and increased occurrences of mastitis (Tizard, 2013). The CXCR family of genes including CXCR1 and CXCR2 have affinities for IL-8 that may result in altered animal form and (or) function.

Very little is known about the impacts of the polymorphisms of the GR and CXCR family of genes. If identified, scientists and breeders could begin to manipulate those genes for a desired phenotype. Cattle could be produced that are more efficient and possess more desirable production traits. The objective of this study was to identify polymorphisms in the GR and CXCR2 genes, and associate a specific phenotype between these polymorphisms and production traits in crossbred cattle.

Materials and Methods

This study used samples from 94 crossbred Angus cows grazing mixed grass pastures over a period of 3 consecutive years (2012, 2013, and 2014). All cows were on a fall calving schedule with a 100% calving rate during those three years. Blood samples were taken from the jugular vein and immediately put in ice. The samples were centrifuged and then buffy coat was extracted. Buffy coats were stored at -20 °C until DNA analysis.

Genomic DNA was extracted from the buffy coats and plated into 96-well plates. These plates were then shipped to GeneSeek in Lincoln, Nebraska to be sequenced and for SNP analysis. Genotyping for GR and CXCR2 SNP was performed using the Sequenom technique, as explained in GeneSeek Brochure: Agrigenomic Solutions for Breeding and Improvement (http://genomics.neogen.com/pdf/catalogs/geneseekbrochure.pdf).

Hair coat scores (HCS) were recorded for all 94 cows during each of the 3 years (2012, 2013, and 2014). Trained personnel determined HCS for each cow monthly and used a scale ranging from 1 to 5 (Table 1) (Gray et al., 2011).

Dependent variables collected from the 94 crossbred cows included cow pre-breeding body condition score (BCS) and weight, Julian calving date, calf birth weight, cow weaning BCS and weight, calf weaning weight, calf adjusted 205-day weight, cow efficiency, and HCS. The experimental unit was the cow. Significance of the genotypes and their relation to the mentioned phenotypic traits was determined using *t*-tests where significance was determined at $P < 0.05$.

Results and Discussion

The SNPs T105G and C777G were identified for the GR and CXCR2 genes, respectively (Table 2). Seventy-eight cows were homozygous dominant for the GR gene. Sixteen cows were heterozygous for the polymorphism and

Table 1. Description of hair coat scores (HCS) used in this experiment.

HCS	Description
5	Full winter coat, 0% shed
4	Initial shedding
3	Half way shed
2	Almost shed
1	Slick summer coat, 100% shed

This table was derived from Gray et al., 2011.

Table 2. Distribution of single nucleotide polymorphism (SNP) in the bovine genes GR (T105G) and CXCR2 (C777G).

	Genotype distribution[b]			MAF[c]
SNP[a]	Homo	hetero	homo	%
T105G	78	16	0	8.5
C777G	79	12	2	8.6

[a] Single nucleotide polymorphism occurred at the number indicated. First letter indicates the primary allele and the letter following the digits is the minor allele.

[b] Number of cows that were homozygous for the primary allele (Homo), heterozygous (hetero), and homozygous for the minor allele (homo).

[c] Minor allele frequency (MAF) expressed as percent.

zero cows were homozygous recessive. The minor allele frequency was 8.5% in the population. Of the 94 cows, 79 were homozygous dominant for the CXCR2 gene. Twelve cows were heterozygous and two were homozygous for the recessive allele resulting in an 8.6% minor allele frequency.

T105G Polymorphism

Cow pre-breeding weight was affected ($P = 0.02$) by genotype (Table 3). The heterozygous cows averaged 500 kg while the homozygous cows averaged 527 kg. The significant difference in weight could be due to the fact that the GR is related to feed intake, feed conversion, and energy production. Cow weight at weaning and calf weight at weaning tended ($P = 0.08$, $P = 0.11$) to be affected by genotype. All other dependent variables were not affected by the genotype.

C777G Polymorphism

Cow pre-breeding body condition score and pre-breeding weight tended ($P = 0.06$, $P = 0.08$) to be affected by CXCR2 genotype. Calf birth weight was affected ($P = 0.0003$) by genotype. Homozygous calves averaged 35 kg and heterozygous calves averaged 29 kg. Calf weaning weight also was affected ($P = 0.05$) by genotype with homozygous calves averaging 199 kg and heterozygous calves at 179 kg. Cow body condition score at weaning and weight at weaning were affected ($P < 0.05$) by genotype. Homozygous cows averaged a 5.0 BCS and 500 kg; heterozygous cows averaged a 4.7 BCS and 456 kg. The differences between genotypes could be attributed to the effect that CXCR2 has on immune responses in the body. Calf adjusted 205-day weight tended ($P = 0.10$) to be affected by genotype.

Cow Age and Year

Cow pre-breeding weight, calf birth weight, cow weaning BCS, cow weaning weight, calf weaning weight, and cow efficiency were all affected ($P < 0.05$) by cow age group (Table 4). These results are to be expected due to the correlation between cow age and productivity. The 4-10 age group provided the most significant results out of the three categories due to their age and productivity traits. Cow pre-breeding BCS, cow pre-breeding weight, Julian calving date, cow weaning weight, calf adjusted 205-day weight, and cow efficiency were affected ($P < 0.05$) by year (Table 4). Year had a significant effect on these traits due to the weather differences exhibited in 2012, 2013, and 2014. Traits were negatively affected during the drought of 2012 and can be seen recovering in the following years of 2013 and 2014.

Hair Coat Score

Cow HCS was affected by year and month ($P < 0.0001$). Over the course of 12 months, HCS tended to be affected ($P = 0.07$) by the genotype C777G. By look-

Table 3. Main effects of GR (T105G) and CXCR2 (C777G) single nucleotide polymorphism (SNP) on bovine productivity traits.

	T105G				C777G			
Productivity Traits[b]	**TT**	**TG**	**SEM**	***P*-value**	**CC**	**CG**	**SEM**	***P*-value**
No.[c]	234	48	-	-	237	42	-	-
Pre-Breeding								
BCS	5.5	5.4	0.12	0.26	5.6	5.1	0.15	0.06
Weight, kg	527	500	8.31	0.02	528	493	12.5	0.08
Calving								
Julian	268	271	2.32	0.42	267	270	2.94	0.78
Birth Weight, kg	34	33	0.88	0.51	35	29	1.01	0.0003
Weaning								
BCS	5.0	4.9	0.08	0.61	5.0	4.7	0.10	0.04
Cow Weight, kg	497	476	8.94	0.08	500	456	13.5	0.05
Calf Weight, kg	198	189	4.45	0.11	199	179	6.35	0.05
Adj. 205 Wt., kg	206	206	4.20	0.94	208	192	6.04	0.10
Cow Efficiency	43	45	1.26	0.26	43	43	1.26	0.63

[a] Single nucleotide polymorphism occurred at the number indicated. First letter indicates the primary allele and the letter following the digits is the minor allele; SEM represents the mean standard error of least square means.

[b] BCS = Body Condition Score; Cow efficiency calculated by dividing the Adj. 205-day weight by cow weight at weaning.

[c] No. = total number of records over 3 consecutive years (2012, 2013, and 2014).

ing at a period of 4 months from May to August, HCS was affected ($P = 0.008$) by the genotype C777G (Fig. 1). Cows with the homozygous gene exhibited HCS of 2.2 while the heterozygous cows exhibited HCS of 2.5. Hair coat score could possibly be linked to immune responses caused by CXCR2.

Conclusions

The polymorphism T105G for the glucocorticoid receptor gene was found to be associated with production traits in crossbred cows. This SNP was related to cow pre-breeding weight and tended to affect cow weight at wean-

Table 4. Main effects of cow age group and year on bovine productivity traits.

	Cow Age Group[a]					Year				
Productivity Traits[b]	**≤ 3**	**4 - 10**	**≥ 11**	**SEM**	***P*-value**	**2012**	**2013**	**2014**	**SEM**	***P*-value**
No.[c]	53	207	22	-	-	94	94	94	-	-
Pre-Breeding										
BCS	5.4^{x}	5.6^{x}	5.0^{x}	0.18	0.07	5.1^{y}	5.4^{xy}	5.6^{x}	0.14	0.002
Weight, kg	476^{y}	546^{x}	510^{xy}	14.5	0.0001	501^{y}	489^{y}	542^{x}	10.8	0.0001
Calving										
Julian Date	271^{x}	270^{x}	267^{x}	3.58	0.71	264^{y}	268^{xy}	275^{x}	3.11	0.02
Birth Weight, kg	30^{y}	34^{x}	31^{xy}	1.18	0.005	31^{x}	32^{x}	32^{x}	0.95	0.41
Weaning										
BCS	5.0^{z}	5.1^{x}	4.5^{y}	0.12	0.007	4.9^{x}	4.9^{x}	4.7^{x}	0.10	0.30
Cow Weight., kg	453^{y}	505^{x}	477^{xy}	16.4	0.002	462^{xy}	488^{x}	484^{x}	37.0	0.008
Calf Weight, kg	166^{xy}	216^{x}	186^{x}	8.10	0.0001	193^{x}	178^{x}	196^{x}	6.88	0.06
Adj. 205 Wt., kg	207^{x}	206^{x}	187^{x}	7.60	0.34	199^{x}	186^{xy}	214^{x}	6.12	0.0003
Cow Efficiency	48^{x}	41^{y}	40^{yz}	1.55	0.0004	45^{x}	39^{xy}	45^{x}	1.41	0.0008

[a] Cow age groups = ≤3 years of age, young; 4–10 years of age, adult; ≥11 years of age, mature adult.
[b] BCS = body condition score; cow efficiency calculated by dividing the adj. 205-day weight by cow weight at weaning.
[c] No. = total number of animals over three consecutive years (2012, 2013, and 2014).
[xyz] shows similarities and differences between categories in cow age group and year.

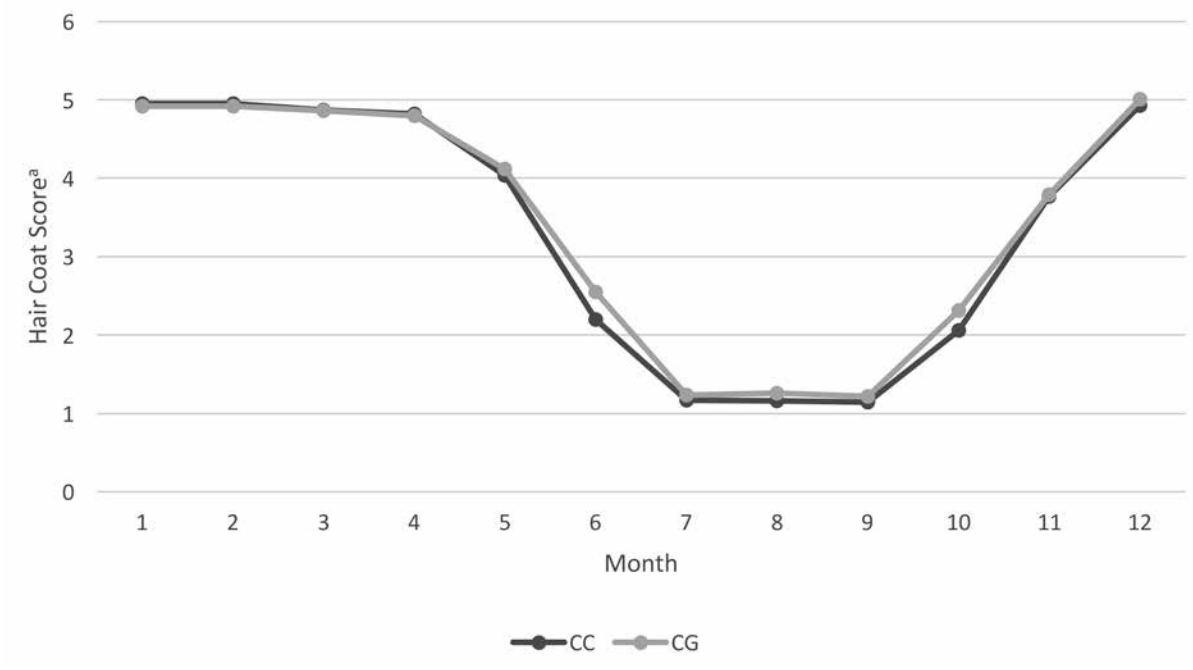


Fig. 1. Genotypic effects of CXCR2 on average hair coat score over three consecutive years (2012–2014). Based on a scale of 1–5; 5 = 0% shed, 1 = 100% shed.

ing and calf weaning weight. The interleukin-8 receptor gene, CXCR2, polymorphism C777G was shown to be associated with calf birth weight, calf weaning weight, cow BCS at weaning, and cow weight at weaning. Specifically for a period over 4 months from May to August, polymorphism C777G also affected HCS in cows. This study also shows that cow age and year have effects on production traits and HCS in cattle. Future research should be done in order to determine if these mutations are related to other traits in cattle and if they occur in great enough frequency to be useful for further genetic modifications.

Literature Cited

Cecchinato, A., C. Ribeca, S. Chessa, C. Cipolat-Gotet, F. Maretto, J. Casellas, and G. Bittante. 2014. Candidate gene association analysis for milk yield, composition, urea nitrogen and somatic cell scores in brown swiss cows. Animal: Int. J. Anim. Biosci. 8(7):1062-1070.

Gray, K.A., T. Smith, C. Maltecca, P. Overton, J.A. Parish, and J.P. Cassady. 2011. Differences in hair coat shedding, and effects on calf weaning weight and BCS among Angus dams. Livestock Science. 140:68-71.

Oakley, R. H. and J.A. Cidlowski. 2013. The biology of the glucocorticoid receptor: new signaling mechanisms in health and disease. J. Allergy Clin. Immunol. 132(5):1033–1044.

Olson, T.S. and K. Ley. 2002. Chemokines and chemokine receptors in leukocyte trafficking. Amer. J. Physiol. Regulat., Integrat. Comparat. Physiol. 283(1): R7-R28.

Poleti, M.D., R.H. DeRijk, A.F. Rosa, C.T. Moncau, P.S. Oliveira, L.L. Coutinho, J.P. Eler, J.C.C. Balieiro. 2014. Genetic variants in glucocorticoid and mineralocorticoid receptors are associated with concentrations of plasma cortisol, muscle glycogen content, and meat quality traits in male Nellore cattle. Domes. Anim. Endocrin. 51:105-113.

Tizard, I. R. 2013. Veterinary immunology (9th ed.). St. Louis, Mo.: Elsevier Saunders.

Umasuthan, N., Q. Wan, K.S. Revathy, I. Whang, J.K. Noh, S. Kim, M. Park, and J. Lee. 2014. Molecular aspects, genomic arrangement and immune responsive mRNA expression profiles of two CXC chemokine receptor homologs (CXCR1 and CXCR2) from rock bream, Oplegnathus fasciatus. Fish Shellfish Immunol. 40:304-318.

Marketing tips for small-scale, local honey bee keepers in northwest Arkansas

Samuel L. Goll[*], *Michael P. Popp*[†], *Jennie S. Popp*[§], *and Donald C. Steinkraus*[‡]

Abstract

The objective of this thesis was to gain market information for beekeepers regarding different honey bee products and to provide information about economic feasibility when produced on a small, local scale. Since cost-of-production information about operating an apiary is widely available, the focus of this work was on gaining marketing knowledge. One of the objectives of the surveys was to develop a better sense of what potential resellers of honey bee products considered locally produced. Another objective was to determine preferences for honey bee product packaging as well as bee pollination services. Using that feedback, a marketing plan for different niche markets can be developed for part-time beekeeping operations. The survey results pertaining to local retailers and end users in Northwest Arkansas in 2016 suggested a supply radius near 100 miles and a preference for small packaging in general. Least cost supply, and at least regional brand recognition were not deemed as important as ensuring locally sourced products that can be sold at a premium. Different niche markets revealed both similar and different priorities related to these marketing aspects.

* Sam L. Goll is a May 2017 honors program graduate in the Department of Agricultural Economics and Agribusiness.
† Michael P. Popp, the faculty mentor, is a Professor in the Department of Agricultural Economics and Agribusiness.
§ Jennie S. Popp is a Professor and Associate Dean, Honors College and Department of Agricultural Economics and Agribusiness.
‡ Donald C. Steinkraus is a Professor in the Department of Entomology.

Meet the Student-Author

Samuel Goll

I was born in Madison, Wisconsin and was raised in Fayetteville, Arkansas where I graduated from Fayetteville High School in 2013. In May 2017, I graduated with honors from the University of Arkansas with a B.S. in Agricultural Business with a focus on Marketing and Management. While enrolled at the U of A I was heavily involved with the Bumpers Honors Student Board, the Agricultural Business Club, the AAEA Quiz Bowl Team, and multiple other organizations.

I started beekeeping when I was 17 years old on a random spark of interest coupled with a passion for insects that I have had from a young age. As I continued to keep honey bees during high school I realized that I could put my entrepreneurial spirit to work and make a business out of the operation. My passions for agriculture, bees, and business manifested in my small business and major, and also in my honors research. I would like to thank my thesis advisor, Dr. Michael Popp, and my thesis committee, Dr. Jennie Popp and Dr. Don Steinkraus, for the immense help they offered. With their aid, I completed research that will hopefully help my business grow, as well as the honey bee population, and help beekeepers market their products. I will continue studying and pursuing other opportunities in this area and in the agricultural industry as a whole.

Introduction

While honey is a delicacy to people around the world, honey bees are respected for both food and pollination services. The common honey bee pollinates roughly $20 billion worth of agricultural goods in the U.S. (Mandal and Mandal, 2011). Approximately 766,000 pounds of honey were produced by small beekeepers with 5 colonies or less in 2016 (USDA-NASS 2017). Unfortunately, bees around the world have been dying due to colony collapse disorder (CCD) with no known cause or cure (US-EPA, 2016). More than $12 million (Purcell-Miramontes, 2017) has been in vested in USDA-NIFA research over the past decade to study CCD. With CCD, there has been a worldwide push for increasing the number of beekeepers and colonies. At this time of need, want, and interest, there are humanitarian and business opportunities (Wu et al., 2014) that can make small-scale beekeeping more than just a hobby.

The objective of this study was to collect marketing data to aid startups and established beekeeping operations interested in meeting consumer demand. From the perspective of business owners, we investigated demand for honeybee products sourced from local small-scale beekeeping operations.

Materials and Methods

Northwest Arkansas was chosen as the focus region to assess potential demand for product type, packaging, pollination services, and to gain a greater understanding of the importance of local production. Three respondent groups that consisted of grocery stores, restaurants, and coffee shops named "Retailers", local fruit and vegetable "Growers" that might also be in need of pollination services, and local "Brewers" that might be interested in honey to make mead (honey beer), honey wine or whiskey were surveyed.

Three on-line surveys were distributed via anonymous e-mail link given cost and time limitations and to simplify data entry (Salant and Dillman, 1995). First contact occurred on 10 November 2016 targeting ten "Brewers," ten "Growers," and twenty "Retailers". While the "Brewers" and "Growers" samples represented the local population of respondents for which e-mail addresses could be obtained, the "Retailers" sample was randomly selected from the local population. Follow up occurred on 15 November with a third contact (22 November) to "Retailers" only as the response rate for this group was lowest. Further detail can be found in Goll (2017).

For each respondent, the surveys assessed what honey bee products were carried and whether there was interest in other products. Next, the "local" concept was defined by the respondent in terms of allowable distance from the retail outlet. Distributions of distances for this response were tested using a Chi-Square test in EViews v. 9 (Lilien et al., 2015). Using a 5-point Likert scale ranging from "Strongly Agree" to "Strongly Disagree" and a "Don't Know" option, respondents were asked to indicate their level of agreement about the importance of local production, production within the U.S., fair retail market access for local small-scale to mid-sized producers, and brand recognition with at least a regional label. Finally, there were two questions about packaging options for honey as well as an open-ended question to elicit further feedback.

To assess relative differences about individual questions related to a topic, responses about level of agreement to a question were averaged across all respondents for that topic to provide a baseline level of agreement to the topic. To assess whether a particular question in a topic carried more relative importance than another question, the average response for the question was compared to the aforementioned overall average baseline level of agreement for the topic. Deviations from the baseline average were then plotted on a bar-graph and shaded in light gray for positive, and dark gray for negative deviations from the average to draw attention to marketing factors that mattered most to respondents (lighter shades of gray).

	# of Responses						Product	
All Responses (# of obs.)	**SA**	**A**	**N**	**D**	**SD**	**DK**	Avg[a]	Dev[b]
Raw Honey (13)	5	5	1	1	0	1	1.83	0.52
Crop-Specific Honey (15)	3	9	1	1	0	1	2.00	0.35
Flavored Honey (16)	1	5	5	3	0	2	2.71	-0.36
Creamed Honey (15)	1	5	7	1	0	1	2.57	-0.22
Honey Comb (16)	3	6	5	1	0	1	2.27	0.08
Honey Straws (16)	0	7	4	3	0	2	2.71	-0.36
Overall Average[c]							2.35	
Brewers								
Raw Honey (3)	0	1	1	1	0	0	3.00	-0.08
Crop-Specific Honey (4)	0	3	0	1	0	0	2.50	0.42
Flavored Honey (4)	0	0	2	2	0	0	3.50	-0.58
Creamed Honey (4)	0	2	1	1	0	0	2.75	0.17
Honey Comb (4)	0	0	3	1	0	0	3.25	-0.33
Honey Straws (4)	0	2	2	0	0	0	2.50	0.42
Overall Average							2.92	
Growers								
Raw Honey (4)	3	1	0	0	0	0	1.25	0.76
Crop-Specific Honey (4)	2	1	1	0	0	0	1.75	0.26
Flavored Honey (5)	1	1	2	0	0	1	2.25	-0.24
Creamed Honey (5)	1	2	1	0	0	1	2.00	0.01
Honey Comb (5)	1	4	0	0	0	0	1.80	0.21
Honey Straws (5)	0	2	0	2	0	1	3.00	-0.99
Overall Average							2.01	
Retailers								
Raw Honey (6)	2	3	0	0	0	1	1.60	0.64
Crop-Specific Honey (7)	1	5	0	0	0	1	1.83	0.41
Flavored Honey (7)	0	4	1	1	0	1	2.50	-0.26
Creamed Honey (6)	0	1	5	0	0	0	2.83	-0.59
Honey Comb (7)	2	2	2	0	0	1	2.00	0.24
Honey Straws (7)	0	3	2	1	0	1	2.67	-0.43
Overall Average							2.24	

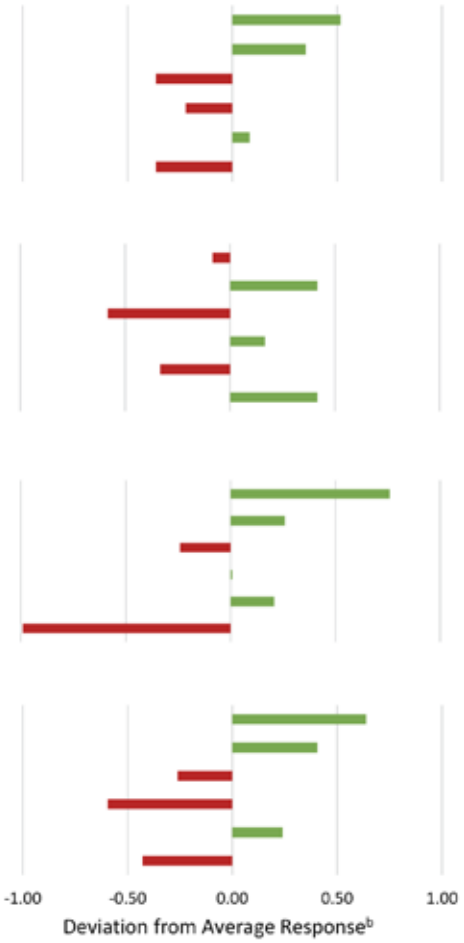


Fig. 1. Description of relative importance about market appeal by respondent group.
Notes: [a] 1 = Strongly Agree(SA)–5 = Strongly Disagree (SD). Don't know (DK) counted as observation but excluded from calculation of parameter averages shown. [b] Deviation from overall average. [c] Average of parameter averages for all respondents and individual respondent groups.

Results and Discussion

Market Appeal

There was interest in every honey bee product (Figs. 1 and 2). Raw honey, crop-specific honey, lip balm, and honey wine drew more attention. Flavored honey, creamed honey, honey straws, and pollen received weaker feedback about relative market appeal with honey whiskey and bees wax generating least value from respondents. While statistical tests comparing frequency distributions of answers across products were not performed, given the small sample size, the bar charts summarized the findings for all respondents and the individual niche markets. "Brewers" were the only respondent group that stated that raw honey had relatively low market potential. They favored crop-specific honey, honey straws, lip balm, mead, and honey whiskey. Additionally, three of the breweries stated that they do not carry mead but indicated that they would like to. "Growers" were mainly interested in food products that would complement sales of their own produce. Out of all twelve honey bee products that the survey asked about, ten products received "Strongly Agree/Agree" from at least half of the "Retailer" respondents. This showed the relatively strong entrepreneurial spirit of "Retailers" that are continually searching for new products, suppliers, and opportunities. Creamed honey and honey straws may be foreign and unknown, leading "Retailers" to be less interested in them.

What Is Considered Local?

The most common response across all three surveys to the question about what distance is considered local was 100 miles (Fig. 3). A Chi-square test about differences in the

	# of Responses						Product	
All Responses (# of obs.)	**SA**	**A**	**N**	**D**	**SD**	**DK**	Avg[a]	Dev[b]
Bees Wax (16)	3	6	5	0	0	2	2.14	0.00
Lip Balm (15)	3	9	1	0	0	2	1.85	0.30
Pollen (15)	1	5	5	0	1	3	2.58	-0.44
Mead (16)	2	10	2	1	0	1	2.13	0.01
Honey Wine (16)	3	6	3	0	0	4	2.00	0.14
Honey Whiskey (16)	2	8	4	0	0	2	2.14	0.00
Overall Average[c]							2.14	
Brewers								
Bees Wax (4)	1	0	2	0	0	1	2.33	0.00
Lip Balm (4)	1	2	0	0	0	1	1.67	0.67
Pollen (4)	0	1	1	0	1	1	3.33	-1.00
Mead (4)	0	4	0	0	0	0	2.00	0.33
Honey Wine (4)	0	1	2	0	0	1	2.67	-0.33
Honey Whiskey (4)	0	3	0	0	0	1	2.00	0.33
Overall Average							2.33	
Growers								
Bees Wax (5)	1	3	1	0	0	0	2.00	-0.06
Lip Balm (4)	1	2	1	0	0	0	2.00	-0.06
Pollen (4)	0	2	1	0	0	1	2.33	-0.39
Mead (5)	1	3	1	0	0	0	2.00	-0.06
Honey Wine (5)	2	2	0	0	0	1	1.50	0.44
Honey Whiskey (5)	2	2	1	0	0	0	1.80	0.14
Overall Average							1.94	
Retailers								
Bees Wax (7)	1	3	2	0	0	1	2.17	0.03
Lip Balm (7)	1	5	0	0	0	1	1.83	0.36
Pollen (7)	1	2	3	0	0	1	2.33	-0.14
Mead (7)	1	3	1	1	0	1	2.33	-0.14
Honey Wine (7)	1	3	1	0	0	2	2.00	0.19
Honey Whiskey (7)	0	3	3	0	0	1	2.50	-0.31
Overall Average							2.19	

Fig. 2. Description of relative importance about market appeal by respondent group.
Notes: [a] 1 = Strongly Agree(SA)–5 = Strongly Disagree (SD). Don't know (DK) counted as observation but excluded from calculation of parameter averages shown. [b] Deviation from overall average. [c] Average of parameter averages for all respondents and individual respondent groups.

distribution of responses by niche market revealed no statistically significant differences ($P = 0.84$) likely due to sample size. Nonetheless, "Brewers" showed the greatest range in responses, likely to increase their supply region. Local "Growers" leaned toward a greater distance, likely to expand their market area. Finally "Retailers" had the narrowest range of responses and desired a more proximal market region, possibly to emphasize the 'local' aspect of products sold.

What Product Attributes Were Deemed Important?

Figure 4 summarizes responses to questions about the importance of local supply, whether the product is made in the U.S., whether opening the marketing channel to small-scale to mid-sized operations was of concern and whether a product with at least regional brand recognition was necessary. Overall and most important was sourcing locally when possible and responses suggest strong market potential for honey bee products. Second, most respondents believed that small and mid-sized farms should be given a chance to participate in the food supply chain, which also favors small bee keepers. Respondents were relatively indifferent on the issue of sourcing within the United States and did not care about the label. Apiaries may therefore be advised not to spend too much time and effort toward branding their product. Responses did not vary by niche market. "Retailers" found it most important to source locally as serving 'locavores' is a current hot topic in retailing (Gogoi, 2008).

Preferred Packaging Size

The general trend among the local businesses was a preference for smaller packaging starting at half-pints (Fig. 5). The exception was honey straws which were not highly attractive across all respondent groups. Honey straws drew the attention of "Brewers" who might use them in their eateries. Further, it is hypothesized that smaller-size packaging allows for honey to be an impulse purchase with smaller packaging impinging less on a purchaser's budget than a larger package. Small packaging also allows the consumer to try out a product that they may not use in large quantity thereby guaranteeing freshness. Overall, glass was the preferred material for packaging honey. Simple and complex designs were ranked equal in appeal, suggesting again that beekeepers may be able to save cost using simple glass containers with labels that draw attention to local production and small-scale farming. Data not shown but available (Goll (2017).

Open Response

Free-form feedback showed legal issues to be of concern to "Brewers" (Table 1). A "Retailer" justified weak honey straw demand given poor ability to price separately and another "Retailer" expressed interest in differentiating 'local' honey from an array of consumer benefit perspectives such as the popular belief that local honey helps with allergies (National Honey Board, 2017).

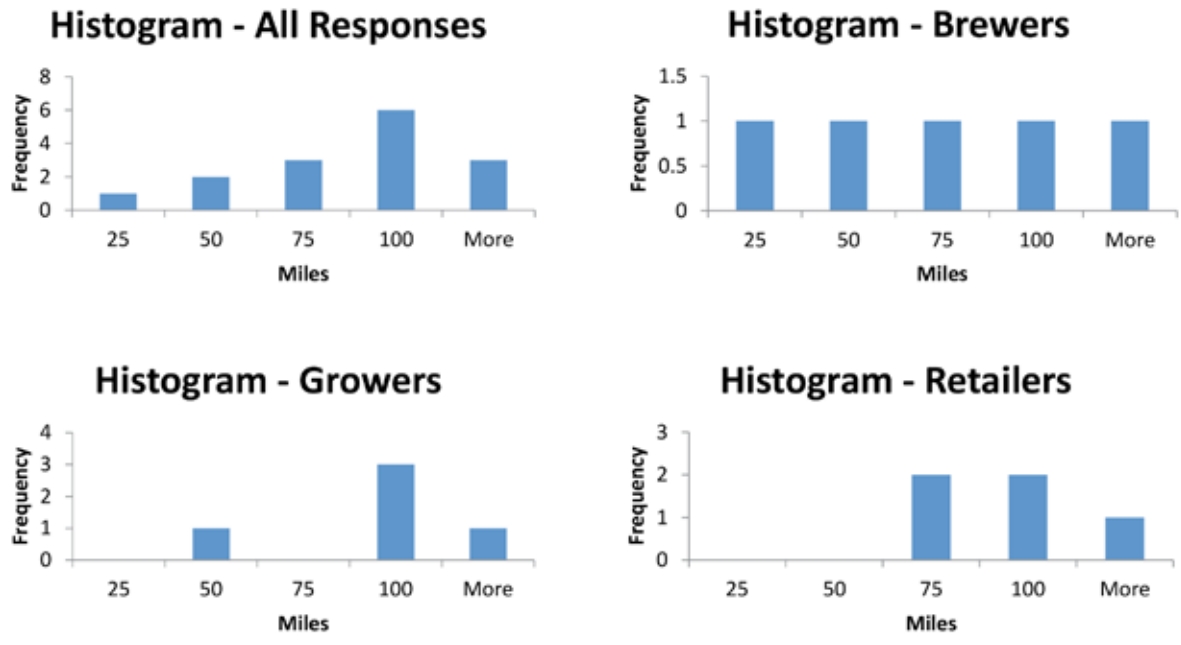


Fig. 3. Retailer response to acceptable supplier distance in miles from retail outlet considered "local" by respondent group.

General Observations

Finally, it is good to build retailer connections with products that are profitable and avoid saturating the market by contacting competitors in the same market or region. This will maintain interest in the product by existing retailers and reduces retailer incentive to lower price to gain market share thereby hurting beekeeper margin and potentially exhausting available inventory with unexpected demand pressure. The national price of honey was $2.08 per pound in 2016. With a price this low, a hobbyist or part-time beekeeper would struggle to meet cost (USDA-NASS, 2017). The key to economic success is to differentiate from the competition and know that a price premium can be charged for local honey given strong demand.

If this project were to be conducted again, a more precise survey tool with actual product samples would elicit more reliable results as respondents would be more keenly aware of product attributes. Expanding the survey to actual consumers rather than retailers would assist in this aspect. Further, an "Arkansas Grown" label in addition to U.S. and local goods (Arkansas Department of Agriculture, 2017) might be of interest. Finally, since level of agreement to statements is subjective and varies by respondent, eliciting willingness to pay in a choice experiment would provide more tangible results.

Conclusions

Marketing small packages offers a lower budget hurdle for the consumer even as packaging cost per pound of honey sold is likely higher. Bulk containers of honey are unrealistic for part-time beekeepers. A larger margin can be secured by a beekeeper that promotes and sells honey with distinctive local attributes. Paying attention to niche market differences is important with different end uses. Glass and a simple label highlighting the importance of local, small-scale production are preferred packaging options in comparison to complex package designs with a brand.

	# of Responses						Param.	
All Responses (# of obs.)	**SA**	**A**	**N**	**D**	**SD**	**DK**	Avg[a]	Dev[b]
Brand Recognition (19)	7	4	6	2	0	0	2.16	-0.50
Fair to Small Farmer (19)	11	5	2	0	0	1	1.50	0.16
US Origin (19)	12	4	0	2	0	1	1.56	0.10
Source Locally (19)	11	8	0	0	0	0	1.42	0.24
Overall Average[c]							1.66	
Brewers								
Brand Recognition (6)	1	0	3	2	0	0	3.00	-0.75
Fair to Small Farmer (6)	2	2	2	0	0	0	2.00	0.25
US Origin (6)	2	2	0	2	0	0	2.33	-0.08
Source Locally (6)	2	4	0	0	0	0	1.67	0.58
Overall Average							2.25	
Growers								
Brand Recognition (6)	2	3	1	0	0	0	1.83	-0.45
Fair to Small Farmer (6)	5	0	0	0	0	1	1.00	0.38
US Origin (6)	4	1	0	0	0	1	1.20	0.18
Source Locally (6)	3	3	0	0	0	0	1.50	-0.12
Overall Average							1.38	
Retailers								
Brand Recognition (7)	4	1	2	0	0	0	1.71	-0.32
Fair to Small Farmer (7)	5	2	0	0	0	0	1.29	0.11
US Origin (7)	4	3	0	0	0	0	1.43	-0.04
Source Locally (7)	6	1	0	0	0	0	1.14	0.25
Overall Average							1.39	

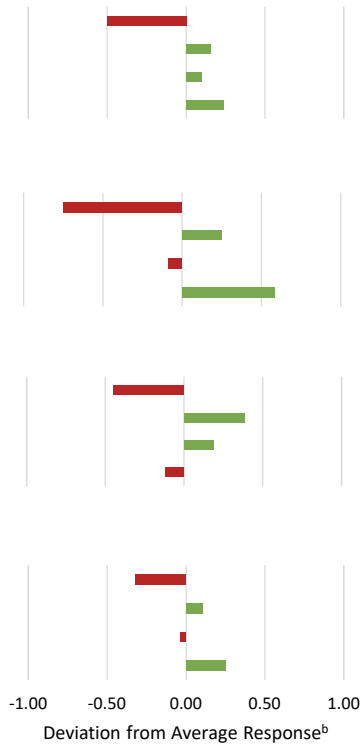


Fig. 4. Description of relative importance of retailing parameters by respondent group.
Notes: [a] 1 = Strongly Agree(SA)–5 = Strongly Disagree (SD). Don't know (DK) counted as observation but excluded from calculation of parameter averages shown. [b] Deviation from overall average. [c] Average of parameter averages for all respondents and individual respondent groups.

Literature Cited

Arkansas Department of Agriculture. 2017. Arkansas Grown Branding Program. Accessed 10 April 2017. Available at: http://arkansasgrown.org/about-us/

Goll, Samuel L. 2017. Putting The Honey On The Table: A Business Plan To Create A Successful Part-Time Beekeeping Operation. Agricultural Economics and Agribusiness Undergraduate Honors Theses. 4. Available at: http://scholarworks.uark.edu/aeabuht/4

Gogoi, P. 2008. The Rise of the 'Locavore'. Accessed 27 March 2017. Available at: https://www.bloomberg.com/news/articles/2008-05-20/the-rise-of-the-locavorebusinessweek-business-news-stock-market-and-financial-advice

Lilien, D., G. Sueyoshi, C. Wilkins, J. Wong, G. Thomas, S. Yoo, E. Lee, K. Sadri, R. Erwin, G. Liang, P. Fuquay, R. Startz, R. Hall, R. Engle, S. Ellsworth, H. Kwakatsu, and J. Noh. 2015. EViews 9. IHS Global Inc, Irvine, Calif.

Mandal, M. D., and S. Mandal. 2011. Honey: its medicinal property and antibacterial activity. Asian Pac. J. Trop. Biomed., 1(2):154–160. http://doi.org/10.1016/S2221-1691(11)60016-6

National Honey Board. 2017. Honey FAQ. Accessed 27 March 2017. Available at: https://www.honey.com/faq

Purcell-Miramontes, M.F. 2017. Colony Collapse Disorder (CCD), Federal Funding and the Challenges of Bee Decline Research: A Bureaucrat's Perspective. USDA-NIFA, United States Department of Agri-

	# of Responses			Pack.	
All Responses (# of obs.)	**No**	**Maybe**	**Yes**	Avg[a]	Dev[b]
Honey Straw (13)	4	4	5	1.08	0.04
Half-Pint (14)	2	3	9	1.50	0.47
Pint (13)	2	3	8	1.46	0.43
Quart (13)	4	2	7	1.23	0.20
Gallon (12)	7	2	3	0.67	-0.37
5-Gallon (11)	9	1	1	0.27	-0.76
Overall Average[c]				1.03	
Brewers					
Honey Straw (3)	0	1	2	1.67	0.94
Half-Pint (3)	1	0	2	1.33	0.61
Pint (3)	1	1	1	1.00	0.28
Quart (3)	2	1	0	0.33	-0.39
Gallon (3)	3	0	0	0.00	-0.72
5-Gallon (3)	3	0	0	0.00	-0.72
Overall Average				0.72	
Growers					
Honey Straw (3)	1	1	1	1.00	-0.33
Half-Pint (4)	0	0	4	2.00	0.67
Pint (4)	0	0	4	2.00	0.67
Quart (4)	1	0	3	1.50	0.17
Gallon (3)	1	1	1	1.00	-0.33
5-Gallon (2)	1	1	0	0.50	-0.83
Overall Average				1.33	
Retailers					
Honey Straw (7)	3	2	2	0.86	-0.17
Half-Pint (7)	1	3	3	1.29	0.26
Pint (6)	1	2	3	1.33	0.31
Quart (6)	1	1	4	1.50	0.48
Gallon (6)	3	1	2	0.83	-0.19
5-Gallon (6)	5	0	1	0.33	-0.69
Overall Average				1.02	

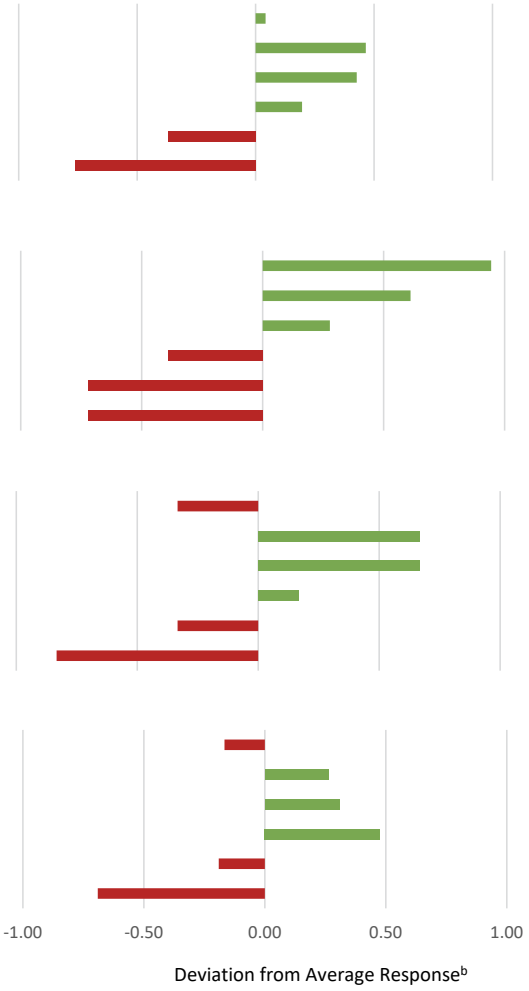


Fig. 5. Description of relative preferences in honey package size by respondent group. Notes: [a] No = 0, Maybe = 1, Yes = 2. The package average was weighted by the number of responses obtained. [b] Deviation from overall average. [c] Average of parameter averages for all respondents and individual respondent groups.

culture-National Institute of Food and Agriculture. Washington, D.C. Accessed 27 March 2017. Available at: http://www.beeccdcap.uga.edu/documents/abjpaper1-25-13.pdf

Salant, P., and D. Dillman. 1995. How to conduct your own survey. New York: John Wiley & Sons, Inc.

USDA-NASS. United States Department of Agriculture - National Agricultural Statistics Service. 2017. Honey Report. Washington, D.C. Accessed 27 March 2017. Available at: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1191

US-EPA. United States Environmental Protection Agency. 2016. "Colony Collapse Disorder." US-EPA, Washington, D.C. Accessed 27 March 2017. Available at: https://www.epa.gov/pollinator-protection/colony-collapse-disorder

Wu, S., J. Fooks, K.D. Messer, and D. Delaney. 2014. Consumer Demand for Local Honey: An Artefactual Field Experiment. University of Delaware. Department of Applied Economics and Statistics. Newark, Del. Accessed 3 April 2017. Available at: http://udspace.udel.edu/handle/19716/17131

Table 1. Open responses by respondent group.

Brewer 1	"I would be more likely to use honey in beer production than sell it to customers."
Brewer 2	"These questions were almost too general to apply to a brewery in our area. For me a lot of raw brewing ingredients are going to be purchased based upon the beer style so it's impossible in some instances to buy local. As far as merchandising goes, we do try to shop as local as possible as long as budget and time constraints are met. As far as honey is concerned we currently aren't licensed to make mead (honey wine) nor do we use raw honey in any of our beer. Nor are we permitted to sell outside food products."
Brewer 3	"We use no honey in our products as of now."
Grower 1	"Blueberry grower looking for hives."
Grower 2	"Hi! We use honey only as a sweetener. It's a free product to our customer, so price is the penultimate thing. Thanks"
Retailer 1	"This info does not necessarily reflect what the retailer desires but more what I've heard from consumer requests. In turn, what the consumer wants will reflect what the retailer desires I suppose."
Retailer 2	"From my experience, customers are usually looking for local honey to help with their allergies. As well as bee pollen, because that works just as well as honey does for allergies. Coming from a customer's point of view, the price matters as well. But once the customer knows that they're getting local, raw honey, they're willing to pay more for the product."
Retailer 3	"I currently am pursuing honeycomb as a featured offing in bakery....small packaging, gift baskets, go with fresh baked goods."

An assessment of economic considerations for industrial hemp production

Luke Lane[*], *Jennie S. Popp*[†], *Michael P. Popp*[§], *and Harrison M. Pittman*[‡]

Abstract

United States farm policy and programs are governed by the Farm Bill. The 2014 Farm Bill allows for the legal production and research of industrial hemp as long as it meets the standards outlined in the Farm Bill. Although it has a wide range of uses (upwards of 25,000 products use hemp), there is a lack of recent information regarding the economic feasibility of hemp production for the private agricultural sector. Through an extensive search of existing literature, information was gathered to construct an enterprise budget for industrial hemp. Data from the enterprise budget were used in a constrained linear programming model to compare how introducing industrial hemp production could change crop allocations in all 75 counties of Arkansas When industrial hemp was introduced, the total number of acres farmed increased by 2.8% to 4.4%, the statewide profit increased by 0.3% to 18.2%, and rice was the only crop that increased in acreage by 5%. While these results suggest that industrial hemp may be an economically promising crop, there are still hurdles to overcome. The lack of clearance (permitting) by the Drug Enforcement Agency and the absence of hemp processing facilities in the United States are clear roadblocks to hemp production. Once permitting hurdles are overcome, additional research will be needed to identify optimal locations for processing facilities and target markets for hemp goods.

* Luke Lane is a May 2017 honors program graduate from the Department of Agricultural Economics and Agribusiness.
† Jennie S. Popp, the faculty mentor, is a Professor of Agricultural Economics and Agribusiness and Honors College Associate Dean.
§ Michael P. Popp is a Professor in the Department of Agricultural Economics and Agribusiness.
‡ Harrison M. Pittman is Director of the National Agricultural Law Center.

Meet the Student-Author

Luke Lane

I am from a very small town in southern Arkansas where baseball is king and hunting is the only other activity. I graduated as the valedictorian from Taylor High School in Taylor, Arkansas in 2013. I graduated Summa Cum Laude in May 2017 from the Dale Bumpers College of Agricultural, Food and Life Sciences with a degree in Agribusiness and a minor in Political Science with a concentration in pre-law. Throughout my undergraduate career I was active in Bumpers College activities and student organizations. I served for three years as an officer on the Agricultural Business Club executive team. I was the public relations officer for one year and the treasurer for two years. I served on the honors student board for three years. I was a member of the Southern Agricultural Economics Association and American Agricultural Economics Association quiz bowl teams. I have traveled from California to south Texas to Boston competing in agricultural quiz bowl and presenting research posters while representing the University of Arkansas.

During the summer of my junior year, I was awarded the Spitze Public Policy Legislative Internship Award allowing me to intern with Representative Rick Crawford in his Washington D.C. office. I married the love of my life in May 2017 shortly after graduating.

I would like to thank Jennie Popp for being the chairperson of my honors committee. She consistently went above and beyond the call of duty keeping me on track and making sure I was achieving my highest potential. Throughout the course of my undergraduate career, she became less of professor and more of a trusted mentor and friend.

Introduction

The omnibus agriculture Farm Bill, passed in 2014, allows producers in America to grow industrial hemp for research purposes; whereas, only universities could grow industrial hemp prior to its passage. The bill passed by the House of Representatives amends "the Controlled Substances Act to exclude industrial hemp from the definition of marijuana, and for other purposes" (House of Representatives, Bill 1778). The 2014 Farm Bill also established a statutory definition of "industrial hemp" as "the plant *Cannabis sativa* L. and any part of such plant, whether growing or not, with a delta-9 tetrahydrocannabinol concentration of not more than 0.3 percent on a dry weight basis" (Johnson, 2015).

The most recent legislation, Arkansas H.B. 1778 (2017), by the State of Arkansas is intended to allow for the further research of the economic power of an industrial hemp crop and commercialization of the hemp products to advance the state agricultural sector. This bill calls for the combined efforts of the State Plant Board, the State Department of Agriculture, the University of Arkansas, and the Cooperative Extension Service to create an in-depth research analysis of an industrial hemp crop and market in Arkansas. This bill allows for the growth and development of an Arkansas-specific seed, a licensing process, renewable energy production, and research of the potential of Arkansas-grown hemp in the world market.

Currently there is limited information, particularly in Arkansas, regarding the economic feasibility of producing and marketing industrial hemp as a commodity. The overarching goal of this thesis is to provide Arkansans and others with information needed to critically assess the feasibility of hemp production within the state. Two objectives will be fulfilled to reach this goal: 1) use information collected from an extensive literature review and the Mississippi State Budget Generator (MSBG) to create a production budget for hemp within the state of Arkansas; and 2) based on this budget, identify which regions of the state will most likely benefit from the production of hemp.

Materials and Methods

This research was conducted in two parts. Using information from Roulac (1977) and Russell et al. (2015), first a spreadsheet-based industrial hemp production budget relevant to producers in Arkansas (thus using English

units) was created. Best management practices were taken from Kaiser et al. (2015); Barta et al. (2013); Cochran et al. (2000); and Bocsa and Karus (1998). Default values for ownership charges of equipment were obtained from the Mississippi State Budget Generator (Laughlin and Spurlock, 2014) and input prices for fuel and fertilizer were taken from University of Arkansas System Division of Agriculture's Cooperative Extension Service enterprise budgets (Flanders et al., 2015). All dollar values were converted to 2016 real prices. The finished budget includes a breakdown of expected yields for fiber and seeds, expected variable and fixed costs, breakeven prices, and expected revenue as partially shown in Table 1.

Second, a constrained linear programming model of Arkansas row crops was modified to include industrial hemp to compare its profitability to competing crops produced in a county. Given historical crop acreage and irrigation constraints, the model solves for profit-maximizing land use choices. This means the model considers what grows well in the county and the expected yield of the crop in the county. The model calculates producer returns above total specified expenses (NR) to 15 crop, hay, and pasture land use choices for each of 75 counties in Arkansas as follows:

$$\max_{x} NR = \sum_{i=1}^{75}\sum_{j=1}^{15}\left(p_j \cdot y_{ij} - c_{ij}\right) \cdot x_{ij}$$

Subject to

$$x_{min_{ij}} \leq x_{ij} \leq x_{max_{ij}}$$
$$iacres_{min_i} \leq \Sigma\Sigma x_{ij} \leq iacres_{max_i} \; \forall \; irrigated \; x_j$$
$$acres_{min_i} \leq \Sigma\Sigma x_{ij} \leq acres_{max_i}$$

Table 1. Total specified expenses for industrial hemp fiber and seed production, 2016 dollars.

Operation/ Operating Input	Size	Units	Month	Amount	Cost in $ per Unit	Total Cost
Soil Testing and Lime			Apr			
Custom soil test	Custom	acre		1	0.60	0.60
Custom lime applied	Custom	ton/acre		0.5	44.00	22.00
Seedbed Preparation, Fertilizer and Planting			Apr			
Custom Fertilizer		$/acre		1	7.00	7.00
Urea (46-0-0)		lbs		235	0.17	38.76
Phosphate (0-45-0)		lbs		62	0.19	11.77
Potash (0-0-60)		lbs		180	0.15	27.43
Disk & Incorporate	32 ft	acre		2	9.15	18.30
Grain Drill	30 ft	acre		1	11.05	11.05
Seed		lbs		70	1.00	70.00
					Subtotal	184.31
Harvest			Oct			
Combine	25 ft	acre		1	23.65	23.65
Grain Cart	1000 bu	acre		1	1.77	1.77
Disc Mower	10 ft	acre		1	9.06	9.06
Hay Rake	8.5 ft	acre		2	5.78	11.56
Large Hay Square Baler	4 ft x 8 ft	acre		1	41.25	41.25
Sisal Twine		$/bale		3.08	1.00	3.08
Large Square Bale Stacker	16 bales	acre		1	4.98	4.98
					Subtotal	95.35
Operating Interest				1	4.75%	5.72
Total Specified Expenses						307.98

where p_j – 5-year averge Arkansas prices for different commodities except hemp [(National Agricultural Statistics Service (NASS)]; y_{ij} – 5-year average county crop yields (2011-2015); c_{ij} –UAEX county and crop-specific 2016 total specified costs; x_{ij} –choice variable describing what crop j to plant in which county i; $x_{\min/\max_{ij}}$–NASS reported min and max county acres by crop since 2000; $iacres_{\min/\max_i}$ – 1987-2012 census based county irrigation acreage restrictions; and $acres_{\min/\max_i}$ – 1987-2012 census based county total harvested acreage restrictions (USDA- NASS, 2016).

Note that hemp acreage was restricted to 25% of harvestable acreage to account for likely crop rotation restrictions. With hemp yields indexed to dryland corn yields, cost of production was modified for the tractor running the baler, twine use, and hauling equipment in the crop model to reflect yield-based changes in harvest cost per acre as a function of yield-driven equipment speed (speed declines with higher yields and thereby raises labor, fuel and equipment charges per acre). With hemp yield indexed to non-irrigated corn, these changes in cost per acre as well as hemp fiber price drive model outcomes.

In the model, hemp price is modified by selecting from $25 to $75 per ton of fiber; whereas seed price was held constant at $0.33/lb. The average industrial hemp price per pound of processed fiber was $0.82 CDN (Canadian dollars) in 2014 for the Alberta Canada providence (Alberta Agriculture and Forestry, 2015). Industrial hemp seed reached prices of up to $1.23 per pound with the 2011 average price being between $0.90 and $1.00 per pound (Hanson, 2015). Alberta Agriculture used a seed price of $0.74 CDN in 2015.

Hemp seed and fiber (and all other crops in the model) are assumed to be sold free on board (F.O.B.) farm site in the model. As such, the prices modeled for fiber and hemp were lower than in the above-mentioned studies. Further, profitability estimates per acre are returns to management and land for production activities on farm that exclude potential gains from storage, transport and marketing.

Expected yields for industrial hemp are not well known for Arkansas. Based on the literature that suggests land suitable for corn production will likely be suitable for hemp production (Russell et al., 2015), the model was modified to grow industrial hemp only on land in counties that grew corn. With a baseline yield expectation of hemp at 3.08 tons/acre of fiber and 700 lbs of seed, fiber yield was indexed to corn yield. Hence, if a particular county had non-irrigated corn yields of 75 bu/acre compared to a 90 bu/acre state level yield, that county's yield expectation for hemp fiber was estimated at 75/90*3.08 tons/acre or 2.57 tons/acre with harvesting costs adjusted for lesser-than-average yield. This yield compares to a range of 3 to 7 dry tons of fiber and 500 to 1000 lbs of hemp seed in the USDA-ERS (2000) study. Russel et al. (2015) list a range of 2.2 to 3.9 ton of fiber along with seed yields of 520 to 910 lbs per acre when contemplating a dual harvest system.

Expert opinion and historical yield differences between irrigated and non-irrigated corn in Kansas were used to adjust irrigated corn yields that are reported for Arkansas to arrive at non-irrigated corn yield and thereby hemp fiber yields in the model.

Results and Discussion

As indicated above, the model was solved for acreage allocation to list crops using hemp fiber prices of $25/ton to $75/ton in $10 increments to determine changes in hemp acreage holding all else constant. At $45/ton for fiber, most row crops demonstrated better returns than non-irrigated industrial hemp (Table 2). Note, however, that the average profit per acre shown is not the same in each county as yields vary among counties. Hence as the price of hemp rises, lowest yielding and thereby least-profitable acreage of competing crops are diverted to hemp production.

These changes in crop acreage due to hemp fiber price changes as well as total agricultural production returns to row crop production including pasture rent and hay can be found in Table 3.

Note that the price of hemp seed was held constant as it proved less volatile historically than hemp fiber prices. These model runs provide a spatial assessment of supply response to hemp fiber prices using the modeling assumptions presented above (Fig. 1).

The maps show the amount of industrial hemp grown in each county at different hemp fiber price levels. At $25/ton, it is first farmed in the Arkansas River Valley, central, timberlands, and the delta regions of Arkansas. As the price increases, there is more change in the Arkansas Delta region than anywhere else. Only the easternmost counties in the Ozark region produce industrial hemp. No industrial hemp is produced in the Ouachitas region of Arkansas as that region is not adapted to corn production (a necessary condition for growers to consider industrial hemp production in this model). All changes in crop acreage due to industrial hemp resulted in a decrease of acreage allocated to the other crops except an increase of 5% of rice acreage after the initial $25/ton hemp fiber price. Irrigated cotton and pasture acres were the only crops not affected. The largest percentage decreases (<25%) in crop acreage occurred in non-irrigated cotton, non-irrigated soybeans, irrigated soybeans, and low-input hay acreage. The highest percentage change in crop acreage allocation at $25/ton of hemp fiber was a 12.9% drop in double-cropped soybeans. The total amount of acres harvested increased with the introduction of non-irrigated hemp, while the total amount of irrigated acres decreased.

The above analysis shows non-irrigated industrial hemp to compete well with other crops in Arkansas. Least profitable irrigated acreage was diverted to rice production when hemp was introduced and more of available crop land was used to grow industrial hemp given its favorable relative profitability when compared to the other crops using five-year average yields and prices. This is encouraging information that leads to a positive outlook for industrial hemp as a competitive cash crop in the state of Arkansas.

That said, industrial hemp sold at the farm gate is not yet processed. Hence, the next step is to research the market for a processing facility and everything that should be considered after the farm gate. This would include factors such as storage and transportation costs, and the possibility of trading industrial hemp futures and options.

Acknowledgements

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Literature Cited

Alberta Agriculture and Forestry. 2017. Industrial hemp enterprise. Edmonton, Alberta Canada: Alberta Agriculture and Forestry Information Management. Ac-

Table 2. Average (Avg.) cost of production and 2011-2015 National Agricultural Statistics Service average prices in 2016 dollars.

Crop	Price	Unit	Avg. Yield	TSE	Avg. Profit
Rice	11.8	cwt	70	528.32	295.95
Cotton	0.75				
Irrigated		lb	1182	735.68	152.67
Non-irrigated		lb	982	612.82	125.04
Corn	4.84				
Irrigated		bu	168	546.74	266.89
Non-irrigated		bu	86	426.12	-10.83
Soybean	11.64				
Irrigated		bu	43	408.51	87.09
Non-irrigated		bu	28	355.03	-29.52
Double cropped		bu	33	414.81	-30.9
Sorghum	4.68				
Irrigated		bu	99	348.16	114.91
Non-irrigated		bu	81	269.69	107.59
Wheat	6.11	bu	56	275.14	68.94
Hay	63.42	ton	2.07	125.6	5.94
Pasture Cash Rent	18.5	acre	1.17	77.45	18.5
Low-input Hay	50.74	ton	1.61	76.56	5.26
Dry Industrial Hemp	45	ton	3.08	307.98	61.63

Note: cwt = hundred weight; bu = bushel. Average cost of production or total specified expenses (TSE) and estimated profitability per acre by crop for the model solution using $45/ton for hemp fiber. All dollar values are in constant 2016 Dollars. Cost of production pertains to 2016 whereas crop commodity prices and yields reflect 2011-2015 averages. Yields, TSE and profitability vary by county.

cessed 14 January 2017. Available at: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex126/$file/153-830-1.pdf?OpenElement

Arkansas H.B.1778. 2017. To create the Arkansas industrial hemp act; And to create a research program to assess the agricultural and economic potential of industrial hemp production in Arkansas. 91st General Assembly. Accessed 1 May 2017. http://www.arkleg.state.ar.us / assembly/2017/2017R/Bills/HB1778.pdf

Barta, Z., L. Björnsson, and E. Kreuger. 2013. Effects of steam pretreatment and co-production with ethanol on the energy efficiency and process economics of combined biogas, heat, and electricity production from industrial hemp. Biotechnol Biofuels 6(1): 1-15.

Bocsa, I., and M. Karus. 1998. The cultivation of hemp: botoy, vartieties, cultivation and harvesting. Hemptech, Sebastopol, Calif.

Cochran, M.J., B. Moore, and T. Windham. 2000. Feasibility of industrial hemp Production in Arkansas. Division of Agriculture University of Arkansas System. Accessed 5 May 2015. https://www.votehemp.com/PDF/Hemp-Feasability-UofA.pdf

Flanders, A. R. Baker, T. Barber, T. Faske, H. Ginn, C. Grimes, H. Hardke, K. Lawson, G. Lorenz, R. Mazzanti, C. Norton, B. Robertson, and G. Studebaker. 2015. 2015 crop enterprise budgets. Division of Agriculture, University of Arkansas System. Accessed 5 May 2016. Available at: https://www.uaex.edu/farm-ranch/

Table 3. Crop production change in Arkansas after introduction of industrial hemp

	Baseline	% Change		
Hemp Fiber Price	**$0**	**$25**	**$45**	**$65**
State Profit (000's $/yr)	1,002,522	0.30%	7.90%	18.20%
Acres (000s)				
Rice	1560	0.00%	5.00%	5.00%
Cotton				
Irrigated	313	0.00%	0.00%	0.00%
Non-irrigated	29	-7.20%	-53.80%	-53.80%
Corn	870	-0.40%	-1.30%	-1.30%
Soybean				
Irrigated	1422	-0.10%	-26.30%	-30.60%
Non-irrigated	336	0.00%	-38.20%	-38.20%
Double cropped	175	-12.90%	-12.90%	-12.90%
Sorghum				
Irrigated	81	0.00%	-13.10%	-13.10%
Non-irrigated	42	0.00%	-7.00%	-7.00%
Wheat	943	-1.10%	-15.00%	-31.20%
Hay	1252	-2.20%	-5.90%	-5.90%
Pasture	3914	0.00%	0.00%	0.00%
Low-input Hay	640	-3.70%	-64.50%	-64.50%
Dry Industrial Hemp (000s of acres)	-	326	1585	1800
Total Harvested	7821	2.80%	4.40%	4.40%
Total Irrigated	4391	-0.60%	-7.70%	-9.10%

Note: Estimated changes to Arkansas state agricultural profitability as modeled with the introduction of industrial hemp at varying hemp fiber Prices. Hemp seed price was held constant at $0.33/lb.

economics-marketing/farm-planning/budgets/Budget_Text_2015.pdfAG-1302
Hanson, R. 2015. Industrial hemp. Agricultural Marketing Resource Center. Accessed 14 December 2016. Available at: http://www.agmrc.org/commodities-products/fiber/industrial-hemp/
Johnson, R. 2015. Hemp as an agriculture commodity. Congressional Research Service. Accessed 16 December 2016. Available at: https://www.fas.org/sgp/crs/misc/RL32725.pdf
Kaiser, C., C. Cassady, and M. Ernst. 2015. Industrial hemp production. Cooperative Extension Service, University of Kentucky. Accessed 5 January 2017. Available at: https://www.uky.edu/Ag/CCD/introsheets/hempproduction.pdf
Laughlin, D.H., and S. R. Spurlock, S.R. 2014. Mississippi state budget generator. Department of Agricultural Economics, Mississippi State University. Accessed 5 July 2016. Available at: http://www.agecon.msstate.edu/whatwedo/budgets/generator/index.asp

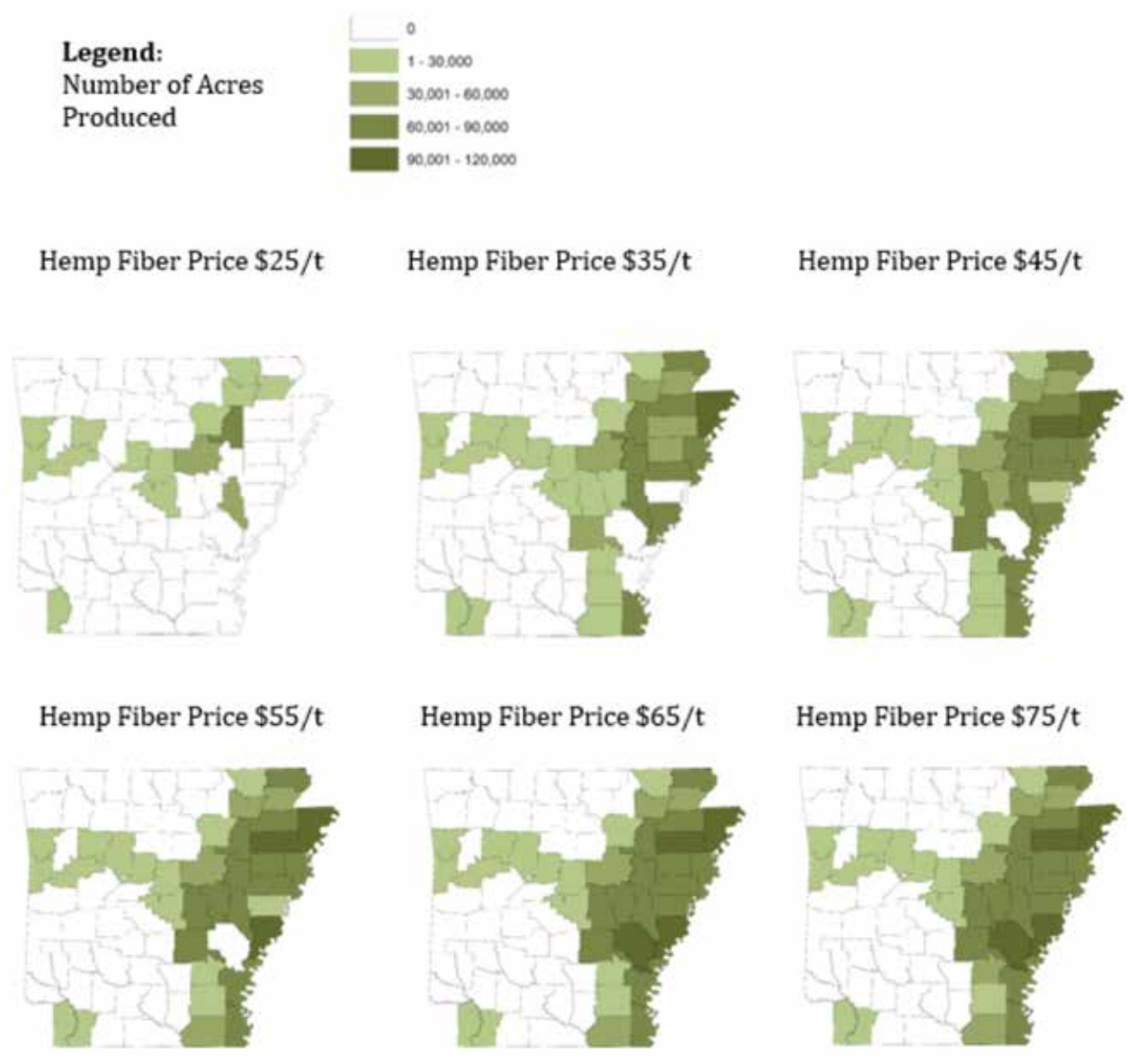

Fig. 1. Hemp production by county at various fiber prices.
Note: Hemp acreage by county at hemp fiber prices ranging from $25 to $75/ton and hemp seed price of $0.33/lb. Seed yield is 700 lbs/acre. Fiber yield averages to 3.08 ton/acre once indexed to non-irrigated corn yield when the price of hemp fiber was set at $45/ton.

Roulac, J. (1997). Hemp horizons: the comeback of the World's Most Promising Plant. Chelsea Green Publishing Company, White River Junction, Vermont

Russell, J., N. Dalsted, J. Tranel, and B.R. Young. 2015. Industrial hemp. Extension, Colorado State University. Accessed 5 January 2017. Available at: http://www.wr.colostate.edu/ABM/Industrial%20Hemp%20ABM_NOTE_Oct2015.pdf

USDA-ERS. 2000. Industrial hemp in the United States: status and market potential. Economic Research Service, US Department of Agriculture. Accessed 10 November 2015. Available at: https://www.ers.usda.gov/publications/pub-details/?pubid=41757

USDA-NASS. 2016. Quickstats. Accessed 4 January 2017. Available at: https://quickstats.nass.usda.gov/#013718E6-86D5-3781-BECF-F6FFCCFD779D

Effects of labeling and consumer health trends on preferred ground beef color characteristics, fat content, and palatability in simulated retail display

Fred W. Pohlman II[*], *Fred W. Pohlman*[†], *Nicholas B. Anthony*[§], *and Famous L. Yang*[‡]

Abstract

Nutritional concerns have impacted the protein market, decreasing red meat consumption as well as prompting the advent of lean and extra lean ground beef. However, such lean blends of ground beef may suffer in palatability. This study seeks to bridge the gap between perceived health and palatability. Participants were asked to identify the relative importance of characteristics commonly used in purchasing ground beef and select a preferred package of ground beef from labeled and unlabeled sections consisting of 4%, 10%, 20%, and 27% fat content. Instrumental color data and their main drivers were also collected. Participants then completed a blind taste sampling of ground beef with variable fat contents as previously described. Color, fat, and price were found to be significantly more important ($P < 0.05$) than label, which was significantly more important than company for package preference. No trend towards fatter or leaner blends was found between labeled and unlabeled selections, with 62.64% of participants selecting identical packages between the two sections. Instrumental color data found significant trends in lightness and oxymyoglobin ratio, the proportion of pigment that is bright cherry red, that may be used to identify leaner product without a label. No significant differences were found between the blends for any trait in sensory taste evaluation. These results suggest that while consumers have specific preferences when purchasing ground beef that can be replicated without a label using visual inspection alone, they are less discerning between cooked ground beef of different fat contents. This may explain the continued demand for lean ground beef.

* Fred Pohlman II is an honors program May 2017 graduate with a major in Animal Science.
† Fred Pohlman, the faculty mentor, is a Professor in the Department of Animal Science.
§ Nicholas B. Anthony is a Professor in the Department of Animal Science.
‡ Famous Yang is a Ph.D. student in the Department of Animal Sciences.

Meet the Student-Author

Fred Pohlman II

I am from Prairie Grove, Arkansas and graduated with honors from Prairie Grove High School in 2013. I graduated from the University of Arkansas in May 2017 with dual honors degrees in Animal Science in the Dale Bumpers College of Agricultural, Food and Life Sciences, summa cum laude, and Biochemistry in the J. William Fulbright College of Arts and Sciences, summa cum laude. I also graduated with Senior of Significance, Razorback Classic, and Phi Beta Kappa distinction.

I was a Sturgis Fellow at the University of Arkansas and was active with the Bumpers College Honors Student Board, Alpha Epsilon Delta Premedical Society, Global Medical Brigades, and the Honors College Service Committee. I studied abroad in Ghana during the summer of 2014, India the summer of 2015, and South Africa the summer of 2017. I will pursue a dual MD/MPH at Duke School of Medicine and the University of North Carolina.

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Introduction

Food has become a topic of intense interest and concern for many consumers, especially those of the millennial generation. This newfound focus on food has many motivations—food sourcing, its production method and the use or lack of technology, perceived health benefits, nutrition, and others can influence consumer preferences through an almost endless combination of these factors. Many consumers are willing to pay significantly more for preferred food that meets all or most of their valued characteristics, evidenced by the rise of luxury and specialty grocery stores and products that fulfill this demand (Batte et al., 2007).

Nutrition and the impact of food on health has become a foremost concern for many consumers, leading to a change in consumption patterns that has affected the food and agriculture industries. Meat consumption trends provide some insight into how growing nutritional concerns and awareness are altering diets. Meats that are considered lean, such as poultry, have seen an increase in consumption over the past decades, while meats associated with higher fat contents have experienced a simultaneous decrease in consumption. Using per capita disappearance of boneless retail weight as a proxy for consumption, United States Department of Agriculture (USDA) data show that from 1975 to 2015, total poultry consumption increased from 33.4 to 75.6 lbs while beef consumption decreased from 83.2 to 51.5 lbs per capita in the U.S. (USDA-ERS, 2017). Similar changes can be seen on a global scale, with data from the Food and Agricultural Organization of the United Nations (FAO) reporting a 7.7% drop in bovine meat consumption and a 76.6% increase in poultry consumption from 1990 to 2009 (Henchion et al., 2014). These changes in protein consumption are not the result of nutritional outlook by consumers alone—price, availability, and convenience have also contributed—but consumer preference in protein has undoubtedly been influenced by health concerns.

Fat and cholesterol have been topics of particular importance regarding the nutrition of protein sources. Consumption of fat, saturated fat, and dietary cholesterol has been a concern since the 1950s when the American Heart Association first issued recommendations that intake should be limited to help reduce the risk of cardiovascular disease (Daniel et al., 2010). The *Dietary Guidelines for Americans* from the USDA and Department of Health and Human Services (HHS) have routinely recommended limited fat, saturated fat, and dietary cholesterol consumption since the inception of the program in 1980 due to concerns of obesity and chronic disease and have also included language recommending consumption of lean meats (HHS, n.d.). These public health concerns and nutritional recommendations resulted in an increased demand for lean-

er protein products. Consumer concerns resulted in the development of leaner protein by the food industry, accomplished through greater trimming of visible fat at the retail level and changes in production, as well as some substitution of red meat for poultry by consumers (Daniel et al., 2010; Scollan et al., 2006). It is noteworthy that the proportion of total fat and especially saturated fat in the American food supply provided by animal protein has slowly decreased even as overall meat consumption has increased, providing some evidence of success in changing practices by the food industry (Daniel et al., 2010). Low-fat/high-carbohydrate diets have not proven successful in reducing incidences of chronic disease, however, and a growing body of evidence suggests that the relationship between dietary and plasma lipids is more nuanced and complicated than previously believed and is reflected in the most recent *Dietary Guidelines for Americans* (Daniel et al., 2010; HHS, n.d.; Mozaffarian and Ludwig, 2015). The "War on Fat" thus greatly impacted the protein market as it responded to public health concerns and consumer demand, changing the relative trajectories of red and white meat consumption as well as pushing the food industry to provide leaner products.

The consumer demand for leaner protein has had noticeable impacts on the beef industry. Improved genetic selection and use of technology such as β-adrenergic agonists as well as other changes in production practices have allowed farmers to produce leaner beef to meet consumer demand (Johnson et al., 2014). For a completely trimmed sirloin steak, total fat content declined 34% from 1963 to 2010 and saturated fat content declined 17% from 1990 to 2010 (Cattleman's Beef Board and National Cattlemen's Beef Association, 2012); USDA-ARS, 1963, 1990, and 2010). Ground beef remains the most popular beef product due largely to its price and versatility in preparation, however, accounting for 63% of foodservice beef sales and 49% of retail beef sales by volume (Speer et al., 2015). This is convenient for the food industry since the fat content of ground beef can be easily reformulated to meet consumer needs. The consumer demand for leaner protein products has led to the advent of "Lean" and "Extra-Lean" ground beef labels, with fat content options dipping to as low as 4%, significantly leaner than the 30% legal limit established by the Food Safety and Inspection Service of the USDA (U.S. National Archives and Records Administration, 2014). Through improved production practices as well as changes in product processing, the beef industry has been able to respond to market demand for leaner products.

Producing leaner ground beef in order to compete with leaner proteins may have some drawbacks in terms of overall palatability, as fat is a driving factor in many quality characteristics in meat. Both trained and consumer panels have consistently found that increased fat content is associated with increased tenderness and juiciness and decreased fat content can substantially decrease palatability, flavor intensity, juiciness, and tenderness, with peak overall acceptability occurring at 20% fat (Cross et al., 1980; Huffman et al., 1991). Low fat blends can also develop a brittle texture upon cooking or become bland with a hard, rubbery texture (Brewer, 2012). Cooking to higher temperatures can exacerbate the quality differences between leaner and fatter ground beef blends as well, resulting in greater moisture loss and producing a drier cooked product (Keeton, 1994; Troutt et al., 1992). Lean products thus require more care during preparation to maximize potential palatability, which evidence suggests is consistently below that of fatter blends, in order to be an acceptable product for consumers from a taste standpoint—meaning fatter ground beef blends are more robust to preparation error and can yield acceptable cooked product under less ideal conditions. Knowing that consumer behavior is actively influenced by informational framing on labels, it is reasonable to conclude that the health trends and concerns about dietary fat intake drove the demand for leaner beef despite apparent losses in palatability—products with label claims of "lean" or "extra lean" are more acceptable to consumers in the grocery store, but are less acceptable on the plate (Levin, 1987; Levin and Geath, 1988). Consumer error in preparation of lean ground beef blends or preference of more well done beef can result in a product that, though initially attractive due to its lower fat content and perceived improvement in nutritional benefit, is unsatisfying or unacceptable.

Regardless of the fat content, ground beef is a nutrient-dense foodstuff. For less than 10% of the daily recommended caloric intake, 85 g (3 oz.) of lean beef can provide more than 10% of ten essential nutrients, vitamins, and minerals. Beef is an excellent source (>20% recommended daily value) of protein, selenium, zinc, vitamins B-6 and B-12, and niacin as well as a good source (>10% recommended daily value) of phosphorus, choline, iron and riboflavin (Cattleman's Beef Board and National Cattlemen's Beef Association, 2012; Institute of Medicine, 2006; USDA-ARS, 2011). Though routinely vilified for its saturated fat content, 85 g (3 oz.) of cooked beef actually has a fatty acid profile with a majority of heart-healthy unsaturated fatty acids (50.3% monounsaturated, 4.1% polyunsaturated) and 45.6% saturated fatty acids (USDA-ARS, 2007). Of the top 5 sources of monounsaturated fatty acids in children in the United States, beef is the only nutrient-dense food (Keast et al., 2013). Despite old concerns, new evidence is also beginning to show that at least unprocessed red meat is not significantly associated with increased risk of cardiovascular disease, stroke, or diabetes mellitus (McAfee et al., 2010; Micha, et al., 2010). As a nutrient powerhouse, beef has a place in a healthy diet and can deliver essential nutrients in a flavorful product.

Growing interest in food, including its nutritional value, as a determinant of overall well-being coupled with a hold-over nutritional orthodoxy that vilified fat has resulted in the advent of leaner protein products, including "lean" and "extra lean" ground beef. However, decreased fat content can potentially lead to a drier, less flavorful product, especially if cooked incorrectly by the consumer, thus making leaner beef less palatable. This potential discrepancy between perceived healthy and palatable beef choices can result in consumer dissatisfaction and decreased beef consumption, resulting in the dietary loss of all the nutrients that beef provides. By evaluating the difference in fat content and color characteristics of ground beef preferred by consumers uninfluenced by labels versus label-following, health-conscious consumers and comparing those results to the fat content of ideal palatability, it may be possible to bridge this gap in consumer preferences in the store and on the plate. This bridging of the healthy-or-palatable gap in protein options has immense possibilities in aiding the effort to curb obesity as well as in encouraging proper nutrition in Arkansas as well as nationally and internationally. A healthy product that is not palatable, and therefore not consumed, has no nutritional benefit in the diet. Thus this project attempts to identify an optimal ground beef composition that marries consumer palatability preferences with desired nutritional benefits.

Materials and Methods

Participants were recruited from the University of Arkansas main campus in Fayetteville, Arkansas to represent a sample of the college-aged millennial generation through mature consumers. Data collection was conducted on four days, 23–25 January 2017 and 14 February 2017. After consenting, participants were asked to complete two phases of the study: a display portion followed by a sensory taste sampling portion. A total of 91 participants completed the display portion of the study, and 88 participated in the sensory taste sampling portion—personal preference and religious beliefs regarding meat/beef consumption prevented three participants from completing the taste sampling portion. All product was purchased from a local grocery store to reflect ground beef blends commonly encountered by average consumers as well as the overall appearance, including grind coarseness, of typical ground beef readily available to consumers.

Display

Using simulated retail display cases with ground beef selections ranging from 4–27% fat, participants were asked as prospective consumers to select ground beef as they would for a typical family dinner. Packages were evaluated under conditions designed to simulate typical retail conditions, with a simulated display case as well as simulated retail lighting (deluxe warm white fluorescent lighting, 1620 lux). Participants selected two products, one from a selection of labeled products and one from a selection of unlabeled products. Both labeled and unlabeled sections contained three one-pound packages each of 4%, 10%, 20%, and 27% fat that were randomly placed in a 4 × 3 grid (Fig. 1). The two sections were grouped at opposite ends of a simulated retail case to allow independent selection. Both labeled and unlabeled selections contained a label with a product number in the upper left hand corner. Labeled product also contained a label in the upper right hand corner detailing percentage lean and percentage fat centered at the top of the label as well as weight and price at the bottom of the label. All packages were 0.45 kg (1 lb) and the price for each package was set at $3.98 to prevent selection based on price alone. Product was purchased as two-pound packages from the grocery store and partitioned into two one-pound portions, repackaged, and labeled each morning. Product was repackaged into 21.96 × 14.61 × 1.27 cm white polystyrene foam trays (Cryovac Food Packaging and Food Solutions, Duncan, S.C.) and wrapped with poly-vinyl chloride film (14,000 cc/mm^2/24 h/1 atm; Koch Supplies, Inc., Kansas City, Missouri, USA).

Fig. 1. Example of simulated retail display portion set up with randomly placed product in labeled and unlabeled sections at opposite ends of a display case.

Demographic data were collected and participants were asked about the relative importance of five traits in their purchasing decision as well as their view on the health impact of beef and the price differential for ideal ground beef. Participants were asked to report their age and gender. They were asked to identify how often they purchased ground beef from five options of Never, Once per month, Once per week, Twice per week, and >3 times per week. Participant views on the health impact of ground beef was determined by asking them to complete the phrase "Lean ground beef is…" from three answer choices of healthy for you, not healthy for you, has no impact on health. Willingness to pay for ideal ground beef was determined by asking participants how much more per pound they would be willing to pay for their ideal ground beef preference. Finally, the importance of common considerations when purchasing ground beef was determined by asking participants to mark a 15-cm line scale ranging from Not Important to Very Important for Color, Label, Fat Content, Company, and Price.

Fat content of preferred selections was recorded. Color characteristics were measured using a HunterLab MiniScan XE Spectrocolorimeter, Model 4500L and were evaluated using illuminant A, 10° observer for meat color values: CIE (L^*, a^*, and b^*) (L^*: 0 = black, 100 = white; a^*: +60 = red, -60 = green: b^*: +60 = yellow, -60 = blue). A reflectance ratio of 630/580 nm was used to approximate the proportion of oxymyoglobin (red form) of the myoglobin pigment in the samples. From these data, hue angle (shift from red to yellow) can be calculated $[\tan^{-1}(b^*/a^*)]$ as can chroma or saturation index (brightness/vividness of color) $[(a^{*2} + b^{*2})^{0.5}]$ (Baublits et al., 2005; Jimenez-Villarreal et al., 2003; Stivarius et al., 2003). The impact of label and visual appraisal on consumer preference was determined and analyzed for statistical significance using the Mixed Model Procedure of Statistical Analyses System software, v. 9.4 (SAS Institute, Inc., Cary, N.C.).

Taste Sampling

Participants were asked to evaluate samples of cooked ground beef patties with identical fat composition to blends in the display portion (4%, 10%, 20%, and 27% fat). Participants were blind to the composition of samples, and samples were presented in a complete block design in which each panelist received all treatments. Sample order was random for each participant, and presented samples were accompanied with a three-digit code later used for identifying sample composition. Patties were cooked using a gas griddle to an internal temperature of 71 °C as measured by a meat thermometer. Edges were trimmed from the cooked patties, then sectioned into 2.54 × 2.54 cm squares. Samples were kept covered and at serving temperature (60 °C) in a food warmer. Participants were asked to evaluate samples on five characteristics using a 15-cm line scale: Juiciness (Extremely Dry–Extremely Juicy), Bind (Extremely Fragile–Extreme Bind), Beef Flavor (Extremely Non-Beef Like–Extremely Beef Like), Off Flavor (Extreme Off Flavor–No Off Flavor), Overall Impression (Extremely Dislike–Extremely Like).

Samples were presented one at a time, and participants were instructed to cleanse their palate with a bite of unsalted cracker and a sip of water before tasting each sample. Sampling was conducted with no contact between participants in individual booths and under low pressure sodium color neutralizing light (48 W, 120 V; Trimblehouse lighting, Norcross, Georgia, USA) to avoid visual bias. Data

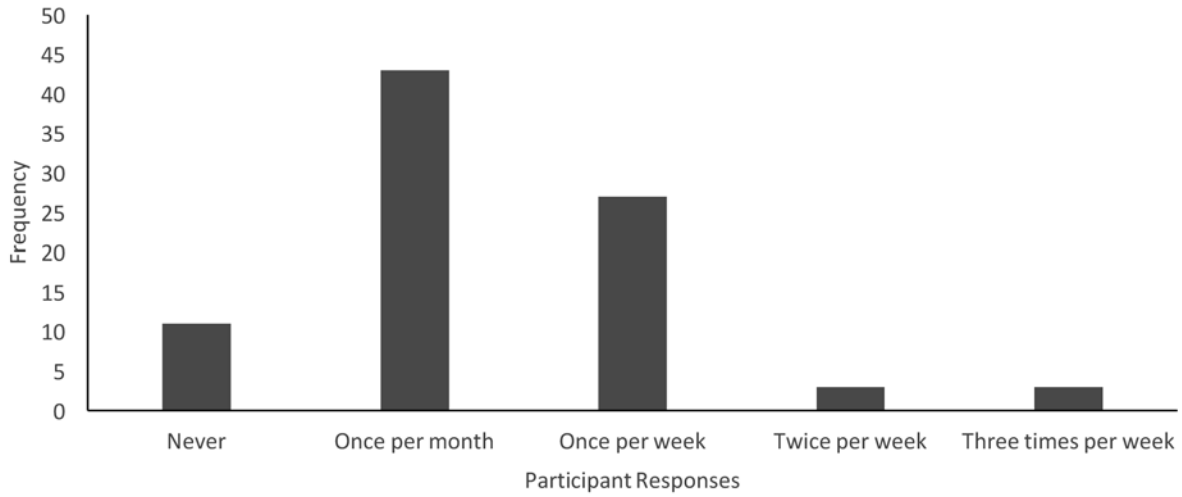

Fig. 2. Frequency of responses for lean ground beef purchasing behavior (n = 91).

were analyzed using the Mixed Model Procedure of Statistical Analyses System software, v. 9.4 (SAS Instutute, Inc., Cary, N.C.).

Results and Discussion

Results

The participant group was 65% female and 35% male with a mean age of 26 ± 11.5 years. The majority of participants (81%) believed that lean ground beef was healthy while 5% and 14% believed that lean ground beef was not healthy or has no impact on health, respectively. Frequency of ground beef purchase varied among participants: 49% reported purchasing ground beef once per month, 31% reported purchasing it once per week, 13% reported never purchasing it, and 3% reporting purchasing it either twice per week or three times per week (Fig. 2). The mean reported willingness to pay for ideal ground beef preference among participants was 2.61 ± 1.76 dollars.

Significant differences were found in the reported importance of common characteristics in ground beef selection. Least squares means for the length of the line (0 = Not Important, 15 = Very Important) along with standard errors for each characteristic are reported in Fig. 3. Company and label were significantly less important than price, fat, and color. Color was significantly more important than price and was not significantly greater ($P = 0.1878$) than fat content of ground beef.

The distribution of preferred fat content in ground beef package selection for labeled and unlabeled product is presented in Fig. 4. The 4% and 20% fat blends showed increases in the proportion of selected packages from labeled to unlabeled section (1.11% and 7.78% increases, respectively). The 10% and 27% fat blends showed decreases in the proportion of selected packages from labeled to unlabeled section (3.33% and 5.55% decreases, respectively). Interestingly, 62.64% of participants selected identical fat blends between labeled and unlabeled sections. However, 17.58% of participants selected a fatter blend in the unlabeled section compared to the corresponding selection in the labeled section while 19.78% selected a leaner blend. The preferred fat content, whether labeled or unlabeled, was 20%.

The L^* values in instrumental color data trended upward significantly with increasing fat content, corresponding to an increase in lightness of the ground beef with increasing fat proportion (Table 1). Values for a^* exhibited significant differences between the two leaner blends and each of the fatter blends, corresponding to differences in red-green values among samples. The highest fat content (27%), as might be expected, was less red in color than leaner ground beef treatments. Measurements for b^* value showed significant differences among treatments, corresponding to differences in yellow-blue values among samples. Chroma determinations yielded significant differences among blends, with 27% being less vivid in color than the three leaner blends. Determination of hue angle resulted in significant differences among treatments, with the 4% blend having a significantly lower hue value (hue angle) corresponding to a more red shift in instrumental color value. Determination of the oxymyoglobin proportion followed the trend in fat content, with leaner ground beef having higher estimates of oxymyoglobin and oxymyoglobin content decreasing as fat content increased.

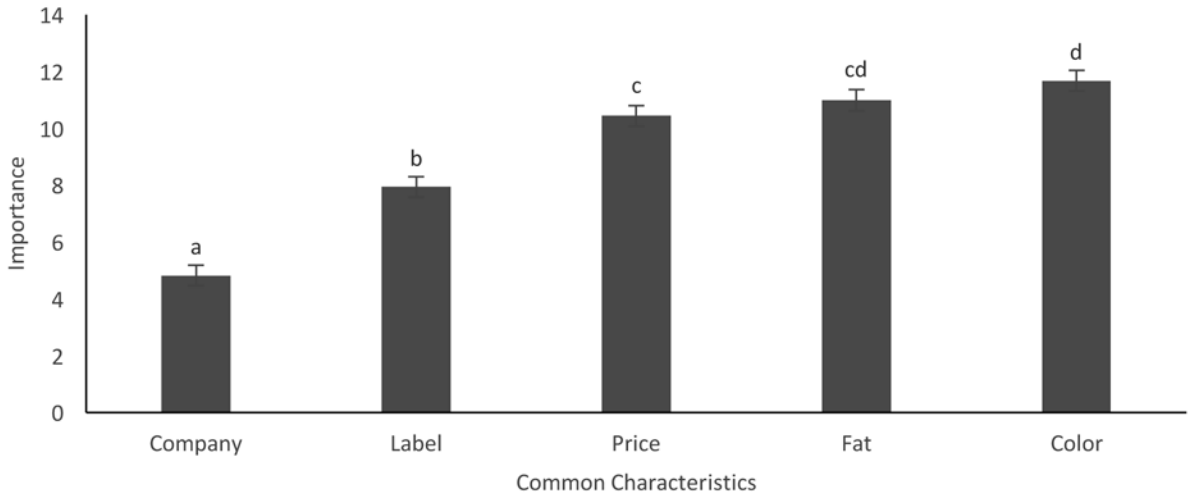

Fig. 3. Frequency of responses for lean ground beef purchasing behavior.
[a-d] Least squares means of columns with different superscripts differ ($P < 0.05$)
Characteristics scored on a 15-cm line scale (0 = Not Important, 15 = Very Important).

Results from the consumer taste panel are summarized in Table 2. The *P*-value for day as a covariant was above 0.05 for each trait. No trait showed statistically significant differences among treatments at the 95% confidence level, however the scores for the 20% blend were nearly significantly higher for off-flavor (less off flavor) and overall impression (*P*-values of 0.0681 and 0.0867, respectively).

Discussion

Participant responses about the healthiness of lean beef, with the majority agreeing that lean beef is healthy, initially seems to stand in contrast to prevailing trends of decreased red meat consumption due to nutritional concerns. The results of this question may be a reflection of recommendations to consume leaner meats, however, and helps explain the growing demand for lean ground beef. Comparisons of consumers' beliefs about the relative healthiness of lean and fatter ground beef cannot be made from the data collected, but this additional question could help further explore beliefs driving ground beef preferences. The belief among the majority of participants that lean ground beef is healthy is still an encouraging statistic to a market that has witnessed decreased consumption.

The frequency of ground beef purchase appears to be low, with nearly half of participants reporting purchasing ground beef only once per month. The next largest proportion of participants indicated purchasing ground beef once per week (31%), but the third most frequent response

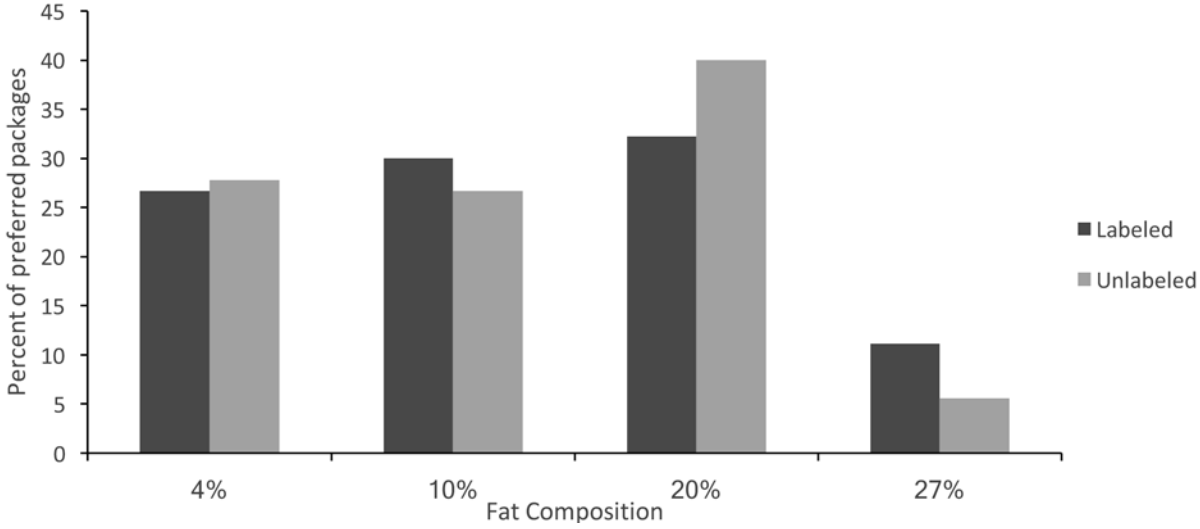

Fig. 4. Proportion of preferred product selected from labeled and unlabeled sections in a simulated retail display case.

Table 1. Impact of ground beef fat content on least squares means for instrumental color characteristics.

Treatment	$L^{*\dagger}$	$a^{*\ddagger}$	$b^{*\S}$	Chroma[¶]	Hue[#]	Oxymyoglobin Ratio[††]
4%	41.7846[a]	33.2925[b]	25.7746[a]	42.1050[b]	37.7437[a]	7.1946[d]
10%	47.2254[b]	32.9121[b]	26.9733[c]	42.5546[bc]	39.3329[c]	5.9375[c]
20%	50.3600[c]	33.7975[c]	26.4667[b]	42.9288[c]	38.0612[b]	5.6667[b]
27%	51.9908[d]	31.6517[a]	26.0325[a]	40.9821[a]	39.4379[c]	4.9846[a]

[abcd] Least squares means within a column bearing different superscripts differ ($P < 0.05$).
[†] L^*: 0=black, 100=white.
[‡] a^*: +60=red, -60=green.
[§] b^*: +60=yellow, -60=blue.
[¶] Calculated as $(a^{*2} + b^{*2})^{0.5}$
[#] Calculated as $\tan^{-1}(b^*/a^*)$.
[††] Calculated as 630 nm/580 nm.

(13%) indicated never purchasing ground beef. This distribution appears to agree more with trends of decreased red meat consumption (USDA-ERS, 2017). Purchasing frequency may not completely align with consumption, however, with bulk purchasing opportunities limiting visits to grocery stores. Additionally, comparison to purchasing and consumption habits of whole muscle beef cuts as well as other protein sources cannot be made from these data so it is difficult to evaluate the overall popularity of ground beef among consumers. Questions regarding ground beef consumption as well as other protein purchase frequency and consumption could help further elucidate the standing of ground beef in consumer protein preferences.

Participants indicated that color, fat, and price were most important when purchasing ground beef, and were significantly different from the importance of label and company. Among the three most important traits, color was significantly more important than price, indicating the importance of visual appraisal by consumers when purchasing ground beef. The quality of any fresh food, including fresh protein and produce, has visual indicators, and though price is important, consumers seem to be willing to pay more for a product they believe is higher quality as determined by visual inspection. Fat was the characteristic with the second highest least squares mean for importance, but it was not significantly less important than color or more important than price. It is not surprising that label and company were less important to participants than traits that indicated quality (color), nutrition (fat), and economics (price). The significant difference in the importance of label over company is nonetheless interesting given that commercial ground beef labels are frequently color coded to correspond with fat content. This study utilized identical white labels for consistency, but label color may play a subtle role in ground beef purchasing preferences.

Results of ground beef product selection indicate an overall preference for leaner blends of ground beef. Though the 20% fat blend exhibited the highest frequency of selection in both labeled and unlabeled groups, collectively the leaner two blends garnered a higher proportion of the preferred product selections than the two fatter blends (56.67% vs. 43.33%). Participants least preferred the 27% fat blend by a large margin in both labeled and unlabeled sections. This agrees with prevailing trends towards leaner protein sources (Daniel et al., 2010). There was no clear trend in change of frequency distribution towards fatter or leaner blends from labeled to unlabeled selection, however, with the majority of participants selecting the identical blend between sections. This indicates that consumers can evaluate ground beef packages reasonably well based upon visual appraisal alone. Previous history with the color characteristics of preferred ground beef may be informing participant choices without a label to help guide selection. The self-reported importance of color to consumers when purchasing ground beef may help explain participant success in replicating preferred package selection.

Instrumental color data revealed significant differences between fat blends for each measurement; however, only two measurements exhibited a trend that could potentially be used by participants in informing preference selections without a label. The L^* measurements increased as fat content increased, corresponding to the lightness of the ground beef. Increasing proportions of white fat in ground beef can logically be expected to increase the lightness of the product, and lightness is a simple visual indicator to evaluate (lighter samples tend to be higher in fat than darker samples). The decreasing oxymyoglobin ratio with increasing fat content provides another trend that may be useful in visually determining fat content without a label. Myoglobin is found in muscle, and

Table 2. Impact of ground beef fat content on least squares means for consumer panel sensory taste panel traits.

Trait	4%	10%	20%	27%	*P*-value
Juiciness[†]	6.19	6.12	6.48	6.28	0.9171
Bind[‡]	8.95	8.99	8.14	8.87	0.2435
Beef Flavor[§]	8.99	8.48	9.12	8.55	0.5311
Off Flavor[¶]	9.12	8.77	10.28	9.14	0.0681
Overall Impression[#]	8.07	7.23	8.57	7.91	0.0867

[†] Juiciness: 0=Extremely Dry, 15 = Extremely Juicy.
[‡] Bind: 0=Extremely Fragile, 15 = Extremely Bind.
[§] Beef Flavor: 0=Extremely Non-Beef Like Flavor, 15 = No Non-Beef Like Flavor.
[¶] Off Flavor: 0=Extreme Off Flavor, 15 = No Off Flavor.
[#] Overall Impression: 0=Extremely Dislike, 15 = Extremely Like.

decreasing the proportion of muscle by increasing fat content within a blend can be expected to decrease the overall myoglobin content of a sample. Under similar conditions among all samples, the ratio of oxymyoglobin, the oxygenated form of the myoglobin pigment, can be expected to similarly decrease with increasing fat content. Oxymyoglobin is bright cherry red, and decreasing redness with increasing fat content is easy to detect visually. The oxymyoglobin ratio then becomes a proxy for muscle content in a blend and its corresponding visual characteristics can be used to determine fat content visually.

A lack of statistically significant differences between samples in the tasting component of this study was surprising. These data indicate that consumers are less discerning of differences in palatability between various fat blends once cooked. Overall impression values peaked at 20% fat, agreeing with the literature, but a higher score for 4% fat disagrees with the consensus that acceptability decreases with decreasing fat content past 20% (Huffman et al., 1991). This may be the result of consumers' expectations of ground beef taste and texture changing as leaner ground beef is consumed more frequently. Therefore, general consumers of ground beef may have come to expect the eating experience of leaner blends as normal. Given that juiciness scores were similar among ground beef fat blend treatments, it may have been possible that cooking may have rendered more fat out of the higher fat treatments. Further, since patties in this study were cooked to a constant internal temperature as determined by a meat thermometer, the impact of cooking abuse on ground beef was not determined. Therefore, it may be possible that at higher degrees of doneness such as cooking abuse, higher fat contents may provide a buffer against cooking abuse. A lack of significant difference in individual traits or with overall impression points to consumers that are less discerning in differences in palatability between various fat blends. If consumers are satisfied with the eating experience of leaner ground beef, the decreased fat and energy consumption associated with leaner beef may prove to be attractive for many consumers.

Conclusions

Concerns about the nutritional value of food has driven demand for lean protein in the past few decades, resulting in the advent of lean and extra lean ground beef. The belief by consumers that lean ground beef is healthy may be tied to this nutritional orthodoxy that pushed for leaner foods. Despite overwhelming responses by participants indicating that lean ground beef is healthy, however, purchasing frequency of ground beef is low. Numerous factors may explain this discrepancy, and the relationship of ground beef consumption and purchasing frequency to whole muscle cuts and other proteins need to be further explored. Further, ground beef purchase activity may also be influenced by the number of meals prepared at home versus consumed outside the home.

When purchasing ground beef, participants place significant importance on color, fat, and price over label and company. These three important traits are tied to quality, perceived nutrition, and the economics of a product, respectively. It was hypothesized that concerns over nutrition drove preferences of lean ground beef and without labels consumers would select lean blends less frequently. However, the majority of participants were able to replicate preferred ground beef selection between labeled and unlabeled sections. This indicates a high level of visual appraisal by consumers aware of their preferences. When unlabeled, panels preferred 20% fat content 40% of the time. Trends in instrumental color data measurements suggest that either lightness or redness associated with oxymyoglobin content may play a role in this visual appraisal. Consumers have clear priorities when purchasing ground beef and can for the most part replicate decisions without a label.

Discerning differences between cooked ground beef samples of different fat blends, however, was more challenging for participants. No trait evaluated in the tasting portion of this study was significantly different among the various fat blends. This suggests that consumers are less able to differentiate the palatability of different fat blends once they are cooked.

Though consumers have priorities when purchasing ground beef that allow consistent selection of preferred fat content, they do not appear to be able to significantly differentiate among cooked product of different fat blends. Concerns about leaner beef being less palatable and turning away consumers, resulting in a loss of the nutrients all beef provides, may thus be exaggerated. If consumers are more comfortable purchasing leaner blends of ground beef and do not experience a significant decrease in palatability, they may continue to purchase the product. This may help explain the continued viability of lean ground beef and the development of extra lean blends.

Acknowledgements

Thank you to Famous Yang for assisting in the collection and analysis of data. Financial support came from an Honors College Research Grant, and this project would not have been possible without the generosity and support of the Honors College. Thanks to the Department of Animal Science as well as Donna Delozier in the Department of Poultry Science for making the resources and facilities needed to conduct this project available to undergraduate researchers. Support also provided by the University of Arkansas System Division of Agriculture.

Literature Cited

Batte, M.T., N.H. Hooker, T.C. Haab, and J. Beaverson. 2007. Putting their money where their mouths are: Consumer willingness to pay for multi-ingredient, processed organic food products. Food Policy.32(2):145-159.

Baublits, R.T., F.W. Pohlman, A.H. Brown Jr., and Z.B. Johnson. 2005. Effects of enhancement with varying phosphate types and concentrations, at two different pump rates on beef biceps femoris instrumental color characteristics. Meat Sci. 71(2):264-276.

Brewer, S.M. 2012. Reducing the fat content in ground beef without sacrificing quality: A review. Meat Sci. 91(4):385-395.

Cattlemen's Beef Board and National Cattlemen's Beef Association. 2012. Evolution of Lean Beef. Accessed 22 March 2017. Available at: http://www.beefitswhatsfordinner.com/CMDocs/BIWFD/FactSheets/Evolution_of_Lean_Beef.pdf

Cross, H.R., B.W. Berry, and L.H. Wells. 1980. Effects of fat level and source on the chemical, sensory and cooking properties of ground beef patties. J. Food Sci. (45)4:791-794.

Daniel, C.R., A.J. Cross, C. Koebnick, and R. Sinha. 2010. Trends in meat consumption in the USA. Public Health Nutr. 14(4):575-583.

Henchion, M., M. McCarthy, V.C. Resconi, and D. Troy. 2014. Meat consumption: Trends and quality matters. Meat Sci. 98(3):561-568.

HHS. U.S. Department of Health and Human Services (HHS). n.d. History of Dietary Guidelines for Americans. Accessed 3 March 2017. Available at: https://health.gov/dietaryguidelines/history.htm

Huffman, D.L., W.R. Egbert, C. Chen, and D.P. Dylewski. 1991. Technology for Low-Fat Ground Beef. Reciprocal Meat Conference Proceedings. 44:73-78.

Institute of Medicine. 2006. Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. The National Academies Press. Accessed 22 March 2017. Available at: https://doi.org/10.17226/11537

Jimenez-Villarreal, J.R., F.W. Pohlman, Z.B. Johnson, and A.H. Brown Jr., and R.T. Baublits. 2003. The impact of single antimicrobial intervention treatment with cetylpyridinium chloride, trisodium phosphate, chlorine dioxide or lactic acid on ground beef lipid, instrumental color and sensory characteristics. Meat Sci. 65(3):977-984.

Johnson, B.J., S.B. Smith, and K.Y. Chung. 2014. Historical Overview of the Effect of β-Adrenergic Agonists on Beef Cattle Production. Asian-Australas J. Anim Sci. 27(5):757-766.

Keast, D.R., V.L. Fulgoni, T.A. Nicklas, and C.E. O'Neil. 2013. Food Sources of Energy and Nutrients among Children in the United States: National Health and Nutrition Examination Survey 2003–2006. Nutrients. 5(1):283-301.

Keeton, J.T. 1994. Low-fat meat products—technological problems with processing. Meat Sci. 36(1-2):261-276.

Levin, I.P. (1987). Associative effects of information framing. Bulletin of the Psychonomic Society. 25(2):85-86.

Levin, I.P. and G.J. Geath. 1988. How Consumers are Affected by the Framing of Attribute Information Before and After Consuming the Product. J. Cons. Res. 15(3):374-378.

McAfee, A.J., E.M. McSorley, G.J. Cuskelly, B.W. Moss, J.M.W. Wallace, M.P. Bonham, and A.M. Fearon. 2010. Red meat consumption: An overview of the risks and benefits. Meat Sci. 84(1):1-13.

Micha, R., S.K. Wallace, and D. Mozaffarian. 2010. Red and Processed Meat Consumption and Risk of Incident Coronary Heart Disease, Stroke, and Diabetes Mellitus. A Systematic Review and Meta-Analysis. Circulation. 135(25):2271-2283.

Mozaffarian, D. and D.S. Ludwig. 2015. The 2015 US Dietary Guidelines Lifting the Ban on Total Dietary Fat. JAMA. 313(24):2421-2422.

Scollan, N., J. Hocquette, K. Nuernberg, D. Dannenberger, I. Richardson, and A. Moloney. 2006. Innovations in beef production systems that enhance the nutritional and health value of beef lipids and their relationship with meat quality. Meat Sci. 74(1):17-33.

Speer, N., T. Brink, and M. McCully. 2015. Changes in the ground beef market and what it means for cattle producers. The Angus Foundation. St. Joseph, Missouri.

Stivarius, M.R., F.W. Pohlman, K.S. McElyea, and J.K. Apple. 2003. Microbial, instrumental color and sensory color and odor characteristics of ground beef produced from beef trimmings treated with ozone or chlorine dioxide. Meat Sci. 65(2):885-891.

Troutt, E.S., M.C. Hunt, D.E. Johnson, J.R. Claus, C.L. Kastner, D.H. Kropf, and S. Stroda. 1992. Chemical, Physical, and Sensory Characterization of Ground Beef Containing 5 to 30 Percent Fat. J. Food Sci. 57(1):25-29.

USDA-ARS. 1963. U.S. Department of Agriculture-Agricultural Research Service. Composition of Foods Pork products; raw, processed, prepared. Agriculture Handbook 8.

USDA-ARS. 1990. U.S. Department of Agriculture, Agricultural Research Service. Composition of Foods: Raw, Processed, Prepared, Agriculture Handbook Number 8.

USDA-ARS. 2007. U.S. Department of Agriculture-Agricultural Research Service. USDA National Nutrient Database for Standard Reference, Release 20. Nutrient Data Laboratory Home Page. Accessed 22 March 2017. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl/ba/bhnrc/ndl

USDA-ARS. 2010. U.S. Department of Agriculture-Agricultural Research Service. USDA National Nutrient Database for Standard Reference, Release 23. Nutrient Data Laboratory Home Page. Accessed 22 March 2017. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl

USDA-ARS. 2011. U.S. Department of Agriculture-Agricultural Research Service. USDA National Nutrient Database for Standard Reference, Release 24. Nutrient Data Laboratory Home Page. Accessed 22 March 2017. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl

USDA-ERS. U.S. Department of Agriculture-Economic Research Service. 2017. Livestock and Meat Domestic Data. Accessed 22 March 2017. Available at: https://www.ers.usda.gov/data-products/livestock-meat-domestic-data/livestock-meat-domestic-data/#Total%20red%20meat%20and%20poultry

U.S. National Archives and Records Administration. 2014. Code of Federal Regulations. Title 9. Miscellaneous Beef Products. Section 319.15.

Anti-cancer and bioavailability of arachidin-1 and arachidin-3 in colon cancer cells

Macy R. Shirley[*], *Cindi Brownmiller*[†], *Wing Shun Lam*[§], *and Sun-Ok Lee*[‡]

Abstract

Cancer is a common cause of death in the United States and locally in the state of Arkansas. Modifiable factors such as tobacco use, physical activity, and diet lead to reduced incidence of colon cancer diagnosis. Plant-based foods may contain phytochemicals that confer health promoting properties. Specifically, peanuts contain phytochemicals known as resveratrol, arachidin-1, and arachidin-3 that have been linked to anticancer activities. However, few research studies have been done on arachidin-1 and arachidin-3 that could develop understanding of their health promoting properties or nutraceutical applications. The objectives of this study were to (1) determine the most effective concentration of arachidin-1 and arachidin-3 for inhibiting cell proliferation and (2) assess the bioavailability of these compounds. Concentrations of 0, 5, 10, and 20 μM arachidin-1 and arachidin-3 were applied and cell viability was measured at 0, 24, and 48 hours. Significant reduction of cell proliferation occurred with treatments of 10 and 20 μM arachidin-1 and 10 and 20 μM arachidin-3 in comparison with the control. Due to the limitations of high performance liquid chromatography (HPLC) detection, no transport values were determined when arachidin-1 and arachidin-3 were applied in 50 and 100 μM concentrations. The findings suggest that arachidin-1 and arachidin-3 inhibit cell proliferation in human colon cancer cells. Further research is needed to understand the bioavailability of arachidin-1 and arachidin-3.

[*] Macy Shirley is a 2017 honors program graduate with a major in Human Nutrition and Hospitality Innovation .
[†] Cindi Brownmiller is a Laboratory Specialist in the Department of Food Science.
[§] Wing Shun Lam is a Graduate student in the Department of Food Science.
[‡] Sun-Ok Lee, the faculty mentor, is an Associate Professor in the Department of Food Science.

Meet the Student-Author

Macy Shirley

I am from Texarkana, Texas and I graduated with honors from Texas High School. I graduated in May 2017 with a Bachelor of Science in Human Environmental Sciences, majoring in Human Nutrition and Hospitality Innovation. During my undergraduate career, I was able to participate in the Pre-Dental Society and Student Dietetics Association, be an active member of Phi Mu Fraternity, participate actively as a member of Cross Church-Fayetteville, volunteer as a Diamond Doll for the University of Arkansas Baseball program, and participate in Cooking for Health, a study abroad program in France during summer 2016.

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Introduction

Cancer is one of the leading causes of mortality in Arkansas and throughout the United States. Specifically, an incidence rate of 50.1 per 100,000 for males and 37 per 100,000 for females exists for colon cancer in Arkansas (Siegel et al., 2017). The mortality rate for colon cancer in Arkansas is approximately 18.2 per 100,000 people, which ranks third highest compared with other states in the United States (National Cancer Institute, 2015).

Genetic and lifestyle factors are potentially influential in the development of colon cancer (Burt et al., 2010). Prevention reduces incidence and mortality rates associated with colon cancer (Siegel et al., 2016). Amin et al. (2009) reported an inverse relationship between a diet rich in fruits and vegetables and diagnosis with colon cancer. This relationship can be attributed to the phytochemicals found in fruits and vegetables (Amin et al., 2009). The peanut plant (*Arachis hypogaea* L.) is a source of phytochemicals known as stilbenoids, which confer cancer preventative properties following extraction from the root or kernel of the peanut plant. Arachidin-1, arachidin-3, and resveratrol are stilbenoids derived from the peanut plant (Huang et al., 2010). While a significant amount of research has been conducted involving resveratrol, there is limited information available about the health-promoting properties of arachidin-1 and arachidin-3 (Chang et al., 2006).

Understanding the bioavailability of phytochemicals is essential for determining their biological and health effects in humans. Therefore, the objectives of the present study were to: 1) determine the effective concentrations of arachidin-1 and arachidin-3 for inhibiting colon cancer cell growth, and 2) assess the intestinal transport of arachidin-1 and arachidin-3 to determine which compound is more bioavailable.

Materials and Methods

Arachidin-1 and arachidin-3 were generously donated by Dr. Medina-Bolivar in their pure form (Arkansas State University, Jonesboro, Ark.). All reagents and media components were purchased from ThermoFisher (Waltham, Mass.).

High Performance Liquid Chromatography Analysis

To measure arachidin-1 and arachidin-3, a System Gold high performance liquid chromatograph (HPLC; Beckman-Coulter, Fullerton, Calif.) with autosampler (model 508), dual pump (model 126), photodiode array detector (model 168) with Beckman-Coulter System 32 Karat software (version 8, 2006) was used. Arachidin-1 and arachidin-3 were separated using the method proposed by Abbott et al. (2010) to ensure use of pure compounds. Separation of the phytochemicals occurred with the Phenomenex

(Torrance, Calif.) Aqua 5 µM C18 (250 × 4.6 mm) column containing a binary gradient of 2% formic acid [mobile phase A] and 99:1 (v/v) acetonitrile/mobile phase A [mobile phase B]. The gradient began with 10% B and increased uniformly to 18% for 8 minutes. The gradient was then held at 18% B for 2 minutes before increasing linearly to 25% B over the course of 5 minutes, and increasing to 35% B for 3 minutes. Then the gradient remained constant and uniform in the mobile phase for 20 minutes at 35%. Mobile phase B increased uniformly to 60% over the course of 59 minutes before returning to the initial binary gradient of 10%. The peaks of arachidin-1 and arachidin-3 were monitored at 340 nm (Bettis, 2016).

Cell Culture

Caco-2 cells, a human epithelial colorectal adenocarcinoma cell line, purchased from American Type Culture collection (ATCC, Rockville, Md.) were incubated at 37 °C in an atmosphere containing 5% CO_2. Cells were cultivated in Dulbecco's Modified Eagle's Medium (DMEM) with 10% fetal bovine serum (FBS), 1% nonessential amino acids solution, and 1% antibiotic-antimycotic (Bettis, 2016; Thurow, 2012). Cell cultures were maintained under sterile conditions and incubated at 37 °C, 70% humidity, and 5% CO_2 in the incubator (VWR® symphony™, VWR® International LLC, Radnor, Pa.).

Cell Viability Assay

Caco-2 cells, passage number 36-42, were used for the viability assay. For a standard curve, cells attached to the chambers of a 96-well microplate (Corning Inc., Tewksbury, Mass.) for 24 hours after being seeded in a range from 0 to 3.2×10^3 cells with 100 µL working media (WMEM). For the experiment, cells (2×10^3) were seeded in wells of a 96 well plate for 24 hours. Three separate plates were prepared for each of the five experiments performed during this study. At the end of the 24 hour period, media was aspirated and cells were treated with 100 µL of 0, 5, 10, or 20 µM concentration of arachidin-1 or arachidin-3. These concentrations were chosen based on results from previous studies evaluating cell viability. Dried arachidin-1 or arachidin-3 was suspended in DMEM in the quantity deemed calculated when the density was converted to moles. The compounds were suspended in media to make a 100 µM stock solution and dilutions with media occurred accordingly. Each treatment was applied in quadruplicate. The control was treated with 100 µL of 0.1% DMSO. Measurements were obtained at 0 (T0), 24 (T24), and 48 (T48) hours following treatment to determine cell viability. When the absorbance was read at T0, T24, and T48, 20 µL of cell titer reagent (CellTiter96® Aqueous One Solution Proliferation Assay, Promega Co., Madison, Wis.) was added to each well. Using a plate reader (Synergy HT Multi-Mode Microplate Reader, BioTek Instruments, Inc. Winooski, Vt.) the absorbance of the cells was measured at 490 nm. This absorbance was converted to the number of viable cells using an equation from the standard curve. Based on the number of viable cells present at T0, a proliferation percentage was calculated for T24 and T48 (Bettis, 2016).

Intestinal Transport Assay

Caco-2 cells were seeded at a density of $1 \times 10^5/cm^2$ cells on polycarbonate membrane inserts (12 mm diameter, pore size 0.4 µm) fitted in bicameral chambers (Corning Inc., Tewksbury, Mass.). Cell monolayer integrity was confirmed by determining the transepithelial electrical resistance (TEER) values using the Millicell ERS-2 Voltohmmeter (EMD Millipore, Billerica, Mass.). After seeding, media was aspirated from both the apical and basal chambers. One mL of phosphate-buffered saline (PBS) was added to the basal chamber and 0.5 mL of 50 and 100 µM arachidin-1 or arachidin-3 was added to the apical chamber.

For time 0 h, transport media containing arachidin-1 (or arachidin-3) was loaded and 0.5 mL of PBS were collected immediately in a vial. Each vial was preserved with 25 µL trifluoroacetic acid (TFA) and 25 µL 70% ethanol. At this point, 0.5 mL of PBS was replaced in the basal chamber. The plate was incubated at 37 °C for 30 minutes. For time 0.5 h and time 1 h, steps performed for time 0 were repeated. The plate was incubated for 1 hour following time 1. At the end of 2 hours, media from the apical was collected in a vial and rinsed with 0.5 mL of PBS three times. Phosphate-buffered saline was removed from the basal chamber, collected in a vial, and rinsed with 1 mL of PBS. Each vial was preserved with 25 µL TFA and 25 µL 70% ethanol. All aliquots were frozen at -20 °C until analysis via HPLC. Apparent permeability coefficients (P_{app}) were calculated using the following equation:

$$P_{app} = \frac{dQ/dt}{C_0 * A}$$

Where dQ/dt is the rate of permeation across the cell, A is the area of the cell monolayer, and C_0 is the initial concentration of the apical chamber.

Statistical Analysis

All statistical analyses were carried out by JMP software v. 13 (SAS Institute, Inc., Cary, N.C.) using a one-way analysis of variance test (ANOVA). The ANOVA results were compared with the student's t test. Data were represented as means ± standard error of mean (SEM). Statistical significance was accepted at $P < 0.05$.

Results and Discussion

Identification of Arachidin-1 and Arachidin-3

Arachidin-1 and arachidin-3 used for this experiment were identified as pure compounds at 304 nm (Fig. 1).

Cell Viability after Arachidin-1 and Arachidin-3 Treatment

Arachidin-1 and arachidin-3 treatments (10 µM and 20 µM) reduced cell viability compared to control (Figs. 2 and 3). At the 48 hour time point, 10 and 20 µM concentrations of arachidin-1 resulted in a significant reduction of cell viability (%) compared to the control ($P < 0.05$) (Fig. 2). There was no significant difference of cell viability between treatments and control at time point 24 hours. The cell viability was significantly reduced in treatments of 10 and 20 µM arachidin-3 compared to 5 µM arachidin-3 and the control at time point 48 hours ($P < 0.05$; Fig. 3). At time point 48 hours, 10 and 20 µM concentrations of arachidin-1 showed the lowest cell viability in comparison with cell viability measured after treatments of 10 or 20 µM arachidin-3 or control ($P < 0.05$; Fig. 4).

Intestinal Transport Assay of Arachidin-1 and Arachidin-3 Treatment

Arachidin-1 was not detected in samples from both apical and basal chambers treated with 50 µM or 100 µM at time point 2 hours (Fig. 5). At time point 2 hours, a trace amount

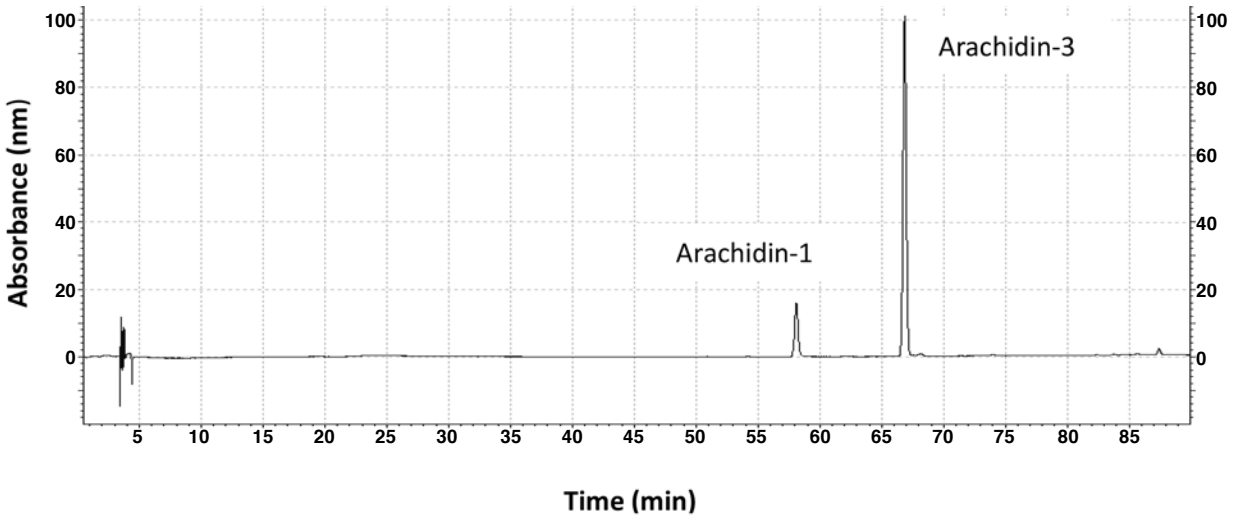

Fig. 1. High Performance Liquid Chromatogram of arachidin-1 and arachidin-3 at 340 nm.

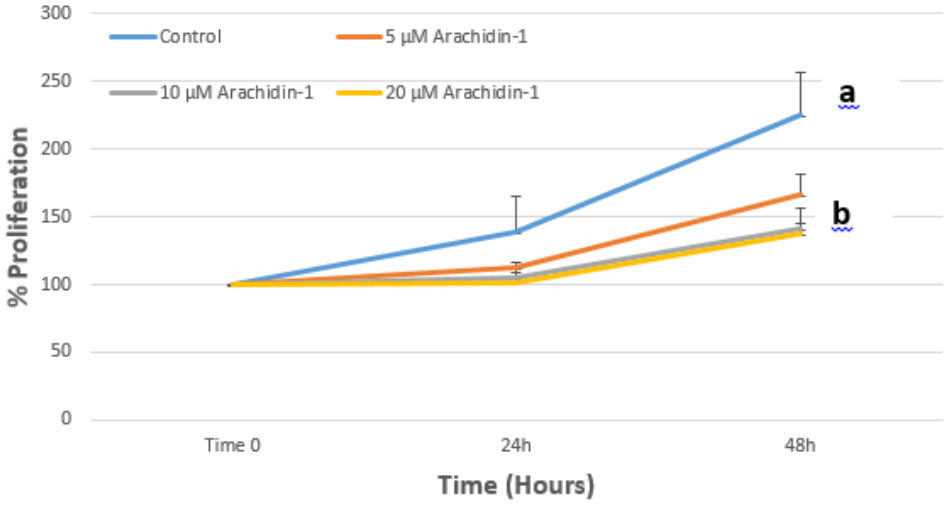

Fig. 2. Effect of arachidin-1 on the survival of Caco-2 cells. Values with different letters at the same incubation time are significantly different ($P < 0.05$).

of arachidin-3 was detected in apical sample treated with 100 µM (Fig. 6). Apparent permeability coefficient (P_{app}) values of arachidin-1 and archidin-3 were not determined.

The peanut root contains phytochemicals that confer anticancer and anti-inflammatory effects to the body for a nutraceutical approach. Arachidin-1 and arachidin-3 have been involved in limited research regarding their health effects for cancer prevention. Therefore, the anti-colon cancer activity and bioavailability of arachidin-1 and archidin-3 have been investigated in this study.

In order to understand the anticancer properties linked with arachidin-1 and arachidin-3, it is important to evaluate the effect of these compounds on colon cancer cell proliferation. In the present study, both arachidin-1 and arachidin-3 treatments (10 and 20 µM) resulted in reduced cell proliferation rates compared with the control ($P < 0.05$). The most significant reduction of cell proliferation occurred at time point 48 hours when arachidin-1 was applied at concentrations of 10 and 20 µM in comparison with the control or 5, 10, and 20 µM arachidin-3 treatments ($P < 0.05$).

A few studies have investigated the anticancer properties of arachidin-1 and arachidin-3 in different cell lines with different concentrations of stilbenoids (Ball et al., 2015; Huang et al., 2010; Ko et al., 2013). Cell viability results

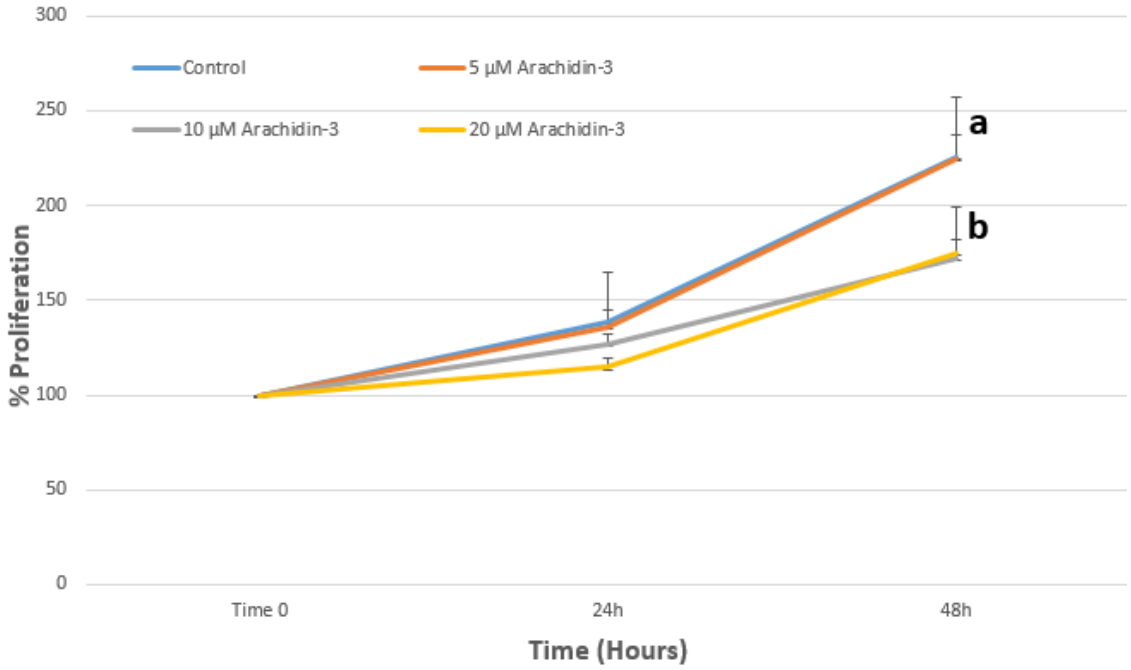

Fig. 3. Effect of arachidin-3 on the survival of Caco-2 cells. Values with different letters at the same incubation time are significantly different ($P < 0.05$).

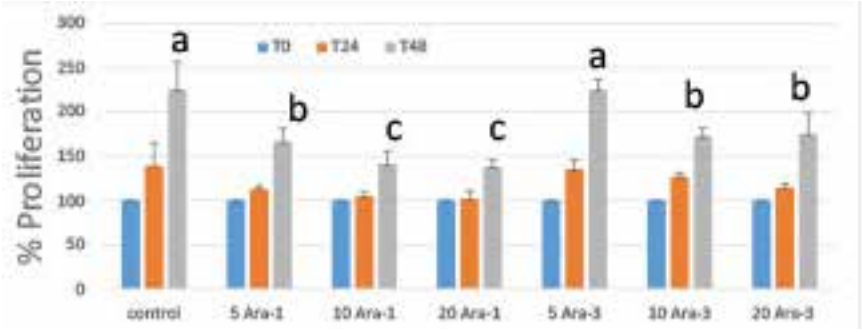

Fig. 4. Summarized effects of arachidin-1 and arachidin-3 on the survival of Caco-2 cells. Values with different letters at the same incubation time are significantly different ($P < 0.05$).

from a study on the effect of 0 to 20 μM concentrations of arachidin-1, arachidin-3, and resveratrol on human leukemia cell (HL-60) proliferation reported that arachidin-1 resulted in reduced cell viability (Huang et al., 2010). Another study investigated the effects of metformin and arachidin-1 upon dose-dependent application to A549 and H1975 human lung cancer cell lines. Metformin is an anti-diabetic drug associated with anticancer properties. Treatments of 0.5, 1, 5, and 10 μM arachidin-1 with 25 μM metformin over the course of a 4-day incubation period resulted in reduced cell viability. (Ko et al., 2013).

The 10 and 20 μM concentrations of arachidin-1, resveratrol, piceatannol, and arachidin-3 were applied to rotavirus infected HT29.F8 cells from the human adenocarcinoma line of the intestine. These concentrations of stilbenoids did not decrease cell viability substantially. However, application of arachidin-1 or arachidin-3 resulted in reduced viral replication and can be attributed to an-

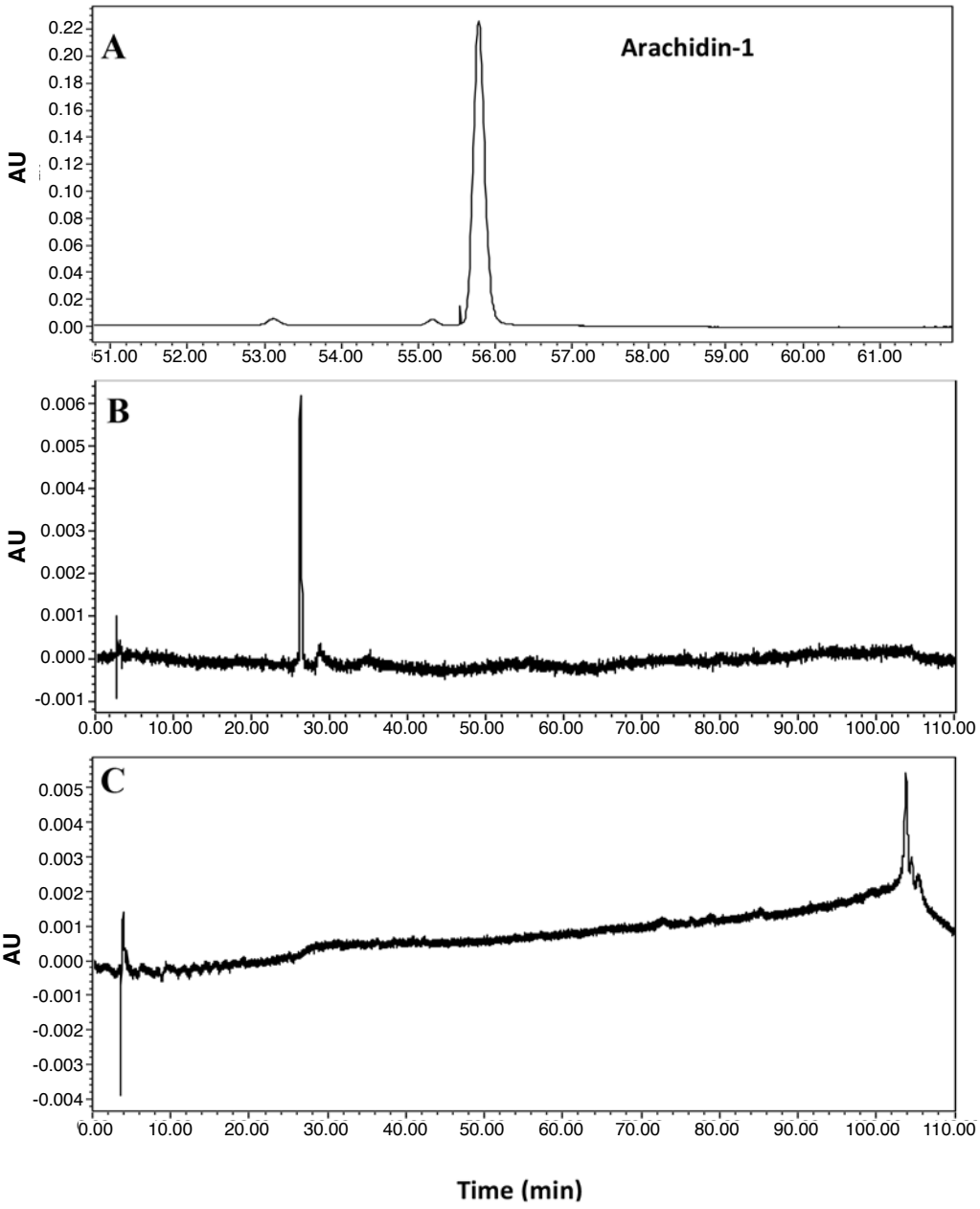

Fig. 5. High performance liquid chromatogram of (A) arachidin-1 standard, (B) apical sample treated with 100 μM of arachidin-1 and (C) basal sample treated with 100 μM of arachidin-1 at time point 2 hours.

tioxidant activity of these compounds (Ball et al., 2015). Additional research must be conducted to understand the effects of stilbenoids from the peanut plant on cell viability.

Previous studies regarding the transport abilities of arachidin-1 and arachidin-3 have not been conducted. Due to the limitations of detection in the HPLC system, the apparent transport of arachidin-1 and arachidin-3 were not calculated. Additional research must be conducted with higher concentrations of arachidin-1 and arachidin-3 to evaluate bioavailability.

Conclusions

The results of this study indicate that concentrations greater than 10 μM arachidin-1 and arachidin-3 reduced cell viability in colon cancer cells in comparison with the control. Arachidin-1 was more effective for inhibiting cell proliferation than arachidin-3. No apparent intestinal transport occurred, so it is likely that concentrations of arachidin-1 and arachidin-3 greater than 100 μM are needed to determine bioavailability. Additional research is

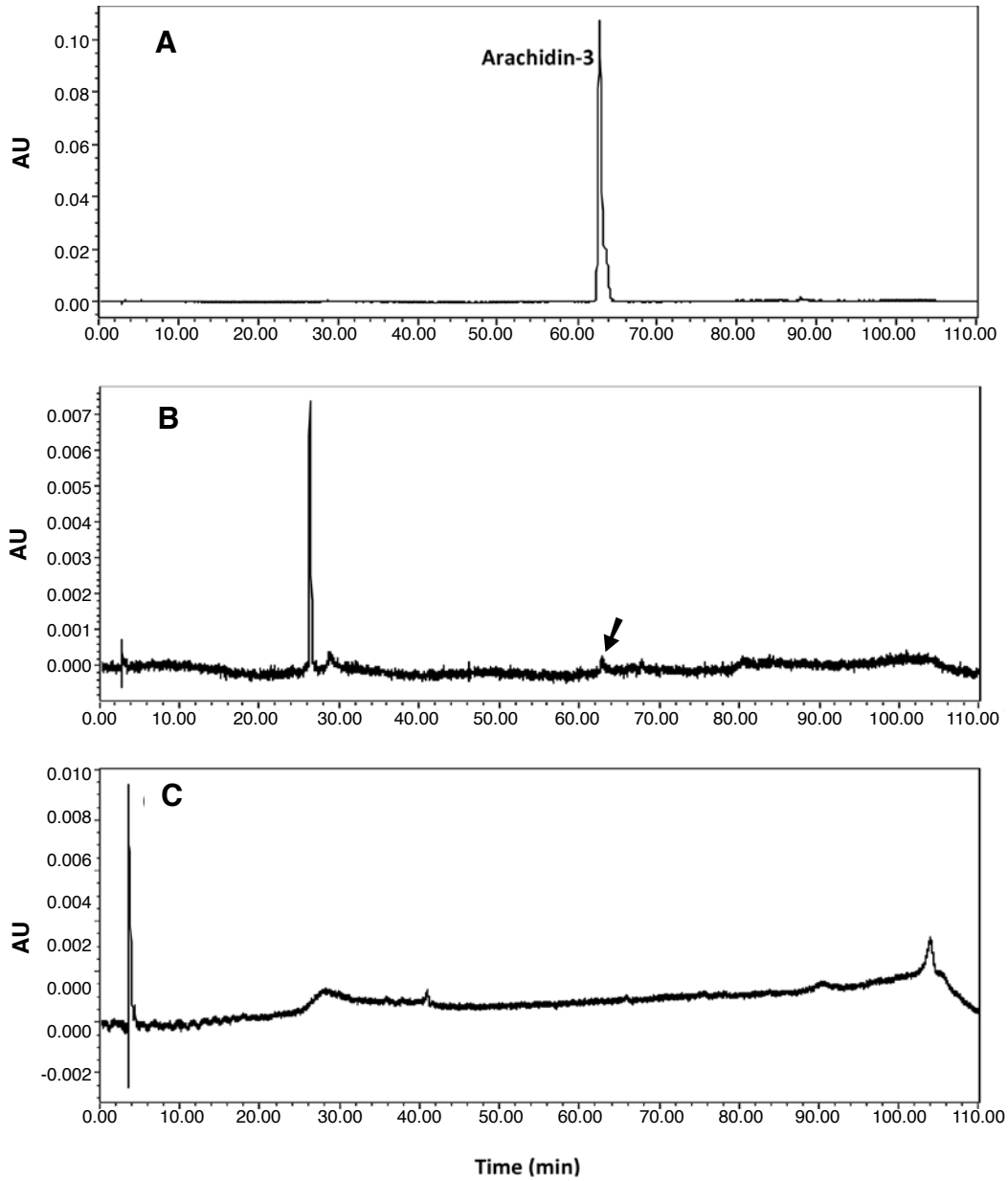

Fig. 6. High performance liquid chromatogram of (A) arachidin-3 standard, (B) apical sample treated with 100 μM of arachidin-3 and (C) basal sample treated with 100 μM of arachidin-3 at time point 2 hours.

needed to establish the chemopreventative or nutraceutical applications of arachidin-1 and arachidin-3.

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Literature Cited

Amin, A. R. M. R., O. Kucuk, F. R. Khuri, and D. M. Shin. 2009. Perspectives for cancer prevention with natural compounds. J. Clin. Onc. 27(16):2712–2725.

Abbott, J.A., F. Medina-Bolivar, E.M. Martin, A.S. Engelberth, H. Villagarcia, E.C. Clausen, and D.J. Carrier. 2010. Purification of resveratrol, arachidin-1, and arachidin-3 from hairy root cultures of peanut (*Arachis hypogaea*) and determination of their antioxidant activity and cytotoxicity. Biotech. Prog. 26(5):1344-1351.

Ball, J.M., F. Medina-Bolivar, K. Defrates, E. Hambleton, M.E. Hurlburt, L. Fang, T. Yang, L. Nopo-Olazabel, R.L. Atwill, R. Ghai, and R.D. Parr. 2015. Investigation of stilbenoids as therapeutic agents for rotavirus gastroenteritis. Adv. Virol. 2015. Article ID293524. 10 pp.

Bettis, J.L. 2016. Effects of arachidin-1 and arachidin-3 on human colon cancer cells. Biol. Sci. Undergrad. Honors Theses.

Burt, R.W., K.W. Jasperson, D.W. Neklason, and T.M. Tuohy. 2010. Hereditary and familial colon cancer. Gastroenter. 138(6):2044-2058.

Chang, J. C., Y. H. Lai, B. Djoko, P. L. Wu, C. D. Liu, Y. W. Liu, and R. Y. Y. Chiou. 2006. Biosynthesis enhancement and antioxidant and anti-inflammatory activities of peanut (*Arachis hypogaea* L.) arachidin-1, arachidin-3, and isopentadienylresveratrol. J. Agri. Food Chem. 54(26):10281-10287

Huang, C.P., L.C. Au, Y.Y. Chiou., P.C. Chung, S.Y. Chen, W.C. Tang, C.L. Chang, W.H. Fang, and S.B. Lin. 2010. Arachidin-1, a peanut stilbenoid, induces programmed cell death in human leukemia HL-60 Cells. J. Agri. Food Chem. 58 (23):12123-12129.

Ko, J.C., Y.C. Huang, H.J. Chen, S.C. Tseng, H.C. Chiu, T.Y. Wo, Y.J. Huang, S.H. Weng, R.Y. Choiu, and Y.W. Lin. 2013. Metformin induces cytotoxicity by down-regulating thymidine phosphorylase and excision repair cross-complementation 1 expression in non-small cell lung cancer cells. Basic Clin. Pharm. Toxicol. 113(1):56-65.

National Cancer Institute. 2015. Probability of developing or dying of cancer software, version 5.2 statistical research and applications branch. NCI. Accessed 19 March 2017. Available at: http://srab.cancer.gov/devcan.

Siegel, R.L., Miller, K.D., Jemal, A. 2016. Cancer statistics, 2016. CA Cancer J Clin. 66 (1):7-30.

Siegel, R.L., Miller, K.D., Jemal, A. 2017. Cancer statistics, 2017. CA Cancer J Clin. 67 (1):7-30.

Thurow, T. 2012. Effect of chlorogenic acid and neochlorogenic acid on human colon cancer cells. Food Sci. Undergrad. Honors Theses. University of Arkansas, Fayetteville.

Love-bombing: a narcissistic approach to relationship formation

Claire C. Strutzenberg[*]*, Jacquelyn D. Wiersma-Mosley*[†]*, Kristen N. Jozkowski*[§]*, and Jennifer N. Becnel*[‡]

Abstract

The current study examined the relationship between attachment style, self-esteem, and narcissism as they pertain to behavioral tendencies, termed love-bombing behaviors, among a sample of young adult millennials. Love-bombing was identified as the presence of excessive communication at the beginning of a romantic relationship in order to obtain power and control over another's life as a means of narcissistic self-enhancement. Millennials have shown a drastic increase in narcissism compared to generations prior, and the need for psychological services on college campuses has also increased. This study sought to establish empirical evidence for the presence of love-bombing behaviors amongst millennials as a gateway for further research to address the problem facing young adult relationships today. The sample consisted of 484 college students from a large southern university who ranged in age from 18 to 30. Results indicated that love-bombing was positively correlated with narcissistic tendencies and insecure attachment styles (lack of trust or value in self and others), and negatively associated with self-esteem. Secure attachment was a positive indicator of love-bombing behaviors. Lastly, love-bombing was also associated with more text and media usage within romantic relationships. In conclusion, love-bombing was found to be a logical and potentially necessary strategy for romantic relationships among individuals with high displays of narcissism and low levels of self-esteem. This is the first study to empirically examine love-bombing behaviors; thus, future research should address the impact that these behaviors may have on young adult relationships. The potential for negative psychological impact on both love-bombers and the subject of their attacks are discussed.

* Claire C. Strutzenberg is a December 2016 honors program graduate with a degree in Human Development and Family Sciences.
† Jacquelyn D. Wiersma-Mosley, the faculty mentor, is an Associate Professor in the School of Human Environmental Sciences.
§ Kristen N. Jozkowski is an Associate Professor and Program Coordinator for the Department of Public Health and a Research Fellow at The Kinsey Institute for Research in Sex, Gender, and Reproduction.
‡ Jennifer N. Becnel is an Assistant Professor in the School of Human Environmental Sciences.

Meet the Student-Author

Claire Strutzenberg

I am from Des Moines, Iowa, and graduated from Urbandale High School in 2012. After graduation, I attended a gap year program in Branson, Missouri for one year, and then participated in an internship in Branson the following year. After having fallen in love with the Ozarks, I applied to the University of Arkansas and began my degree in Human Environmental Sciences in the fall of 2014. While pursuing a major in Lifespan Development and a minor in Communications, I was given numerous opportunities to learn from the excellent faculty of Bumpers College in a number of ways. I am immeasurably grateful for those experiences, but especially to Dr. Jacquelyn Wiersma-Mosley for the countless hours she put into helping me with my honors thesis project. Her effort and passion for research showed me a whole new side of academia, and allowed me to learn about the process of conducting research studies that further our understanding of the world around us and the people within it. Additional thanks expressed to Dr. Kristen Jozkowski and Dr. Jennifer Becnel for their direct contribution to this project. After graduating from Bumpers College in December of 2016, I began a graduate program at the University of Arkansas in order to earn my Master of Arts in Communication.

Introduction

The rise in narcissism among millennial generation college students (i.e., those born between 1980 and 2000; Twenge et al., 2008a; Twenge et al., 2008b), has resulted in a trend that has been termed "love-bombing" by internet users. Anecdotal bloggers have described love-bombing as the tendency of narcissistic individuals to "bomb" their significant other with constant communication via texts, emails, phone calls, and social media sites. The praise from the narcissist to their relational partner may be flattering at first, but over time, becomes overwhelming and sometimes debilitating. It is assumed that whether consciously or not, the narcissist is making an effort to secure their place as the most important person in their significant other's life. Narcissists ultimately praise themselves by way of praising their significant other in hopes that their partner will return the praise, but eventually the narcissist's excessive flattery and need for affirmation will result in the end of a relationship when it becomes apparent that the misplaced affection reaches no further than the narcissist's affection for him/herself (Campbell and Foster, 2002).

Millennials have been described as optimistic, team-oriented, and high-achieving rule followers in many of the studies conducted by generational specialists (Broido, 2004); yet millennials simultaneously show a higher likelihood of mental health problems compared to generations prior (Watkins et al., 2012). When surveyed, more than one in three undergraduate students reported experiencing depressive symptomology and nearly one in ten students expressed that they had contemplated suicide (American College Health Association, 2008). Depression, coupled with low self-esteem often leads individuals to engage in reassurance-seeking behaviors; a need for affirmation that coincides with the definition of narcissism (Campbell et al., 2002). A study that compared reports of college students in the 1980s to similar data collected in 2008 found a significant gradual increase in narcissism (Twenge et al., 2008a). This increase in narcissism, along with other mental health disorders could, as Bennett (2006) suggests, be the result of the influence of attachment patterns on the internal working model of the individual, which could lead to the display of more severe personality disorders later in life. The current study examines the connection among attachment styles, self-esteem, and narcissism with love-bombing tendencies.

Attachment Theory

Attachment theory (Bowlby, 1958) is a widely held view in the field of human development that suggests the security of an individual throughout the lifespan stems from the interactions between a child and their caregiver (Bowlby, 1980). The child's expectations of others develop based on their understanding of how the world operates, and

is the basis of an internal working model that will determine the individual's view of self and of others in infancy, adolescence, and adulthood (Bowlby, 1980; Lee and Hankin, 2009). Those with secure attachment feel protected, and they know that they can depend on others, including parents and romantic partners. Insecurely attached individuals develop an internal working model of themselves as unworthy and of others as unreliable (Thompson and Zuroff, 1999) and are subcategorized as being either avoidant or anxious. Avoidant attachment is characterized by a tendency to view others as unreliable and holding a high resistance to emotional attachment (Bowlby, 1980). Alternatively, anxious attachment is characterized by a strong desire for emotional attachment, while simultaneously doubting the reliability of others to reciprocate this affection (Bowlby, 1980).

Roberts et al. (1996) found that individuals with insecure attachment view their self-worth according to an "if… then" contingency, basing self-esteem on accomplishment or success/failure. For instance, an individual with insecure attachment may think, "If my partner doesn't respond to my text message, they must not love me" or "If they cared, then they would call." When these contingencies affirm the insecurity the individual already feels, the result is a significant decline in self-esteem (Roberts et al., 1996).

Self-Esteem

Self-discrepancy theory, developed by Higgins (1987) and expanded by Ogilvie (1987), suggests that there are four domains of "self": actual-self, ideal-self, should-self, and undesired/feared-self. Self-discrepancy theory postulates that the "self" portrayed to others is based on not only self-concept, but also the interpretation of what others expect. The "actual" self represents the attributes one actually possesses (Higgins, 1987). The discrepancy lies in the differences between the attributes we actually possess, the attributes we wish we could display (ideal-self), the things that we believe we ought to display (should-self), and the attributes we fear displaying (feared-self; Carver et al., 1999; Higgins, 1987). These views of self are the standard to which we compare our actual-self, and represent the valence, or the extent of positive or negative value, with which we hold our view of self.

A study addressing the self-discrepancy theory conducted by Barnett and Womack (2015) explored the association between self-esteem and narcissism: "Pathological narcissism is a duality; a deep insecurity shrouded by grandiosity … Narcissism does not flow from excessive self-love as much as it does from fear of being an undesired self". This indicates that narcissism is more strongly correlated with low self-esteem, or the fear of being undesired, than self-confidence. Out of the urgency to resist an undesirable representation of self, individuals with low self-esteem will engage in reassurance-seeking behaviors (Higgins, 1987). This reassurance may be sought in the form of seeking excessive feedback that affirms others' care, or by expressing high needs of dependency in relationships (Katz et al., 1998), as in love-bombing behaviors.

Narcissism

Narcissism is defined by the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders (5th ed., 2013) as holding beliefs about being special or unique and the assumption of only being understood by special or high-status people or institutions, as well as requiring excessive admiration, experiencing frequent envy, and displaying arrogant or haughty attitudes and behaviors. Narcissism can present itself in multiple different ways such as "one who aims to enhance ego, pursues success, acts autonomously and chooses short-term goals that will result in admiration from others" (Rogoza et al., 2016). Narcissism has also been described as being characterized by entitlement in relationships, self-indulgence, self-assuredness, and disrespect for the needs of others, which leads to both aggressive behaviors and the generalized devaluation of others (Brown et al., 2009; Paulhus, 1998; Rogoza et al., 2016).

The narcissist's ideal mate is someone who is highly positive, admires them, and enhances their self-worth either directly through praise, or indirectly by association as in that of a "trophy spouse" (Campbell et al., 2002). Narcissists often see relationships as a "forum for self-enhancement" (Buffardi and Campbell, 2008). There are attributes of narcissists that make them attractive to those whom they may seek out and ultimately victimize via love-bombing behaviors. Narcissists are generally perceived as exciting (Foster et al., 2003), socially confident (Brunell et al., 2004), and likeable in initial interactions (Oltmanns et al., 2004). Though these attributes are attractive in the beginning, they fade throughout the course of the relationship, revealing the tendency of narcissists to use relationships as a means of self-enhancement (Campbell, 1999). In turn, the "victims" of relationships with these initially likable narcissists find themselves stuck with psychologically controlling, non-committal partners, often characterized by "game-playing" in relationships (Campbell and Foster, 2002).

Researchers have identified that narcissists consistently use social relationships for three main purposes: to regulate their personal self-esteem, to create a positive self-concept, and to produce a self-gratifying personal construct (Buffardi and Campbell, 2008; Campbell, 1999; Campbell et al., 2006; Morf and Rhodewalt, 2001; Raskin et al., 1991). Essentially, narcissists rely on their interactions with others to determine how they feel about themselves. For that reason, individuals with low-self-esteem will engage in reassurance-seeking behaviors in romantic relationships,

especially when they are depressed (Campbell et al., 2002). This desire for reassurance sought through romantic relationships is more than likely to involve love-bombing behaviors, because of the narcissist's desire for affirmation by means of association.

It has been asserted by Buffardi and Campbell (2008) that social networking sites such as Facebook act as a low-risk, high-reward resource for narcissists to self-regulate through social connectivity. Social networking sites allow individuals to feel connected by promoting high numbers of "friendships," while simultaneously protecting themselves from the necessity of emotional disclosure (Buffardi and Campbell, 2008). The current study is not assessing romantic relationships through social networking sites, and instead seeks to understand how narcissistic tendencies in romantic relationships will reflect a high usage of mediated communication, primarily via text messaging, in order to maintain the same level of self-presentation control.

Current Study

Although there have been anecdotal assertions made regarding the existence of "love-bombing" tendencies among millennials, no empirical study has assessed this form of narcissism within the context of romantic relationships. The current study addresses this gap via three main goals: 1) identify love-bombing behaviors among millennial young adults; 2) correlate love-bombing behaviors with other similar construct scales, such as attachment, self-esteem, and narcissism; and 3) identify characteristics of love-bombers in order to better understand their behaviors within romantic relationships concerning texting and social media usage. The current study's hypotheses include: love-bombing behaviors would be positively associated with insecure attachment styles (i.e., avoidant, anxious) and narcissistic tendencies, while negatively associated with secure attachment styles and self-esteem; and love-bombers would be more likely to use texting to communicate with their romantic partners as compared to non love-bombers.

Materials and Methods

Participants and Procedure

A survey was constructed to measure attachment, self-esteem, narcissism, love-bombing, and text message use in young adult romantic relationships. The survey was distributed online to graduate and undergraduate students recruited from predominately social science classes at a large southern university. Participants were given the chance to enter their name for a drawing for a $50 gift card, and some participants were offered extra credit by their professors for their participation. Of 499 total participants, those who failed to complete the questionnaire, or did not take adequate time to thoughtfully answer each question (total duration 2 minutes or less) were dismissed from the analysis (n = 15), resulting in a final sample of 484. The final sample had a mean age of 20.36 (SD = 1.38; range 18–30; 86% female). In the sample, 84% of the participants identified as Caucasian, 5% as Hispanic/Latino, 4% as African American, while 9% identified as other.

Measures

Attachment. Participants completed the Adult Attachment Scale (AAS; Collins and Read, 1990). The AAS contains 18 statements on a five-point Likert-type scale (1 = strongly disagree; 5 = strongly agree). After reverse coding five items, responses were summed and grouped according to a subscale as secure (6 items, mean (*M)* = 17.95, SD = 2.67), anxious (6 items, *M* = 17.98, SD = 5.06), or avoidant (6 items, *M* = 17.20, SD = 4.18). Higher scores indicated higher secure, avoidant, and anxious attachment styles.

Self-Esteem. Participants completed the Rosenberg Self-Esteem scale (RSES; Rosenberg, 1965). Each of the ten items were measured on a five-item Likert-type scale (1 = strongly disagree; 5 = strongly agree). After recoding 5 items, all items were summed, and higher scores indicated higher self-esteem (*M* = 36.93, SD = 6.56).

Narcissism. Participants completed the Hypersensitive Narcissism Scale (HSNS; Hendin and Cheek, 2013). The HSNS is a 10-item scale to measure an individual's tendency towards narcissism. Participants were asked to answer to each item on a five-point Likert-type scale (1 = strongly disagree; 5 = strongly agree). Level of agreement was summed, with higher scores indicating higher levels of narcissism (*M* = 28.67, SD = 5.66).

Love-Bombing. A set of 8 items regarding specific love-bombing behaviors was created for the current study, based on previous literature regarding the tendencies of narcissists in romantic relationships (Campbell, 1999; Campbell et al., 2002; Campbell and Foster, 2002; Foster et al., 2006; Oltmanns et al., 2004) as well as assertions made by anecdotal accounts published to internet blogs. These items (shown in Table 1) were measured on a five-point Likert-type scale (1 = strongly disagree; 5 = strongly agree). Items were summed, with higher scores indicating increased display of love-bombing behaviors (*M* = 22.26, SD = 4.75, Range: 8–37). The created items were reliable (α = 0.74).

Texting. An adapted 21-item scale was created to examine text message usage between romantic partners rather than friendships (Hall and Baym, 2011). Participants were asked to answer each item on a five-point Likert-type scale (1 = strongly disagree; 5 = strongly agree). One item was reverse coded, and items were summed with higher scores indicating higher levels of text usage between romantic partners (*M* = 66.17, SD = 11.41; α = 0.89; see Table 2 for scale items).

Statistical Analyses

The current study sought to identify characteristics of love-bombing behaviors in millennial college students. First, correlations were run among love-bombing behaviors and measures of attachment, self-esteem, narcissism, and millennials' use of texting in romantic relationships. Next, in order to examine group differences among "love-bombers" and "non love-bombers", participants with scores from the 8-item love-bombing scale greater than the mean (22.26) were placed into the group "love-bombers" (n = 230, 48%), and those participants with scores less than the mean were placed in the group "Non love-bombers" (n = 254, 52%). Finally, a *t*-test was conducted to compare the two groups on text message usage.

Results and Discussion

There were significant correlations in most of the predicted directions (Table 3): love-bombing tendencies were not only positively associated with insecure attachment styles (i.e., avoid, anxious), but also positively (not negatively, as predicted) associated with secure attachment style ($r = 0.17$, $P < 0.001$). Self-esteem was negatively correlated with love-bombing behaviors, and narcissistic tendencies were positively associated with love-bombing behaviors. love-bombing items (higher scores indicating higher love-bombing behaviors) were significantly and positively correlated ($r = 0.32$, $P < 0.001$) with the total summed response of texting habits. This correlation supports the hypothesis that love-bombing behaviors are correlated with higher text message expectations within romantic relationships. Next, a *t*-test was run to examine whether the two groups (love-bombers and non love-bombers) differed significantly on text message usage within romantic partnerships, indicating a significant group difference ($t = 5.08$, $P < 0.001$). Love-bombers reported significantly higher text usage within their romantic partnerships ($M = 68.95$, SD = 10.75) as compared to non love-bombers ($M = 63.69$, SD = 11.43).

The current study demonstrated that love-bombing behaviors are prevalent among young adult millennials. By identifying items to describe love-bombing behaviors, it was found that individuals who display love-bombing behaviors are likely to act from an insecure attachment, perhaps leading them to rely on the affirmation of another person to determine their self-worth and value within society. Contrary to the hypothesis, the current study also found that love-bombing was positively correlated with higher secure attachment. While attachment as a scale may not be a clear indicator of love-bombing tendencies, it is likely that further research would display categorical attachment styles having a direct correlation to the presence of love-bombing behaviors in romantic relationships. Further research is needed to identify developmental processes that might lead individuals to engage in love-bombing behaviors. Perhaps the use of qualitative methods could provide further insight as to the establishment of attachment, and disentangle the presence of secure attachment in these individuals.

There was also a significant negative correlation between self-esteem and the display of love-bombing behaviors. The contingency of self-esteem placed on another individual is inevitably going to cause one's view of self to waiver. When an individual's self-esteem is high, there is no need to look for affirmation in another individual. However, when an individual's self-esteem is low, it is like-

Table 1. Love-bombing items.

		M	SD
1.	When past relationships have ended, I have realized that I was more invested in the relationship than my partner was.	3.19	1.05
2.	I desire praise/appreciation/ affirmation to be communicated by my partner.	3.90	0.80
3.	I feel as though the presence of my partner increases my social standing.	2.97	0.95
4.	I feel more confident and secure when I am in a relationship.	3.04	1.07
5.	I am insecure with the idea of being single.	2.38	1.04
6.	I am only content in a relationship until I find another, better option of a partner.	1.93	0.91
7.	I view relationships as a means to feel better about myself.	2.16	0.99
8.	When I feel insecure, I like to turn to another person to assure me of my worth	2.69	1.14

Note: These are items asked in questionnaire with means and standard deviations ($N = 484$).

Table 2. Text message usage items.

		M	SD
1.	Texting plays an important role in my dating life.	3.51	0.93
2.	I usually ask someone out through the use of text/phone, rather than in person.	2.47	1.00
3.	Texting is a good way to flirt or get to know someone.	3.46	0.97
4.	I enjoy texting my partner.	3.89	0.76
5.	Texting is my partner and I's primary form of communication.	2.95	1.14
6.	I would like it if my romantic partner used texting more to communicate.	2.60	0.94
7.	I share many of my day-to-day activities through texting with my partner.	3.48	0.99
8.	Texting is an ongoing conversation that I usually have with a dating partner.	3.94	0.93
9.	I expect my dating partner to call/text throughout the day to keep me posted on how their day is going.	3.35	1.00
10.	I like it when my partner keeps me informed as to what they are doing and who they are with throughout the day through texting.	3.42	1.00
11.	I feel disconnected from my dating partner when I have not heard from them via text.	3.10	1.02
12.	When my partner does not text me throughout the day, I often question how important I am in their life.	2.59	1.08
13.	When my partner takes longer than usual to respond, I often feel forgotten about or insignificant to them.	2.58	1.05
14.	I respond to texts immediately when I receive them from my partner.	2.98	0.94
15.	When my partner or significant other texts me first, I feel as though I have a level of significance/importance in their lives.	3.45	0.90
16.	I immediately text my partner when I want to tell them something, rather than waiting until we could talk about it in person.	3.40	0.89
17.	I prefer to communicate with my dating partner mainly through text/social media.	2.12	0.89
18.	I get upset when I can't get ahold of someone I'm dating/seeing.	3.28	0.97
19.	I often send my partner texts to express my affection for him/her.	3.33	0.96
20.	When I express my feelings for my partner via text or social media, I expect my partner to reciprocate by expressing their feelings for me.	3.18	1.00
21.	I find it annoying when a romantic partner texts me multiple times an hour, multiple times throughout the day.	3.44	1.07

Note: These are items asked in questionnaire with means and standard deviations (*N* = 484).

ly, as suggested by the current study, that they will engage in love-bombing behaviors in order to increase the feeling of being valued in a relationship and reduce the potential of becoming an undesired self. This fear of becoming an undesired self is often what pushes individuals to pursue behaviors in which they are displayed as their ideal-self (Barnett and Womack, 2015). So if it is assumed that individuals with low self-esteem partake in love-bombing behaviors as a means of confirming the fact that they are not, actually, undesirable, then it could be assumed that they are simultaneously seeking to become the ideal form of themselves by engaging in narcissistic behaviors which aim to increase their self-esteem, thereby producing a positive self-concept and a satisfactory personal construct (Buffardi and Campbell, 2008; Campbell, 1999; Campbell et al., 2006; Morf and Rhodewalt, 2001; Raskin et al., 1991). Narcissists of the millennial generation are facing relational problems that are ultimately ultimately increasing the number of romantic partners an individual may have, while decreasing the level of significance of these relationships, and increasing the average age of first marriage compared to generations prior (Kaya, 2010; Twenge et al., 2015). The current study supports these assumptions by indicating a strong correlation between narcissism and the likelihood that an individual would partake in love-bombing behaviors.

Love-bombing was also positively associated with excessive expectations for communication through texting in romantic relationships. This correlation, though not surprising, indicates a need for self-regulative protection and a desire for control in a relationship. The root of this need for security and power is not easily identifiable to those affected by the love-bomber's attacks, but is an obvious consequence of a psychological need for affirmation. It could be assumed that narcissistic individuals not only require more control in a relationship, but simultaneously increased affirmation. Because there is a strong correlation between self-esteem and narcissism (Barnett and Womack, 2015), we see that narcissists, by engaging in love-bombing behaviors, seek reassurance in their romantic relationships. This may involve a lack of trust in their partner's fidelity as expressed by the expectation that they would want to know their partner's whereabouts at all times, as is implied by an insecure-anxious attachment style. Additionally, narcissistic individuals with an insecure-anxious attachment style may doubt that their partner's feelings for them are truly as strong as their own. In the case of a narcissist with low self-esteem, love-bombing is a potential means of survival for a romantic relationship, especially within the early stages. These feelings are only increased when the individual holds an insecure attachment. For that reason, love-bombing may continue to present itself in romantic relationships of individuals who display higher than average levels of narcissism, and low levels of self-esteem.

Limitations and Implications

The sample was collected from mostly female college students on one campus at a public university. Thus, it would be fruitful to increase diversity in order to obtain a more generalizable sample; data from additional college campuses would also increase generalizability. Perhaps, with an equal balance of participants identifying as women and men, future analyses could identify whether love-bombing behaviors differ by gender within romantic relationships. Additionally, the range of ages sampled was between 18 and 30, however, the study aimed to look at the entire population of "millennials"; this group's age ranges from 16 to 36 (Beaton, 2016). Thus, there is a substantial segment of this demographic unaccounted for in the sample.

The current study identified that love-bombing is a sometimes psychologically necessary means by which relationships are formed for the narcissistic individual; however, there is no data regarding the characteristics of those affected, or the long-term effect of love-bombers' narcissistic displays on their victims. Future research should examine the characteristics of those prone to experiencing love-bombing attacks in romantic relationships, and the impact of these failed relationships on the individual's mental health. Additionally, love-bombing behaviors could be a

Table 3. Correlations of love-bombing behaviors.

Variables	LBOMB	SECURE	AVOID	ANXIETY	SELFEST	NARCISSISM	TEXT USAGE
LBOMB		0.167**	0.126**	0.357**	-0.279**	0.482**	0.320**
SECURE			0.129**	0.217**	-0.062	0.244**	0.052
AVOID				0.580**	-0.430**	0.351**	0.095*
ANXIETY					-0.514**	0.527**	0.235**
SELFEST						-0.458**	-0.108*
NARCISSISM							0.307**
TEXT USAGE							

Note: LBOMB = Love-bombing behaviors; SECURE = secure attachment; AVOID = avoidant attachment; ANXIETY = anxious attachment; SELFEST = self-esteem; NARCISSISM = narcissistic behaviors; TEXT USAGE = texting behaviors. $N = 484$. * $P < 0.05$; ** $P < 0.001$ (2-tailed).

gateway into more serious behaviors such as psychological abuse/control or intimate partner violence, which warrants further research.

In conclusion, the current study suggests that narcissists, driven by their low self-esteem, are likely to engage in love-bombing behaviors as well as excessive text messaging in romantic relationships. For this reason, it is important that researchers develop a means of recognizing these maladaptive behaviors early, in order to prevent problems from escalating into harmful interpersonal relationships.

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Literature Cited

American College Health Association. 2008. American College Health Association–National College Health Assessment: Reference Group Data Report. pp. 14. American College Health Association, Baltimore, Md.

American Psychiatric Association. 2013. Diagnostic and Statistical Manual of Mental Disorders. 5th ed. American Psychiatric Association.

Barnett, M.D., and P.M. Womack. 2015. Fearing, not loving, the reflection: Narcissism, self-esteem, and self-discrepancy theory. Pers and Ind Diff. 74:280-284.

Beaton, C. 2016. The oldest Millennials just turned 35: How gen Y is growing up, getting wise and beating the odds. Forbes. Accessed 11 October 2016. Available at: https://www.forbes.com/sites/carolinebeaton/2016/02/29/the-oldest-millennials-just-turned-35-this-is-how-gen-y-ages/#5a758f3368d9

Bennett, C.S. (2006). Attachment theory and research applied to the conceptualization and treatment of pathological narcissism. Clin Soc Work J. 34:45-60.

Bowlby, J. 1958. The nature of the child's tie to his mother. Internat. J. Psycho-Ana. 39:350.

Bowlby, J. 1980. Attachment and loss: Sadness and depression. Basic Books: New York.

Brown, R.P., K. Budzek, and M. Tamborski. 2009. On the meaning and measure of narcissism. Pers. Soc. Psych. Bull. 35:951–964.

Broido, E.M. 2004. Understanding diversity in millennial students. New Directions for Student Services 106:73–85.

Brunell, A.B., W.A. Gentry, W.K. Campbell, B.J. Hoffman, K.W. Kuhnert, and K.G. DeMarree. 2004. Leader emergence: The case of the narcissistic leader. Pers. Soc. Psych. Bull. 34:1663-1676.

Buffardi, L.E., and W.K. Campbell. 2008. Narcissism and social networking web sites. Pers. Soc. Psych. Bull. 34:1303-1314.

Campbell, W.K. 1999. Narcissism and romantic attraction. J. Pers. Soc. Psych. 77:1254-1270.

Campbell, W.K., and C.A. Foster. 2002. Narcissism and commitment in romantic relationships: An investment model analysis. Pers. Soc. Psych. Bull. 28:484-495.

Campbell, W.K., C.A. Foster, and E.J. Finkel. 2002. Does self-love lead to love for others? A story of narcissistic game playing. J. Pers. Soc. Psych. 83:340-354.

Campbell, W.K., J.D. Foster, and I. Shrira. 2006. Theoretical models of narcissism, sexuality, and relationship commitment. J. Soc. Pers. Rel. 23:367-386.

Carver, C.S., J.W. Lawrence, and M.F. Scheier. 1999. Self-discrepancies and affect: Incorporating the role of feared selves. Pers. Soc. Psych. Bull. 25: 783-792.

Collins, N.L., and S.J. Read. 1990. Adult attachment, working models, and relationship quality in dating couples. J. Pers. Soc. Psych. 58:644-663.

Foster, J.D., I. Shrira, and W.K. Campbell. 2003. The trajectory of relationships involving narcissists and non-narcissists. Poster session presented at the annual meeting of the American Psychological Society, Atlanta, Ga.

Foster, J.D., I. Shrira, and W.K. Campbell. 2006. Theoretical models of narcissism, sexuality, and relationship commitment. J. Soc. Pers. Rel. 23:367-386.

Hall, J.A., and N.K. Baym. 2011. Calling and texting (too much): Mobile maintenance expectations, (over)dependence, entrapment, and friendship satisfaction. New Media & Soc. 14:316-331.

Hendin, H.M., and J.M. Cheek. 2013. The hypersensitive narcissism scale. Measurement instrument database for the social science. Accessed 4 September 2016. Available at www.midss.ie

Higgins, E.T. 1987. Self-discrepancy: A theory relating self and affect. Psych. Review. 94:319-340.

Katz, J., S.R. Beach, and T.E. Joiner. 1998. When does partner devaluation predict emotional distress? Prospective moderating effects of reassurance-seeking and self-esteem. Pers. Rel. 5:409-421.

Kaya, B. 2010. U.S. Census bureau reports men and women wait longer to marry. census.gov

Lee, A., and B.L. Hankin. 2009. Insecure attachment, dysfunctional attitudes, and low self-esteem predicting prospective symptoms of depression and anxiety during adolescence. J. Clin. Child Adol. Psych. 38:219-231.

Morf, C.C., and F. Rhodewalt. 2001. Unraveling the pardoxes of narcissism: A dynamic self-regulatory processing model. Psych. Inq. 12:177-196.

Ogilvie, D.M. 1987. The undesired self: A neglected variable in personality research. J. Pers. Soc. Psych. 52:379-385.

Oltmanns, T.F., J.N.W. Friedman, E.R. Fiedler, and E. Turkheimer. 2004. Perceptions of people with personality disorders based on thin slices of behavior. J. Res in Pers. 38:216-229.

Paulhus, D.L. 1998. Interpersonal and intrapsychic adaptiveness of trait self-enhancement: A mixed blessing. J. Pers. Soc. Psych. 74:1197–1208.

Raskin, R., J. Novacek, and R. Hogan. 1991. Narcissism, self-esteem, and defensive self-enhancement. J. Pers. 59:19-38.

Roberts, J.E., I. H. Gotlib, and J.D. Kassel. 1996. Adult attachment security and symptoms of depression: the mediating roles of dysfunctional attitudes and low self-esteem. J. Pers. Soc. Psych. 70:310.

Rogoza, R., P. Wyszyńska, M. Maćkiewicz, and J. Cieciuch. 2016. Differentiation of the two narcissistic faces in their relations to personality traits and basic values. J. Pers. Ind. Diff., 95:85-88.

Rosenberg, M. 1965. Society and the adolescent self-image. Princeton University Press, Princeton, N.J.

Thompson, R., and D.C. Zuroff. 1999. Development of self-criticism in adolescent girls: Roles of maternal dissatisfaction, maternal coldness, and insecure attachment. J. Youth Adol. 28:197-210.

Twenge, J.M., S. Konrath, J.D. Foster, W.K. Campbell, and B.J. Bushman. 2008a. Egos inflating over time: A cross-temporal meta-analysis of the narcisstic personality inventory. J. Pers. 76:876-901.

Twenge, J.M., S. Konrath, J.D. Foster, W.K. Campbell, and B.J. Bushman. 2008b. Further evidence of an increase in narcissism among college students. J. Pers. 76:919-928.

Twenge, J.M., R.A. Sherman, and B.E. Wells. 2015. Changes in American adults' sexual behavior and attitudes, 1972-2012. Arch. Sex. Behav. 44:2273-2285.

Watkins, D.C., J.B. Hunt, and D. Eisenberg. 2012. Increased demand for mental health services on college campuses. Perspectives from administrators. Qual. Soc. Work. 11:319-337.

Eco-cosplay: upcycling as a sustainable method of costume construction

Sarah West* and Kathleen Smith†

Abstract

This research addresses sustainability in the apparel industry from the specific perspective of repurposing materials for use in costume development. Repurposing discarded materials, also referred to as upcycling, is examined as a viable approach to waste management and evaluated for its impact on sustainability in apparel and textile production, especially in relation to costume development. Current issues in sustainability in the apparel industry that are a focus for this research include waste from production as well as post-consumer waste. The project includes the design and construction of two costume pieces based on a style of costume known as cosplay. Cosplay is a subculture of costume enthusiasts that dress up to resemble one or more characters from a fan universe. The rise of popularity in cosplay contiguous to upcycling is one reason the project combines the two concepts. Secondly, cosplay costume development can repurpose materials beyond textiles, such as plastics, glass, metal, and wood. Finally, many cosplay hobbyists may have budget constraints that can be resolved by purchasing materials to upcycle from resale stores. Resale stores are a source of materials because the maintenance of the discarded materials removes a portion of cleaning from the project. Results of the research are the established efficacy of upcycling in costume development as an approach to waste management, the determination of acceptable aesthetic quality of upcycled costumes, and general guidance for cosplay participants to follow with the intention to utilize as much repurposed or upcycled materials as individual skills allow.

* Sarah West is a May 2017 honors program graduate in Apparel Merchandising and Product Development.

† Kathleen Smith, the faculty mentor, is a Clinical Associate Professor in Apparel Merchandising and Product Development.

Meet the Student-Author

Sarah West

I am from Russellville, Arkansas and graduated from Russellville High School with highest honors in 2013. In May 2017, I graduated from the Dale Bumpers College of Agricultural, Food and Life Sciences in the School of Human Environmental Sciences with a degree in Apparel Merchandising and Product Development. I was a recipient of the Chancellors and Distinguished Governor's scholarships throughout my degree and grants from the Honors College and Bumpers College for my undergraduate research. I completed a study tour in Las Vegas at the MAGIC tradeshow and was a summer intern at Material Concepts in Fayetteville. I am pursuing a Master's degree from the Apparel Merchandising and Product Development program where I plan to continue research that enriches and improves daily life.

I would like to thank Dr. Kathleen Smith for her guidance and influence as my faculty mentor. Her encouragement expanded the audience and funding for my research. I would like to thank my committee members Dr. Laurie Apple, Lance Cheramie, and Stephanie Hubert for their time and support. Lastly, I would like to thank my husband, Michael Sacco, for all his help, including serving as a model.

Introduction

Between 2011 and 2016, the terms "upcycling" and "cosplay" have separately had an increase of more than 60% in Google searches (Google trends, 2016). While both rise in popularity, it is possible that the individuals interested in upcycling will also have interest in cosplay. The words are distinct in their definitions and range. Upcycling refers to reusing or repurposing discarded material to create a valuable product, and cosplay refers to dressing in costume as a character (Bond, 2012).

Participants in cosplay have shown an affinity for repurposed material. If cosplay culture were to embrace an environmental mindset, such as embodied in fashion upcycling, the current strategy for management of textile waste would extend into other recyclable materials, such as plastics, glass, and wood, with a growing population of participants. Cosplay is often built with materials beyond textiles, such as plastics, glass, metal, and wood. Compared to the practice of upcycling, which mostly repurposes textile waste, cosplay participants would be repurposing a wider breadth of post-consumer waste categories. As the population of cosplay participants grows, upcycled cosplay costumes could potentially present a viable approach to waste management. The creative work of this project is the building of two cosplay style costumes. One goal of this project is to provide a description of the development of the costumes for cosplay participants to follow with the intention to utilize as much repurposed or upcycled materials as individual skills allow.

To represent the plausibility and efficacy of upcycling in cosplay costume building, this project will consist of two full costume designs that will encompass popular, but challenging, components found in cosplay pieces. The cosplay costumes will be created from source material that is mostly repurposed or recycled. The costumes will be demonstrative of the possible results upcycling and cosplay could yield. The process of building the costumes will provide guidance and suggestions for early adopters. Cosplay participants are likely to embrace upcycling as a primary material source due to the lower price of used materials and the creativity needed for the challenge. The practice of upcycling in cosplay likely stems from budget constraints, as cosplay is most often practiced as a hobby and therefore funded by an individual's discretionary budget (Donellen, 2014). When given the choice to buy a completed cosplay piece for $50, or replicate the piece for $5, a cosplayer with limited funds would likely opt for the cheaper option that requires more effort.

Thrift stores are retail locations that exclusively sell products that have been used then donated, often as an alternative to trashing the items. The cosplay community is one group of creative hobbyists that may purchase materials from thrift stores because of the lower cost. Though it cannot be determined what purchasers do with products from thrift or resale stores, revenue in the U.S. of $16 billion (NARTS, 2016) from such stores suggests that it is a mainstream market. Evidence of fashion upcycling for casual wear can be found on internet blogs and websites like Pinterest. Bloggers who redesign clothes purchased from thrift stores or repurpose items from their home are

becoming popular, with one such blog maintaining over 300,000 followers on social media (Recycled Crafts, 2016).

The phrase "fashion repeats itself" can now describe a revolutionary wave of repurposed fashion. In the U.S., about 5% of municipal waste is post-consumer textile waste (PCTW), with a projected 35.4 billion pounds to be sent to landfills in the year 2019 according to the Council for Textile Recycling (CTR, 2009). Cosplay costume building could remove waste from textiles, but also plastics, metal, glass, and cardboard paper waste. This means that up to half of the materials in the U.S. considered waste could be reconsidered as supplies for costumes. The average American consumes 70 pounds of textiles a year, and discards all but 10 pounds (CTR, 2009). Costume building could repurpose the excess weight, plus other municipal waste.

To create cotton, a natural fiber, there is an immense amount of water needed; more than 200,000 liters for enough cotton to make a t-shirt and a pair of jeans (Claudio, 2007). Agricultural chemicals are potential sources of pollution for any fiber generated from a crop, which can ruin a water supply. The loss of topsoil associated with modern farming practices is another form of environmental degradation. Organic fibers are exposed to pesticides while being processed as raw material, and these pesticides can be toxic to both the ecosystem and workers processing the fiber (Gardetti and Torres, 2013). Agriculture production in the United States is regulated by the United States Department of Agriculture and complies with environmental standards. However, the United Nations Environment Programme, UNEP, states that persistent consequences of textile production are freshwater consumption, water pollution, and air pollution (UNEP, 2012). Repurposing of existing textiles reduces environmental impact of textile production. As the cosplay community grows, so can the practice of upcycling and repurposing materials. As more materials are recycled rather than discarded, the landfills will be smaller and the need for manufacturing new textile products reduced.

Cosplay is a combination of the two words: costume and play. Most often, cosplay describes either a costume piece or the act of portraying a character while in costume. Costume pieces titled cosplay are usually representations of a character from popular culture, most popularly comic books and movies based on comic books. For this reason, cosplay participants, called cosplayers, will most often cosplay at comic book conventions. As the number of participants expanded, the conventions broadened to accommodate the varying interests of attendees. Therefore, the scope of this project is presently expanding.

Due to the present lack of scholarly references to cosplay, information and conclusions about cosplay are based on personal attendance to comic book conventions and participation in the cosplay community. As cosplay continues to gain western popularity, more academic sources are likely to become available. All descriptions below are based on anecdotal experience; however, the inferences are necessary to understand the purpose of the project.

Materials and Methods

To address the challenges that building cosplay with repurposed material presents, two original costume designs were created to avoid copyright and trademark issues. One men's and one women's costume were designed based on a review of popular cosplay, including emergent themes that would be perceived as difficult to replicate with repurposed materials. These designs were broken down into flat technical drawings and drafted as flat patterns. Following completion, designs were evaluated for potential materials and important key features, such as color.

Themes that appeared most popular and visibly distinct in cosplay are apocalyptic, horror, medieval or Renaissance, realistic, science fiction, superhuman, such as superheroes, and Victorian inspired design. Since some popular women's cosplay calls for large skirting, corset style bodices, and decorative accessories while other women's cosplay calls for body contouring items and armor, the design was created to accommodate significant aspects of as many styles as possible while remaining cohesive (Fig. 1). The men's cosplay design includes a large proportion of armor with a base layer to represent cosplay without emphasis on armor (Fig. 2). The men's cosplay is intended to be a combination of multiple styles as well (see https://discoverymag.uark.edu/issues/ for color versions of figures).

Materials were purchased at thrift stores, yard sales, and by reclaiming disposed materials. Each item purchased or collected was recorded in a log including product description, price, location, intended use, fiber or material content, weight in ounces, waste category, and secondary waste. Secondary waste is the amount of discarded material that is not used in the construction of the costume. Using the initial weight and the weight of the secondary waste, repurposed weight was more accurately measured.

The method of construction was expected to include the use of safety equipment, a rotary tool and kit, a multiple-temperature setting glue gun and heat gun, an orbital sander, a wood burner tool, a hobby knife set, contact cement, multiple-use scissors, fabric scissors, pliers, an eyelet tool with eyelets, a riveter and rivets, and a significant amount of machine and hand sewing for altering and garment production.

The design of the costumes started with an industry method of creating a trend board. A trend board is created by collaging photographic inspiration including colors, silhouettes, and other images as the basis of a design or set of designs. One board was created for both costumes and consisted of cosplay and live-action roleplay costume im-

ages. Based on the trend board, the industry method of trend analysis followed, which is to draw conclusions and predict trends. Sketches were done in pencil then uploaded onto Adobe Illustrator and live-traced. A random color palette generated through Adobe color was used because the colors of cosplay costumes are often predetermined and not chosen by the cosplayer. Coloring was done in Adobe Photoshop. The final color sketches were used to create flat sketches in Illustrator, which were organized and paired with verbal and visual ideas for possible materials to purchase and repurpose. The color images and materials guides were printed and stapled in booklets to use while in thrift shops gathering materials (color versions available at: https://discoverymag.uark.edu/issues/).

Patterns were created before material purchases to determine the amount of fabric that would be needed. However, some pieces were best suited to be created from alteration, such as pants or simplistic shirts. When no item was found that could be altered, a pattern was drafted. Pattern pieces were cut out of the garments. If the structure was difficult to manipulate, the original garments were disassembled to lay flat. Pattern pieces that would not be dramatically changed visually were cut into smaller pieces to ease placement and use more of the available material. Throughout construction, plans were adjusted and most steps were a process of trial and error. Each step was taken carefully to reduce waste, and failures were addressed from a standpoint of conservation and adjustment rather than new attempts or restarting.

Fig. 1. Women's costume design. The original illustration used to create the women's costume.

Fig. 2. Men's costume design. The original illustration used to create the men's costume.

Results and Discussion

Both costumes were constructed in an order that would be difficult to recreate exactly. Repurposed source material makes the construction process vary greatly from one part of a costume to another as well as one project to the next. Since each step is partially taken with another, it is ineffective to provide a step-by-step guide. Instead, the process is described for each costume by an explanation of how each piece was created.

Men's Costume

The final costume (Fig. 3) shows the inclusion of armored themes and the base layer of a more fabric-based costume.

- *Shoulder pieces*: The plastic was cut from a flattened bin and laced together with polyester string. To contain the plastic, the shoulder guard piece has a leather side, with applique trim, and a lining side that is less visible.
- *Neck guard*: The raised portion of the shoulder is sewn with one side to the lining and one side to the leather, with plastic inserted and riveted to the outer piece, and the casing edgestitched closed.
- *Arm scales*: Four arm scales with a leather side and a lining side were sewn, right sides together with the top, and whip-stitched to a shoulder guard lining.
- *Chest pieces*: The back and front armor pieces were cut from the flattened plastic bin. The chest and back were edgestitched closed around the plastic.
- *Arm braces*: Forearm covers were created from leather, plastic from the flattened bin, and eyelets. Hand flaps were turned, stitched, and sewn to the arm braces.
- *Waist armor*: On the waist, two layers of skirting were basted on. The waist armor and trim were sewn to the lining and leather flaps were sewn to the edges of the front where the belt buckle and loop were attached with rivets.

Fig. 3. Men's costume. The completed costume on the model.

- *Boot covers*: Leg pieces were sewn with each scale turned and sewn then basted to the larger pieces.
- *Underneath the armor*: The undershirt was made from alteration. The center front was sewn closed, the cuffs removed, and the neck cut wide. The vest was altered to be slightly more fitted and shorter, with a wide neck and sleeves removed. Center front was altered to be an eyelet and leather lace closure. Another alteration was the pants, which were sewn to fit more like tights. Excess fabric from the pants was used to make a slip-on neck scarf.
- *Helmet*: A draped pattern for the helmet was cut, sewn, and simply glued to the plastic helmet pieces, with a face cover riveted to the leather.

Women's Costume

The final women's costume (Fig. 4) successfully matched the trends of women's cosplay, including body contouring as well as large skirting. The women's costume was much simpler to construct because most of the steps were exclusively alteration or basic sewing.

- *Top*: The corset style shirt was created from a dress that was shortened, sleeves removed, and seams released at the bust.
- *Waist*: The hip belt was created using material from a purse for interfacing and a purple shirt. The buckle in the front is permanently connected through a cut plastic buckle to one side with a sewn fabric loop, and removable to the opposite side with a loop closed by hook and eye.
- *Skirt*: The skirting is attached to the stiff hip belt with a simple sewn channel through which drawstrings made from the purple shirt run. The skirting was part of a formal dress and the hem was left intact from the original garment.
- *Under skirt*: Underneath the skirting, the pants were created in two separate pieces to create the appearance of two separate garments.

Fig. 4. Women's costume. The completed costume on the model.

- *Leg pieces*: The leg covers have leather patches attached with an embroidery finish. At the bottom of the covers, there is beading that was hand-sewn with beads transferred from the bodice of the formal dress.
- *Sleeves*: The forearm portion of the sleeve was cut from the same material as the lower portion of the pants. At the hand, there is beading and a finger loop to hold the sleeve. Above the elbow, the elastic waist of a turquoise dress was used to create a puff sleeve cap. A shortened belt and belt cover is attached at the top of the sleeve to hold the sleeve up. The same strategy of sewing a cover and inserting a belt is used for the chest and shoulder accessory and the leg accessory.

Design Versus Product Comparison

The final costumes (Figs. 3 and 4) compared to the original designs (Figs. 1 and 2) can be evaluated as successful or unsuccessful based on fit and silhouette, which had to be reconciled between the body type of the design and body type of the model, color matching, and total material repurposed. Cosplay participants do not always have the same body proportions as the source material, and if the design is not original, there will need to be compromises to maintain an overall aesthetically appealing appearance. This is why the original designs were not based on a specific model, but rather sketched onto croquis, or basic fashion body drawings. Color is usually not something that would call for compromise; however, since this project had limited material resources, there was a challenging but infrequent need to compromise some color choices. I was encouraged to adjust within already constructed pieces rather than remake pieces due to the material repurposing weight being recorded, and so these choices resulted in imperfect appearances in some instances.

The men's final costume compared to the original design seems successful overall. The model has a wider and more muscular body than the design, and shorter legs and arms. The helmet also has a much rounder appearance than the design due to the helmet base being a youth baseball helmet. The mask has a different appearance as well to accommodate the shape of the helmet and the face and eyes of the model. Slight variations in the armor color, which is mostly uniform in the original design, is due to multiple leather jackets of different colors and color differences within single jackets. The colors match well, so the difference could pass as a design choice or at the least be considered acceptable variance. The color of the vest, skirting, pants, and neck scarf are visually very close in color and successful recreations. The undershirt is much whiter than the original design, but the color change is not a large enough compromise to negatively affect the complete costume. Repurposing for the men's costume had an average of 54% by weight, which is a considerable reduction in waste if the source material is defined as post-consumer waste (Table 1).

The comparison of the women's final costume (Fig. 4) to the original design (Fig. 1) shows a successful recreation. The model is again wider and has shorter proportions than the original design; however, the silhouette of the design is less affected by the difference than the men's costume. As mentioned, the proportions and aesthetics were reconciled by slight adjustments to less significant parts of the costume. The most obvious variations are the leg cover due to proportions, the headband due to available material, and the choice to keep two straps because of the model's

Table 1. Weight measurements throughout assembly and repurposing rates for upcycled items used in construction of men's costume.

Product Description	Material Weight (oz)	Secondary Waste (oz)	Total Waste Repurposed (oz)	Repurposed (%)
brown leather jacket	40.35	26.45	13.90	34%
brown pants	17.30	2.15	15.15	88%
plastic bin	37.40	19.99	17.41	47%
red-brown leather jacket	35.05	23.75	11.30	32%
white shirt	13.12	2.90	10.22	78%
orange shirt	15.50	9.00	6.50	42%
brown jacket	19.70	14.75	4.95	25%
dark brown leather jacket	34.50	14.85	19.65	57%
youth baseball helmet	21.55	3.90	17.65	82%
2-inch belt	5.55	1.50	4.05	73%
plastic bin w/ lid	18.15	11.15	7.00	39%

body type. The colors are very well matched to the original design, although the medallions were matched with paint rather than selections from thrift shops. The one color that could be better is the fabric of the corset style shirt. The women's costume repurposing percentage had an average of 52%, with some items being totally repurposed with no secondary waste (Table 2). Complete upcycling is ideal and would contribute to a goal of zero waste, but further research and practice would be required to achieve this goal. The women's costume provides evidence that it is possible.

Both designs were realized in the costume to a recognizable level. Whether the final costume is satisfactory is dependent on the cosplay participant's personal preferences and intended use. For example, if the cosplay participant hopes to place in a cosplay costume contest, it may be less likely that they would be willing to upcycle. To this extent, opening a category within cosplay competitions for upcycled costumes could lend to an increased practice of upcycling in cosplay costumes. Since some of the material collection depends on skill and partly on probability and availability, individuals in metropolitan areas would likely be more successful with more options in resale shops and a higher volume of donated items. If donated items are considered to be post-consumer waste, 47% reuse by weight in this particular project is significant enough to consider repurposing and upcycling as a material source for cosplay costumes, but would require further investigation and a stronger development of repurposing skills.

Conclusions

The industry skills necessary to complete this project included trend analysis, pattern drafting, pattern draping, apparel production, garment alteration, and adept use of computer design. The designs were created using Adobe and inspired by trend analysis. Using technical sketches and model measurements, the patterns were created and cut from material. The pieces were then assembled or altered into garments and accessories. The skills unique to this project were discovered throughout the process and should be utilized by cosplay enthusiasts that would use repurposed materials to construct their costumes. When cutting pattern pieces from the fabric, disassembling the source garment was the easiest solution. This meant that items with few style seams, such as men's clothing, and large amounts of fabric, such as larger sizes, would be ideal purchases. Alternative or congruent strategies include opening darts that will not be used and hiding seams with overlying garments or applique. Another approach is to maintain symmetry in style lines, such as left and right pieces being cut in way that style lines are mirrored, so that the design seems intentional. To increase popularity of upcycling in cosplay, conventions and cosplay events could begin emphasizing the construction method by introducing a prize category or entire contests focused on upcycled material in costumes. Beyond cosplay participants utilizing these strategies, projects could include everyday cloth-

Table 2. Weight measurements throughout assembly and repurposing rates for upcycled items used in construction of women's costume.

Product Description	Material Weight (oz)	Secondary Waste (oz)	Total Waste Repurposed (oz)	Repurposed (%)
plastic bin w/ lid	18.15	11.15	7.00	39%
dark purple shirt	10.50	6.15	4.35	41%
turquoise dress	8.70	5.90	2.80	32%
1-inch belt, white	1.40	0.55	0.85	61%
1.5-inch belt, dark brown	1.80	0.40	1.40	78%
green dress, stretch	13.10	8.90	4.20	32%
green dress	8.25	6.85	1.40	17%
2-inch belt	6.90	1.10	5.80	84%
dark purple dress	14.95	4.70	10.25	69%
earrings	0.45	0.15	0.30	67%
feather necklace	0.25	0.20	0.05	20%
blue multi-strand necklace	2.55	1.45	1.10	43%
wood necklace	0.75	0.50	0.25	33%
green circle gem necklace	0.65	0.00	0.65	100%
turquoise beaded dress	17.35	6.25	11.10	64%
purse	13.65	10.30	3.35	25%
brown leather jacket	21.65	19.50	2.15	10%
1-inch belt, brown	1.35	0.15	1.20	89%
1-inch belt, graphic	2.00	0.20	1.80	90%

ing, formalwear, occupational clothing, and home goods. By expanding the range of participants in upcycling, and providing possible strategies, the viability of upcycling having a lasting effect increases by becoming applicable to more people and broader contexts.

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Literature Cited

Bond, V. 2012. Film biz recycling does just that–finds uses for old props. Waste and Recycling News.

Claudio, L. 2007. Waste couture: Environmental impact of the clothing industry. Environmental Health Perspectives, 115(9):448-454.

CTR. 2009. Council for Textile Recycling. The facts about textile waste. Avalable at: http://www.weardonaterecycle.org/about/issue.html

Donellen, J. 2014. Merchandise Buying and Management. New York, NY: Bloomsbury Publishing Inc.

Gardetti, M.A. and A.L. Torres. 2013. Sustainability in Fashion and Textiles: Values, Design, Production and Consumption. Sheffield, UK: Greenleaf Publishing Limited.

Google trends. 2016. Available at: https://www.google.com/trends/

NARTS. 2016. The Association of Resale Professionals. Available at: https://www.narts.org/i4a/pages/index.cfm?pageid=3310

Recycled Crafts. 2016. Available at: http://recycledcrafts.craftgossip.com/

UNEP. 2012. United Nations Environment Programme. Resource efficient & cleaner production. Available at: http://www.unep.org/resourceefficiency/Business/CleanerSaferProduction/ResourceEfficientCleanerProduction/tabid/102615/Default.aspx

Limiting food waste in child care facilities through implementation of portion sizes

Margaret E. Wright and Kelly A. Way†*

Abstract

Food waste in child care facilities is both a monetary waste and a danger to the environment. The purpose of this study is to explore the impact of portion control in a child care facility on the amount of food wasted and the costs associated with food waste. It was hypothesized that establishment of portion control will result in a reduction in the amount of food waste of lunches and afternoon snacks generated by preschool children attending the University of Arkansas Bumpers College Jean Tyson Child Development Study Center (JTCDSC). A four-week study was conducted where two trials were introduced: 1) a two-week trial using the current "family-style" serving method that was "un-portioned", and 2) a two-week trial using a "portion-sizing" that followed USDA portion serving recommendations. A 12.54% reduction in the amount being served in kilograms, a 33.26% reduction in the amount of food being wasted in kilograms, and a reduction of $73.22 being thrown away as monetary waste occurred when comparing the portioned method to the un-portioned method. In conclusion, the portioning method as implemented was successful in reducing food waste and monetary loss from food waste when compared to the current food serving method in a child care facility.

* Margaret E. Wright is a May 2017 honors program graduate with a major in Human Nutrition and Hospitality Innovation.
† Kelly A. Way, the faculty mentor, is an Associate Professor in Human Nutrition and Hospitality Innovation.

Meet the Student-Author

Margaret Wright

I was born and raised in Dallas, Texas and graduated from Highland Park High School in the spring of 2013. I graduated in May 2017 from the Dale Bumpers College of Agricultural, Food and Life Sciences with a degree in Food, Human Nutrition and Hospitality, concentrating in Dietetics, and a minor in Human Development and Family Sciences. After graduation, I participated in the UAMS/VA dietetic internship in Little Rock, Arkansas with the intention of becoming a Registered Dietitian.

I am a member of Phi Upsilon Omicron Honor Society, and served as Vice President my junior year. I represented the Bumpers College as a New Student Orientation Mentor in the summer after my sophomore year. I am also a member of Alpha Delta Pi Sorority, where I served as Homecoming Co-Chair my junior year.

I would like to thank Dr. Kelly Way for being my honors thesis mentor, for guiding me through this process and always encouraging me to succeed. Dr. Sabrina Trudo and Mardell Crandall were also instrumental in conducting this study, as their expertise in data collection and child development, respectively, were indispensable. I would also like to thank Cathy Moses, Doug Walsh, and Debra Modisette for their help throughout the study.

Introduction

Food waste is both a monetary waste and a danger to the environment. Food that decomposes in landfills contributes to the production of carbon dioxide and methane emissions into the environment, which impacts global climate change (Hall et al., 2009). Wherever food is served, there will most likely be food waste generated, including child care facilities. The USDA programs, such as the Child and Adult Care Food Program (CACFP), provide nutritional assistance to those who struggle with food insecurity and the USDA has multiple programs that focus on the nutritional standard of schools and other institutions that serve food to children. The CACFP contains a set of guidelines that pertain to the required amounts of food that infants, children, and adults should be served at breakfast, lunch, and afternoon snack (CACFP, 2015). The guidelines state that children must be served a specified amount of each of the 4 food groups during lunch (fruits, vegetables, grains, and protein) and at least 2 of the 4 food groups during snack. The purpose of this study is to explore the impact of portion control in a child care facility on the amount of food wasted and the costs associated with food waste. It is hypothesized that the establishment of portion control will result in a reduction in the amount of food waste of lunches and snacks created by children attending the University of Arkansas Bumpers College Jean Tyson Child Development Study Center (JTCDSC).

Materials and Methods

Participants were chosen based on their enrollment at JTCDSC during the months of August and September 2016. A total of 45 parents signed required permission slips, allowing for a total of 45 participants within four classrooms (classrooms A, B, C, and D) to participate in the study. A 10-day lunch and afternoon snack menu was created by the main cook and the research team. Food selections were based on meals to which the children had been previously exposed; therefore, the food chosen would not be new or unusual to the participants. The lunch meals consisted of 5 food components: grain, fruit, vegetable, protein, and milk. The afternoon snack meals consisted of at least 2 of the 5 food components listed above.

All meals served at JTCDSC are made in the on-site kitchen and provide morning snack, lunch, and afternoon snack. The preschool children currently eat in their classrooms "family-style" meaning that they sit at a table with their peers and 1 teacher. The food component bowls are placed in the center of the table, and the children are given an opportunity to serve themselves as much of each component as they desire. They serve directly from the bowls using a large serving spoon. Instead of the current method of filling the food component bowls without portioning, the altered trial implemented consisted of pre-portioning food in both the kitchen and the preschool classrooms.

For the first trial, labeled the "un-portioned days", the amount of food served and wasted was measured using the current meal serving methods performed by JTCD-SC. No special instructions were given to the classroom teachers or students on how to serve food. The food components were pre-weighed in the kitchen before being served to the classroom. Each bowl containing a food component, as well as a disposal bin containing food waste was weighed and recorded when the food was returned to the classroom after mealtime for disposal. For the second trial, labeled the "portioned days", the amount of food served and wasted was measured using USDA recommended guidelines for children ages 3–5 in a child care setting. Food components were pre-portioned in the kitchen prior to meal time, and the teachers assisted in serving out the designated portion to each child by following guidelines provided on the food cart. Once each food component was portioned, the children were given the opportunity to serve themelves more food if they desired. Each bowl containing a food component, as well as a disposal bin containing food waste was weighed and recorded when the food was returned to the classroom after mealtime for disposal. Each trial lasted 10 days, or two school weeks, each. After the trials were completed, the obtained data were analyzed to observe the amount of food eaten, the amount of food thrown away, and the cost of food served during lunch and snack meals for both un-portioned and portioned meals.

Results and Discussion

During the 10 un-portioned days, 224.98 kg of food were served in total to the 4 classrooms (Table 1). On the 10 portioned days, 196.68 kg of food were served (Table 2), resulting in a 28.3 kg and 12.54% reduction in the total amount served. The amount of food served decreased in 67.5% of the 20 meals served in the 2-week period to each of the four classrooms when using the portioning method as compared to not using the portioning method.

Over the 10 un-portioned days, 75.86 kg were wasted by the combined 4 classrooms (Table 3). On the 10 portioned days, 50.58 kg were wasted by the combined 4 classrooms (Table 4), resulting in a 25.28 kg and 33.26% reduction in the amount of food wasted by the 4 preschool classrooms over the 2 weeks of portioned meals. Of the 20 meals served to 4 classrooms in each 2-week trial, the amount of food wasted was reduced in 71.25% of the meals when using the portioning method as opposed to not using the portioning method. Thirteen of the 23 meals that increased in the amount of food wasted came from Room A.

Table 1. Amount of food served: all classrooms for lunch and afternoon snack 10 un-portioned days.

Meal: un-Portioned	Room A (kg)	Room B (kg)	Room C (kg)	Room D (kg)
Day 1 Lunch	3.68	6.22	4.77	5.49
Day 1 Afternoon Snack	0.91	0.86	0.95	1.23
Day 2 Lunch	2.18	4.31	3.63	5.36
Day 2 Afternoon Snack	1.23	1.14	2.68	2.22
Day 3 Lunch	3.13	4.09	4.59	5.27
Day 3 Afternoon Snack	1.14	1.41	2.22	2.27
Day 4 Lunch	2.36	3.72	4.45	4.63
Day 4 Afternoon Snack	0.50	0.68	0.91	1.00
Day 5 Lunch	2.54	4.36	5.08	5.18
Day 5 Afternoon Snack	0.68	1.95	2.59	2.91
Day 6 Lunch	1.77	4.04	3.90	5.27
Day 6 Afternoon Snack	0.64	0.73	1.41	0.82
Day 7 Lunch	2.41	6.27	5.27	5.72
Day 7 Afternoon Snack	1.50	2.04	2.22	2.50
Day 8 Lunch	2.13	4.45	4.09	5.13
Day 8 Afternoon Snack	0.68	1.32	1.45	1.54
Day 9 Lunch	2.68	5.18	5.95	6.31
Day 9 Afternoon Snack	0.32	0.59	0.54	0.54
Day 10 Lunch	2.59	3.77	4.68	4.45
Day 10 Afternoon Snack	1.50	1.59	1.45	1.41

Table 2. Amount of food served: all classrooms for lunch and afternoon snack 10 portioned days.

Meal: Portioned	Room A (kg)	Room B (kg)	Room C (kg)	Room D (kg)
Day 1 Lunch	3.54	3.27	4.99	3.63
Day 1 Afternoon Snack	1.14	1.63	1.41	1.45
Day 2 Lunch	3.04	4.49	4.72	4.36
Day 2 Afternoon Snack	1.63	1.86	1.27	1.82
Day 3 Lunch	2.32	4.00	3.54	4.68
Day 3 Afternoon Snack	1.54	1.27	1.18	2.00
Day 4 Lunch	2.59	3.18	3.59	3.72
Day 4 Afternoon Snack	1.63	0.73	0.77	0.45
Day 5 Lunch	2.50	3.86	5.04	3.63
Day 5 Afternoon Snack	2.18	2.41	2.13	2.68
Day 6 Lunch	1.63	3.81	4.59	4.09
Day 6 Afternoon Snack	0.77	1.14	1.09	1.14
Day 7 Lunch	2.54	4.31	5.04	4.18
Day 7 Afternoon Snack	2.09	2.22	2.04	2.41
Day 8 Lunch	2.50	3.22	2.72	3.77
Day 8 Afternoon Snack	0.95	11.36	1.27	1.54
Day 9 Lunch	2.63	3.41	3.13	4.40
Day 9 Afternoon Snack	0.32	0.50	0.23	0.32
Day 10 Lunch	2.22	3.00	2.95	4.09
Day 10 Afternoon Snack	0.54	0.91	0.95	1.47

Table 3. Amount of food wasted: all classrooms for lunch and afternoon snack 10 un-portioned days.

Meal: Un-Portioned	Room A (kg)	Room B (kg)	Room C (kg)	Room D (kg)
Day 1 Lunch	0.73	1.18	1.68	1.18
Day 1 Afternoon Snack	0.05	0.32	0.50	0.45
Day 2 Lunch	0.32	1.45	1.45	1.14
Day 2 Afternoon Snack	0.50	0.95	0.90	0.32
Day 3 Lunch	0.86	2.54	2.77	1.95
Day 3 Afternoon Snack	0.05	0.23	0.10	0.32
Day 4 Lunch	0.59	2.00	1.91	1.54
Day 4 Afternoon Snack	0.01	0.23	0.36	0.36
Day 5 Lunch	0.01	2.00	1.54	1.23
Day 5 Afternoon Snack	0.23	1.09	1.14	1.86
Day 6 Lunch	0.50	1.73	0.73	1.18
Day 6 Afternoon Snack	0.02	0.32	0.18	0.54
Day 7 Lunch	0.27	2.81	1.73	2.13
Day 7 Afternoon Snack	0.32	0.77	1.50	0.54
Day 8 Lunch	0.64	2.13	1.09	2.13
Day 8 Afternoon Snack	0.00	0.23	0.27	1.36
Day 9 Lunch	0.95	2.41	1.95	0.41
Day 9 Afternoon Snack	0.02	0.36	0.32	2.18
Day 10 Lunch	0.02	2.13	0.95	0.64
Day 10 Afternoon Snack	0.64	0.64	1.27	0.32

Table 4. Amount of food wasted: all classrooms for lunch and afternoon snack 10 portioned days.

Meal: Portioned	Room A (kg)	Room B (kg)	Room C (kg)	Room D (kg)
Day 1 Lunch	0.59	0.82	0.73	0.32
Day 1 Afternoon Snack	0.32	0.18	0.23	0.14
Day 2 Lunch	0.59	1.95	1.36	0.95
Day 2 Afternoon Snack	0.41	0.68	0.32	0.59
Day 3 Lunch	0.41	1.63	1.09	1.54
Day 3 Afternoon Snack	0.41	0.50	0.03	0.36
Day 4 Lunch	0.64	1.45	1.23	1.40
Day 4 Afternoon Snack	0.05	0.23	0.27	0.09
Day 5 Lunch	0.09	1.00	1.32	0.59
Day 5 Afternoon Snack	0.73	1.77	0.77	0.91
Day 6 Lunch	0.77	1.41	1.18	1.18
Day 6 Afternoon Snack	0.14	0.32	0.14	0.27
Day 7 Lunch	0.50	0.91	1.36	1.04
Day 7 Afternoon Snack	0.59	1.41	0.59	0.77
Day 8 Lunch	0.50	1.00	0.80	0.73
Day 8 Afternoon Snack	0.23	0.50	0.32	0.14
Day 9 Lunch	0.45	1.36	0.41	0.68
Day 9 Afternoon Snack	0.23	0.18	0.14	0.09
Day 10 Lunch	0.50	1.00	0.82	0.64
Day 10 Afternoon Snack	0.36	0.54	0.50	0.32

Table 5. Amount of food served for lunch and afternoon snack combined for each child during un-portioned and portioned days.

Day	Rm. A unport. (kg)	Rm. A port. (kg)	Rm. B unport. (kg)	Rm. B port. (kg)	Rm. C unport. (kg)	Rm. C port. (kg)	Rm. D unport. (kg)	Rm. D port. (kg)	Avg. food served/Rm. unport.[d] (kg)	Avg. food served/ Rm. port.[d] (kg)
Day 1	0.67[a]	0.69[b]	0.52[a]	0.40[b]	0.54[a]	0.60[b]	0.66[a]	0.42[b]	0.60	0.52
Day 2	0.47	0.66	0.61	0.61	0.67	0.60	0.54	0.48	0.58	0.58
Day 3	0.60	0.54	0.54	0.42	0.63	0.43	0.54	0.50	0.58	0.47
Day 4	0.47	0.46	0.32	0.32	0.48	0.40	0.45	0.32	0.43	0.38
Day 5	0.46	0.66	0.54	0.53	0.67	0.64	0.66	0.45	0.58	0.57
Day 6	0.39	0.47	0.36	0.41	0.45	0.49	0.84	0.37	0.51	0.44
Day 7	0.55	0.65	0.63	0.55	0.84	0.65	0.64	0.46	0.66	0.64
Day 8	0.40	0.51	0.47	0.39	0.45	0.36	0.49	0.43	0.45	0.42
Day 9	0.42	0.41	0.52	0.33	0.60	0.35	0.52	0.36	0.56	0.36
Day 10	0.57	0.46	0.47	0.39	0.62	0.49	0.42	0.39	0.52	0.43
10-Day Total[c]	0.50	0.55	0.50	0.44	0.60	0.50	0.57	0.42	0.55	0.48

[a] Amount of food served to each child in specified classroom.
[b] Amount of food served to each child in specified classroom on the portioned days.
[c] Average number of ounces served to each child in specified classroom over 10-day period.
[d] Average amount of food served to child in each classroom.

The amount of food served decreased by 77.5% on the portioned days as compared to the un-portioned days (Tables 5 and 6). The average amount of food served per child among the 4 classrooms combined decreased 9 out of the 10 days when comparing each un-portioned day to its respective portioned day. When comparing the amount of food served based solely on weight between the un-portioned and portioned days, the average grams served decreased 62.94 g in Room B, 96.39 g in Room C, and 151.39 g in Room D, and increased 49.61 g in Room A. For the 10-day average combining all 4 classrooms, the amount of food served per child decreased 65.77 g when comparing the portioned average to the un-portioned average. The amount of food wasted per child decreased in 75% of the meals served. The average amount of food wasted per child amongst the 4 classrooms combined went down 9 out of the 10 days when comparing each un-portioned day to its respective portioned day. When comparing the amount of food served based solely on weight between the un-portioned and portioned days, the average amount of grams wasted per child was reduced by 40.54 g in Room B, 87.32 g in Room C, and 70.87 g in Room D, and increased by 17.29 g in Room A.

A cost analysis was also conducted to measure the financial implication of portion sizing meals at JTCDSC (Table 7). During the 10 un-portioned days, $574.51 was served and $218.30 was wasted, resulting in 38% of money spent on food being thrown away. During the 10 portioned days, $445.40 was served and $145.08 was wasted, resulting in 32.51% of money spent on food being thrown away. The cost to serve the meals was reduced by $129.11 and the cost of food thrown away was reduced by $73.22 when comparing the cost of serving meals during the portioned days versus the cost of the un-portioned days. The cost of food went down due to the reduction in the amount of food being served to the children using the portioning method. The percentage of money being thrown away went down in 9 of the 10 days when compared to the portioned percentage of money wasted to the un-portioned percentage of money wasted. If the center were to implement the portion sizing method utilized during the portioned trial, it is projected that the center would save $258.22 per month, or $3098.64 per year serving the 4 participating classrooms.

Throughout the process of this study, every child was allowed as much food as they desired to eat. No child was denied access to additional food after the initial portion was given. The results of this study support other studies that found portion-sizing meals to children can reduce the amount of food wasted in a school setting.

Conclusions

Portion-sizing lunch and afternoon snack meals for preschool children showed a reduction in the amount of food thrown away and the amount of money spent on food, as well as reducing the amount of money being diminished because of food waste. It is advised that the JTCDSC consider incorporating the portion sizing method used during

Table 6. Amount of food wasted for lunch and afternoon snack combined for each child during un-portioned and portioned days.

Day	Rm. A unport. (kg)	Rm. A port. (kg)	Rm. B unport. (kg)	Rm. B port. (kg)	Rm. C unport. (kg)	Rm. C port. (kg)	Rm. D unport. (kg)	Rm. D port. (kg)	Avg. food wasted/Rm. unport.[d] (kg)	Avg. food wasted/Rm. port.[d] (kg)
Day 1	0.13[a]	0.13[b]	0.12[a]	0.08[b]	0.21[a]	0.10[b]	0.16[a]	0.04[b]	0.16	0.09
Day 2	0.12	0.14	0.32	0.25	0.25	0.17	0.14	0.12	0.20	0.17
Day 3	0.13	0.11	0.32	0.17	0.26	0.10	0.16	0.15	0.22	0.13
Day 4	0.10	0.11	0.16	0.14	0.20	0.14	0.15	0.09	0.15	0.12
Day 5	0.05	0.11	0.25	0.24	0.23	0.19	0.26	0.11	0.20	0.16
Day 6	0.08	0.13	0.16	0.15	0.08	0.11	0.14	0.10	0.12	0.12
Day 7	0.09	0.15	0.27	0.20	0.40	0.18	0.21	0.13	0.24	0.16
Day 8	0.09	0.11	0.20	0.10	0.11	0.10	0.13	0.11	0.13	0.10
Day 9	0.16	0.10	0.25	0.13	0.22	0.10	0.18	0.05	0.20	0.10
Day 10	0.11	0.14	0.25	0.16	0.25	0.18	0.07	0.07	0.17	0.14
10-Day Total[c]	0.10	0.12	0.20	0.16	0.22	0.14	0.16	0.09	0.18	0.13

[a] Amount of food wasted by each child in specified classroom.
[b] Amount of food wasted by each child in specified classroom on the portioned days.
[c] Average number of kg wasted by each child in specified classroom over 10-day period.
[d] Average amount of food wasted child in each classroom.

this study into their regular foodservice practices. Further research pertaining to the impact of portion sizing on amounts wasted and cost is encouraged, such as research performed in different child care facilities with children of varying socioeconomic backgrounds or adding a composting component to the facility for composting uneaten food rather having the food wasted.

Acknowledgements

Funding for this study was graciously provided by the Dale Bumpers College of Agricultural, Food and Life Sciences through a Bumpers Honors Undergraduate Research Grant and by the University of Arkansas Honors College through a Honors College Research Grant. The author also wants to thank the Jean Tyson Child Development Study Center faculty and staff for their assistance and compliance for the duration of the conducted study. Support also provided by the University of Arkansas System Division of Agriculture.

Literature Cited

CACFP. 2015. Child and Adult Care Food Program. Nutrition Standards for CACFP Meals and Snacks. Accessed 13 March 2016. Available at: http://www.fns.usda.gov/cacfp/meals-and-snacks

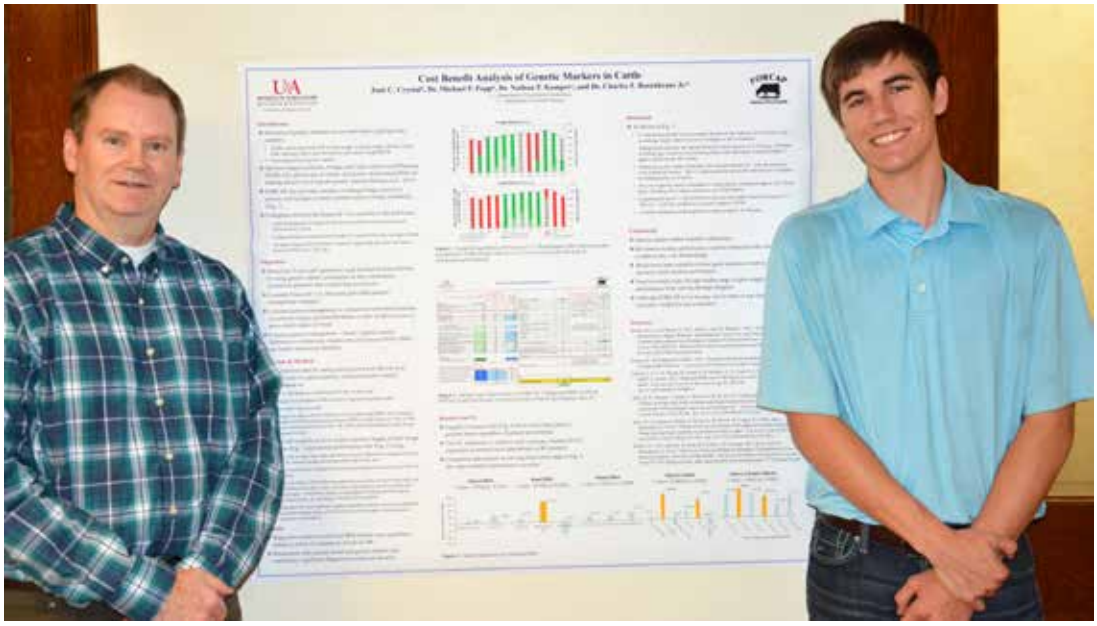
Hall, K.D., J. Guo, M. Dore, and C.C. Chow. 2009. The progressive increase of food waste in America and its environmental impact. PloS one. 4:11. e7940.

Table 7. Cost analysis of food served and wasted involving 10 different lunch and afternoon snack combinations in all four classrooms combined for each un-portioned and portioned day.

Day	Un-portioned: cost of food served ($)[a]	Portioned: cost of food served ($)[a]	Un-portioned: cost of food wasted ($)[b]	Portioned: cost of food wasted ($)[b]	Un-portioned: percentage money wasted (%)[c]	Portioned: percentage money wasted (%)[c]
Day 1	51.93[d]	39.03[d]	13.20[e]	6.64[e]	25.42	17.01
Day 2	65.38	54.25	33.90	24.07	51.85	44.37
Day 3	47.93	36.50	22.28	12.72	44.62	34.85
Day 4	59.27	40.32	20.32	13.76	34.28	34.13
Day 5	69.14	55.98	22.59	13.76	32.67	32.44
Day 6	54.51	49.88	22.40	18.17	41.09	36.43
Day 7	70.41	61.85	28.40	19.25	40.34	31.12
Day 8	49.13	36.71	14.09	8.35	28.68	22.75
Day 9	60.27	39.47	24.66	12.72	40.92	32.23
Day 10	46.54	31.41	16.46	11.24	35.37	35.78
10-Day Total	574.51[f]	445.40[f]	218.30[f]	145.08[f]	38.00	32.57

[a] Sum cost, in dollars, to serve lunch and afternoon snack for one day.
[b] Sum cost, in dollars, wasted from served lunch and afternoon snack for one day.
[c] Cost of food wasted divided by cost of food served in one day.
[d] Total cost to serve lunch and afternoon snack to all four classrooms (A, B, C, and D).
[e] Total cost wasted from lunch and afternoon snack in all four classrooms (A, B, C, and D).
[f] Sum cost for all ten days.

Bumpers College Students In Action



Josh Crystal. (**Agricultural Economics and Agribusiness, AEAB).** Josh and his faculty mentor, Michael Popp, Professor in AEAB, pose with the poster from his research, "Cost-Benefit Analysis of Genetic Markers in Cattle." This poster was presented 10-12 April 2017 at the Dale Bumpers College Honors Student Board Research Competition.

Sarah West (Apparel Merchandising and Product Development). Sarah presents her project, Eco-Cosplay: Upcycling as a Sustainable Method of Costume Construction" on a panel at the Pop Culture Association/American Culture Association National Conference, April 15, 2017 in San Diego, California. This research and travel was funded by the University of Arkansas Honors College and the Bumpers Honors College programs.

Sarah West (Apparel Merchandising and Product Development, AMPD). Sarah and her faculty mentor, Kathleen Smith, Assistant Director and Clinical Associate Professor, AMPD, take a break for the camera at the Popular Culture Association/American Culture Association National Conference, April 15, 2017 in San Diego, California.

Laura Corral; and Kaitlyn Walker (from left to right), Apparel Merchandising and Product Development). Laura and Kaitlyn traveled with their faculty mentor, Stephanie Hubert to the Gerber Technology Roadshow in San Francisco. They were able to network with industry experts and hear about the latest technology influencing the apparel industry. A highlight of this trip was meeting with 3D printing designer Danit Peleg and having the opportunity to discuss their research. In this photo, Laura and Katie are enjoying a side trip to Ghirardelli Square. A University of Arkansas Honors Program Research Grant and a Dale Bumpers Honors Program Research Grant provided partial funding for this trip.

Kaitlyn Walker, Laura Corral, and Stephanie Hubert, the faculty mentor (from left to right), Apparel Merchandising and Product Development). The co-authors pose with Laura wearing the 3-D printed top they created for their research project, "Exploring the abilities of 3-D printing and its viability for consumption in the fashion industry." Corral and Walker's research was funded in part by a University of Arkansas Honors Program Research Grant and the Dale Bumpers Honors Program Research Grant. Their thesis has been accepted for presentation at the 2017 International Textile and Apparel Association (ITAA) Annual Conference held in November 2017 in St. Petersburg, Florida.

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- Indicate footnotes for tables using sequential superscript lowercase letters (a, b, c, etc.) Place table footnotes below last horizontal rule of table. Footnotes used to clarify or annotate text should be placed at the bottom of the page in which the reference appears and indicated with sequential superscript numbers (1, 2, 3, etc.)
- Use a comma before the word *and* in a series: *The U.S. flag is red, white, and blue.*

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- an abstract
- a footnote identifying each author by classification and major for students; rank and department for faculty and staff
- a footnote identifying faculty sponsor or mentor

Abstract

The *Abstract* summarizes the purpose, procedures, and main findings in 250 words or less.

Introduction

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Acknowledgments

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