

**FINAL REPORT**  
**August 30, 2013**

**“Phase 2: Waste Bin Liner Development” &  
“Addendum to Phase 2: Waste Bin Liner Development”**

**Principal Investigator:** R. Andrew Hurley, Assistant Professor  
ruperth@g.clemson.edu  
Department of Food, Nutrition and Packaging Sciences  
318 Harris A. Smith Building  
Clemson University  
Clemson, SC 29634

**Date Submitted:** August 2012

**Project Start Date:** September 2012

**Duration of Project:** 12 months

## **Lay Summary:**

From September 2011 to February 2012, over 100 plastic resins were researched and analyzed to determine if a worthy replacement could be determined for the polyethylene liners (plastic bags) currently utilized in 44-gallon waste bins throughout the rendering supply chain. A plastic known as Novamont Mater-Bi was selected in preliminary testing and subsequently studied in a full field test at a Darling International batch processing facility. Over 900 3-gallon liners made of 0.88 mil thick Novamont Mater-Bi were mixed with product. Post-test analysis yielded negative on PCBs and pesticides, and the polyethylene count did not differ from the control (where bags were not present in one of the batch cookers). In addition, meal processed with the liners was run through a hammermill and after microscopic inspection, liner remnants were undetectable. Lastly, the 0.88 mil liner was placed into a 44 gallon Rubbermaid Brute waste bin and passed a modified ASTM-D 4169 distribution test, where it upheld an incline impact and random vibration when filled with water and secured with lid. This was the reported conclusion of the first study, presented to the ACREC board in August 2012.

This new final report is a follow-up to the first study with an extensive field test of 24,000 liners made of Novamont Mater-Bi at two different thicknesses (0.88 and 1.5 mils). The liners produced were distributed to store clients of 4 continuous process facilities within four different geographic locations in the United States. The liners were used at 100+ store locations and picked-up over a four-week period by route drivers who purposely collected the liners in addition to product. Because the previous study indicated that Mater-Bi would not contaminate product, the expected learning outcomes in this project was to determine in-store operation, collection, ideal thickness and processing impacts from use of Mater-Bi liners.

## **Objective (s):**

To conduct an extensive study to determine the operational use of the 0.88 and 1.5 mil Mater-Bi 44-gallon liners throughout the real-world constraints of the rendering supply chain.

## **Project Overview:**

### Experimental Procedures:

Liners made of Novamont Mater-Bi at two different thicknesses were purchased from Bio-Bag, a division of BIOgroupUSA, Inc., P.O. Box 369, Palm Harbor, FL 34682-0369. 12,000 bags were purchased in 0.88 mils and 1.5 mils thicknesses and tested at two Darling International, Inc. commercial collection routes for a rendering operation. Another 12,000 bags were purchased in 0.88 and 1.5 mil thicknesses and tested at two Central-Bi commercial collection facilities. The filled bags were collected and transported to one of four different continuous-operation rendering facilities over a four-week period for each respective company. Both companies collected samples of finished fat by rendering plant personnel 10 times (at the end of weeks 0, 1, 2, 3 and 4 at both facilities) and submitted to Modern Labs and Survey Co., 9100 Plainfield Road #8, Brookfield, Il, 60513 for “Polyethylene – AOCS Recommended Practice CA 16-75.”

At least 12oz of finish meal samples were collected by employees at all four facilities at least twice, during the last week of testing at both Darling International facilities, and sent to Clemson University (Attention: Dr. Andrew Hurley, 318 Harris A. Smith Building, Clemson University, Clemson, SC 29634) for visual inspection to determine if particles of the bags remained in the finished rendering product. If particles were identified, the number of particles was to be enumerated per 1 oz sample of meal in 3 total samples.

A brief survey was developed by both Andrew Hurley and David Kirstein (Darling International, Inc.) to record driver, plant manger and store manger commentary on the test liners over 4 instances during the study (week 2 and week 4 at both test facilities). Drivers and mangers were asked to rate statements concerning the integrity and usability of the liners as well as areas to comment.

Over the four-week test period, the plant managers from all test facilities collected and mailed 5, 16oz samples of fat to Modern Labs and Survey Co., 9100 Plainfield Road #8, Brookfield, Il, 60513. Sterile sampling containers were provided to the plant managers in advance of sample collection.

## Results and Discussion

### **Crax Samples:**

2 facilities submitted physical crax samples (Darling) and the remaining 2 facilities (Central-Bi) submitted manager reports. There were no visual indicators of the liners in the crax reported by plant managers as well as microscopic inspection of received samples. All final meal samples had been run processed through a hammermill.

### **Rendering Equipment Operations:**

Most facilities submitted reports and completed the surveys. The percent compliance was not reported as each respective facility printed and implemented surveys independently. Since managers directly submitted reports to their respective superiors, a high rate of compliance is assumed.

## Plant Manager Survey

Did rendering the brown liners create any processing problems associated with the operation of any of the following equipment?

Plant Manager	mixed		0.88 mils		1.5 mils	
	Francis	Denson	LeBlanc	whitten	whitten 2	LeBlank III
raw material conveyors	no	no	no	no	no	no
raw material conveyor pump	no	no	no	no	no	no
material grinders	no	no	no	no	no	no
production fat screens or filters	no	no	no	no	no	no
production fat centrifuges	no	no	no	no	no	no
fat work or finish storage tanks	no	no	no	no	no	no
production fat pipes or valves	no	no	no	no	no	no
rotex screens	no	no	no	no	no	no
any visual evidence of presence in crax/meal?	no	no	no	no	no	no
other negative or positive observations	no	no	no	no	no	no

Table 1: Plant Manager Survey

It was determined that management reports from each facility tested yielded no indication of the liners causing any issues associated with rendering equipment. Not a single manager reported any issues or problems related to processing the 0.88 and 1.5 mil liners.

## Poly-Count Reporting

An independent lab (Modern Labs and Survey Co.) conducted all ‘poly count’ testing (Polyethylene – AOCS Recommended Practice CA 16-75) on the oil samples mailed directly from each participating facility. All four facilities reported back poly counts. Due to confidentiality reasons, facilities did not want their respective poly counts published, however the following summaries have been compiled:

1. Full Compliance. All facilities submitted at least 4 test samples to Modern Labs (2 samples taken during the 2 control weeks and 2 sample taken during 2 test weeks).
2. No Difference Reported. Three out of four facilities poly count did not significantly differ between the control and test weeks. Thus, 6,000 liners purposely rendered at each of the four facilities did not increase poly count.
3. Unique Finding. One facility saw a 50+% reduction in poly count. Out of curiosity, the plant compared the new number to the previous 6 months of poly-count data and confirmed a continued 50+% reduction.

It should be noted that the major finding was that the bags resulted in no difference – thus, the insertion of 6,000+ bags into the rendering system did not reduce or increase poly count. One facility, which is assumed to intake a large quantity of polyethylene bags, saw a tremendous reduction. Another take-away was that 75% of the facilities tested have drivers skilled enough to not collect polyethylene liners. However, if the Mater-Bi liners enter into the rendering system, they do not increase poly count, as per “Polyethylene – AOCS Recommended Practice CA 16-75.”

## Route Driver Reporting

10 route drivers participated in the survey. Because route drivers' pick-up from many clients, and that each facility negotiated with their own clients when implementing the new liners, only a select number of drivers actually used the new liners. The percentage of client participation was not disclosed to the PI. Various questions were asked of the drivers and responses are organized by bag thickness (0.88 and 1.5 mils)

How did damage to the brown liners during use differ from the normal liners?

*more, less or some damage?*

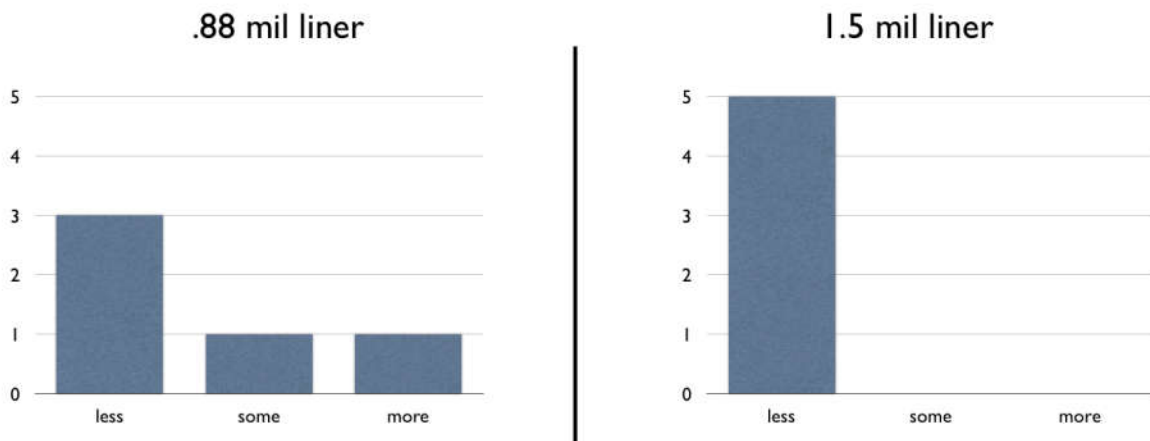


Figure 1. Route Driver Bag Damage

Figure 1 illustrates that only 1 out of 5 drivers indicated "more" damage with the brown bag (0.88 mils) versus every driver who used 1.5 mil liners reported "less" damage. It was concluded that 0.88 mil bags were slightly more advantageous than regular bags and 1.5 mil bags were overwhelming more advantageous than regular bags in terms of damage.

### If damage was observed, what type and describe

*stretching, ripping, tearing, leaking, melting, other*

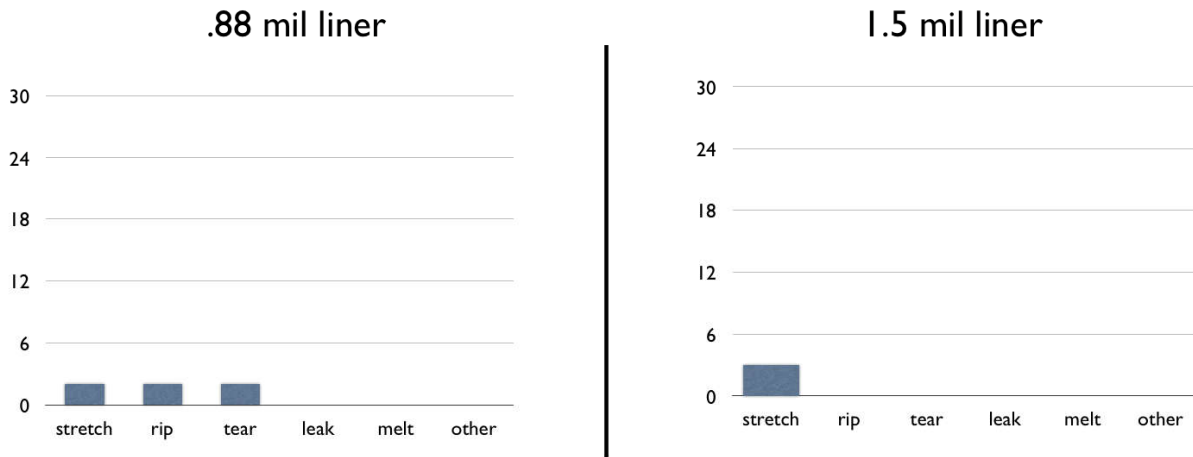


Figure 2. Route Driver Bag Damage Type

Figure 2 illustrates the type of damage found, if any, on the new bags respective to thickness. Minimal damage was reported for both thicknesses. Also, the source of damage (either route truck driver or client) was not disclosed to the PI. Either way, specific damage claimed was minimal – “stretching” being the largest, and only reported by 2 drivers.

### How easy did the brown liners come off of and out of the barrels

*easy - difficult, 1-5 scale*

.88 mil liner

1.4

1.5 mil liner

1.2

Figure 3. Route Driver Ease of Removal

Figure 3 illustrates that both liner thicknesses were “easy” to remove from the barrels. Out of a 1-5 scale, 1 being easy and 5 being difficult, neither of the bags averaged over 2 out of 5.

### Did the use of the brown liners change the cleanliness of the barrels?

*yes / no / no change*

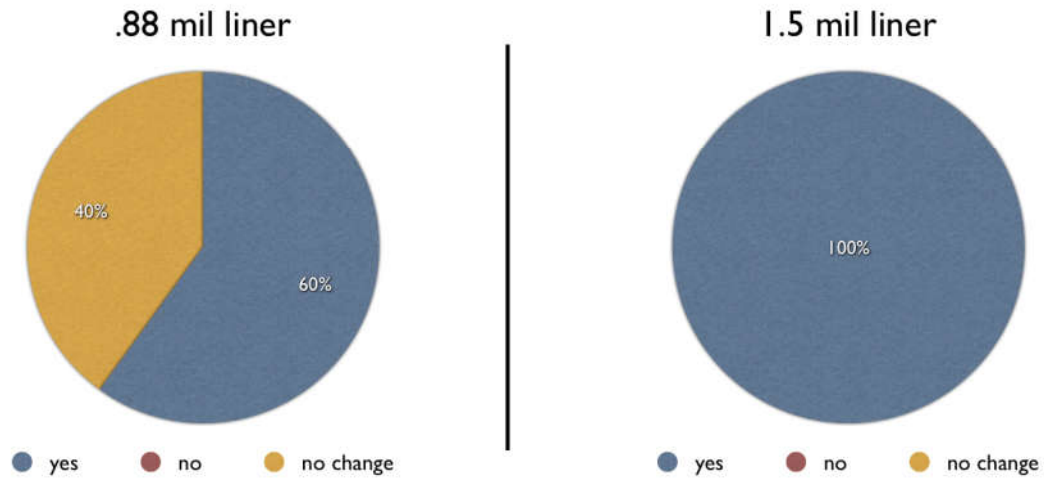


Figure 3. Route Driver Bag Cleanliness

Figure 3 provides unfortunately unclear feedback. The question was too vague to understand if the drivers intended to say “more clean” or “less clean.” It can be assumed the drivers reported a major increase in cleanliness, but this cannot be confirmed from the data collected.

### What describes your thoughts best?

*liners are worse than, better than or same as the normal liners*

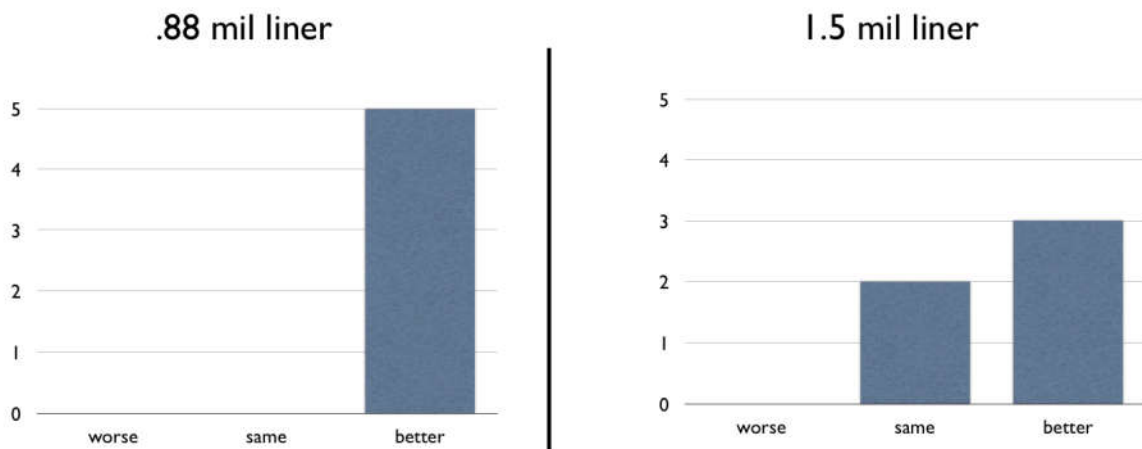


Figure 4. Route Driver Bag Overview

Figure 4 illustrates that drivers prefer the new liner when compared to the current liner. None of the drivers indicated that either thickness of liner was “worse” than the current liner.

comments on advantages and disadvantages	
.88 mil liner	1.5 mil liner
“easily removed from the barrel than normal liners”	“don’t leak”
“customer seems to like brown liners better than their bags. All HEBs are asking for brown bags every day”	“good thing all the stores likes them”
“makes my job faster”	“stores would over-stretch liners”
“farmer friendly”	“better than clear plastic bags”

Figure 5. Route Driver Bag Open-Ended Comments

Lastly, drivers had the opportunity to comment openly on the various liners. Their feedback is reported in Figure 5. All comments are positive towards the new liner.

### Client Evaluation

Surveys were also distributed to the respective pick-up location’s store managers. Some of the surveys list the store or back-end manager as the reporter of the survey. 99 stores participated in the survey: 42 stores used the 0.88 bag and 57 stores used the 1.5 bag.



Please rate the ease of use of the liners  
*easy, moderate, difficult*



Figure 6. Client Survey ease of use

Figure 6 illustrates how stores overwhelmingly considered the Mater-Bi liners to be “easy” to use.

If damage was observed, what type and describe  
*stretching, ripping, tearing, leaking, melting, other*

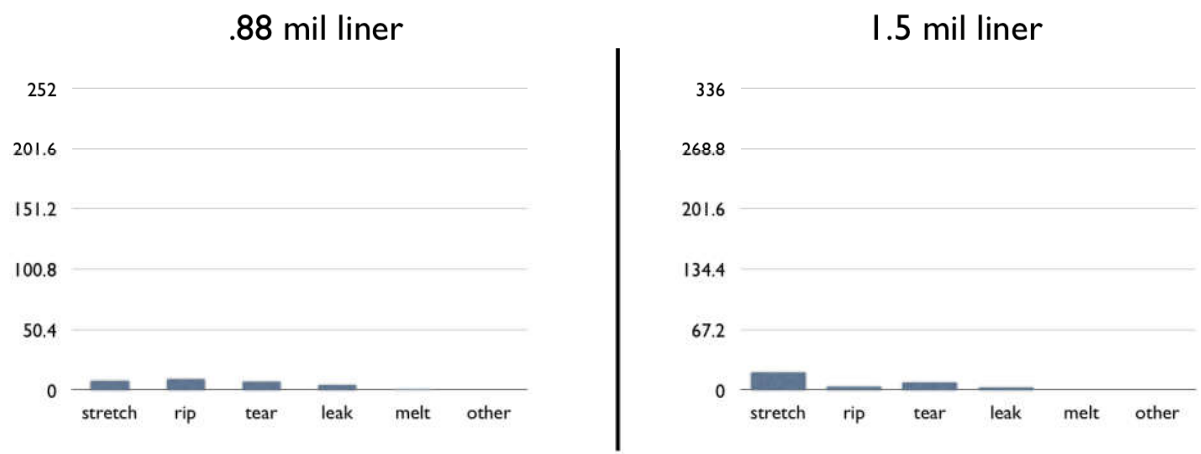


Figure 7. Client Survey damage

Stores indicated very little damage to either of the 0.88 or 1.5 Mater-Bi bags (Figure 7).

### Damage difference between brown and normal liners

*less damage, same damage, more damage*

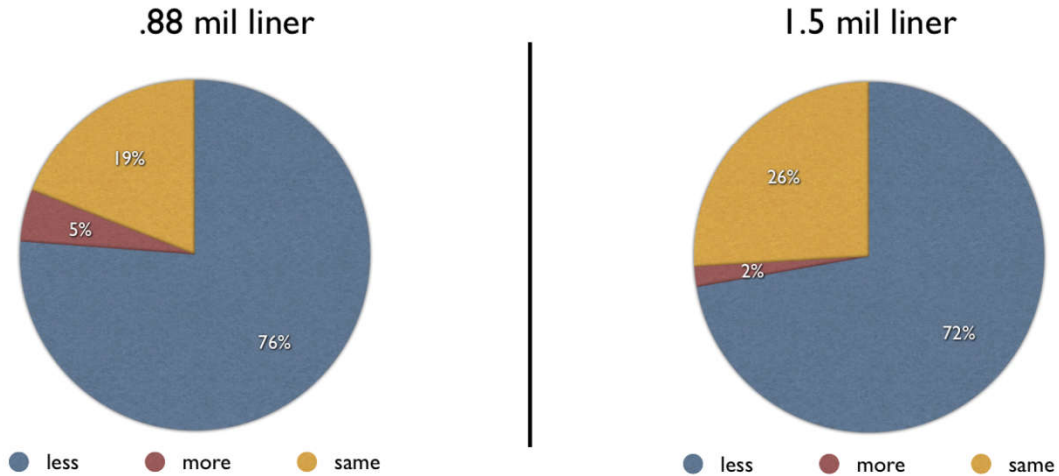


Figure 8. Client Survey damage difference

Figure 8 depicts that the majority of respondents found the Mater-Bi liners to have “less damage” than the current polyethylene bags. Few respondents (less than 6%) reported “more damage” while approximately a quarter of respondents reported “same.” Both bag thicknesses showed similar results.

### Did the use of the brown liners change the cleanliness of the barrels?

*Cleaner, dirtier, or no change?*

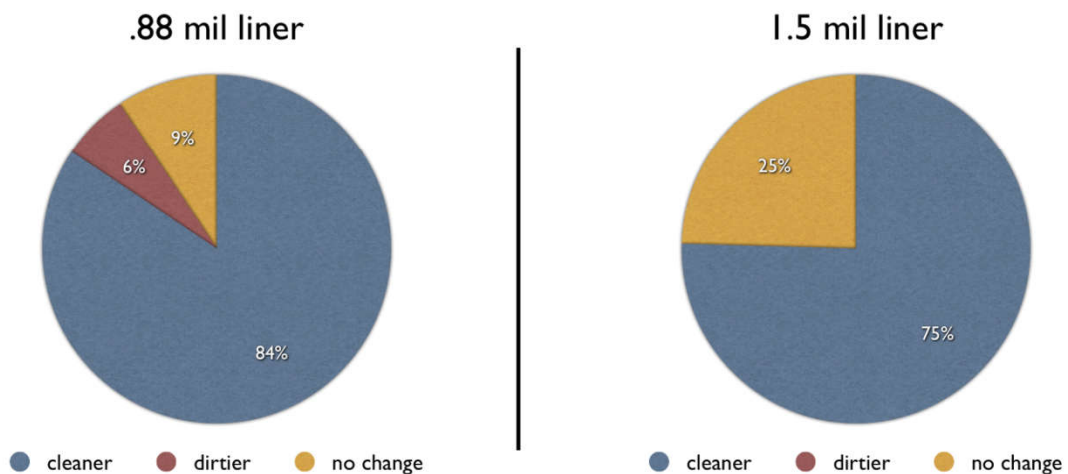


Figure 9. Client Survey cleanliness

Store respondents overwhelmingly indicated the Mater-Bi liners were “cleaner” than the current polyethylene bags (Figure 9).

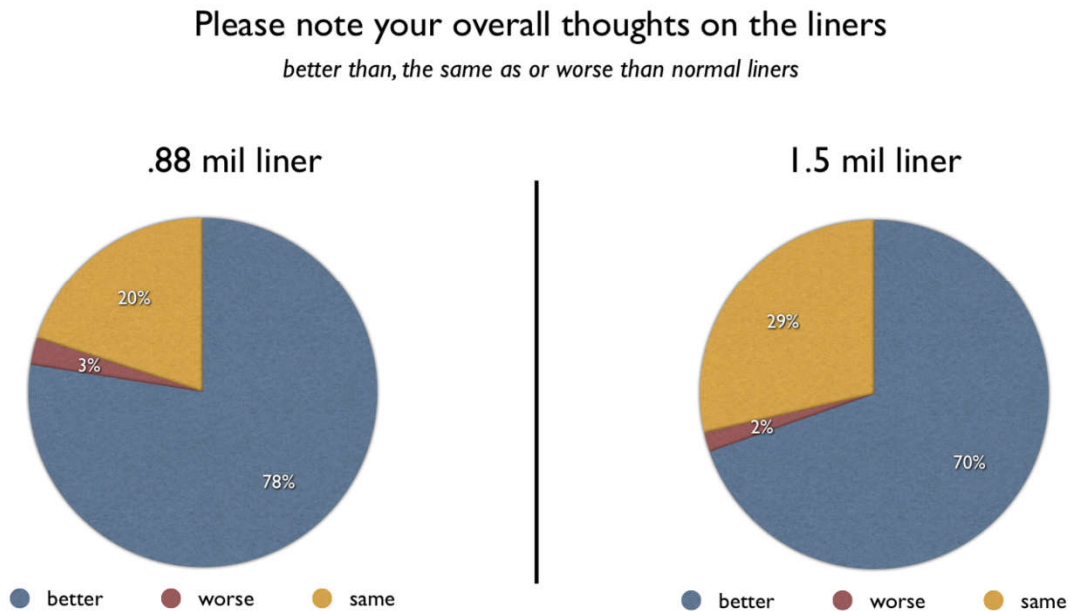


Figure 10. Client Survey overall thoughts

Store clients greatly preferred the Mater-Bi liner to the current polyethylene liners for both thicknesses (Figure 10).

Clients were also given the opportunity to write comments about their respective liners. Below are the comments from store managers concerning the 0.88 mil bag:

- great product, eco friendly, no leaks
- worked great - please continue using.
- Please leave a box of bags at a time
- Great
- easier to tear than regular
- rips-make stronger
- easy stretch fit
- cleaner and faster to wash
- Free!
- SAVES TIME
- kills the smell better
- good liners, stayed on barrel
- more bags
- no leaks
- easier to clean!
- easy to put on
- saves time
- barrels are cleaner
- cleaner than regular
- easy to put on
- great liner easier to work with
- product stays in the barrel
- less time cleaning barrels
- more durable and eco friendly
- very handy
- minimal damage
- Cuts down on cleaning
- fits barrels easier

Clients were also given the opportunity to write comments about their respective liners. Below are the comments from store managers concerning the 1.5 mil bag:

- stay in barrel better
- stayed in better
- work better
- cleaner after use
- less cleaning required, no problems
- we LOVE the brown liner
- better quality
- smells good
- easier to use
- less foul odor
- less labor
- more durable
- easier to use and cleaner
- Less odor
- less splitting when removed
- more durable
- tremendous improvement
- go on tight and stay put
- worked perfect
- fit well
- do not puncture
- better product
- barrel walls are cleaner
- NONE
- biodegradable is a good thing

It is clear that stores greatly preferred the Mater-Bi liners to the current polyethylene bags. It should be noted that 8 stores, in different areas of the country, reported a significantly reduced odor. It is assumed that the strong starch-like odor trumps the byproduct odor.

### **Water Savings**

In the store surveys, it was found that less water was required to clean barrels after use. Thus, a rough calculation was created to estimate the cost savings from water savings. Please note that this calculation should be re-evaluated prior to public disclosure:

- 99 stores participated in the results
- 88.37% of stores reported “water savings” and “time saved while cleaning”
- modal time saved while washing barrels (includes 0s) = 5
- at 9gmp - savings of 22.5 gallons of water / barrel
- assuming 50% of time using water (barrel + dock + lift clean)
- cost savings of \$0.11/barrel
- Considerable environmental and labor savings

Thus, it is hypothesized that stores will see a \$0.11 savings for each barrel dumped with the new liner. This is a significant savings and may dramatically offset any additional cost for the Mater-Bi liner.

### **Labor Reduction**

Within the store surveys, store managers indicated the time saved while cleaning barrels (as the liner and the product was picked-up at the same time). Thus, a rough calculation was created to estimate the cost savings from labor savings. Please note that this calculation should be re-evaluated prior to public disclosure:

- 99 stores participated in the results
- 88.37% of stores reported “time saved while cleaning”
- average time savings reported at 5.3 minutes
- average ‘actual cost’ of minimum wage employee is \$29.40/hr<sup>1</sup>
- savings of \$2.50/barrel

With an estimated savings of \$2.61 per barrel when water and labor savings are considered, the additional cost of the Mater-Bi bags is moot.

### **Impacts and Significance:**

The goal of the project was fulfilled and both of the liners proved to be positive. It is suggested that rendering facilities who are experiencing liner contamination immediately implement the Mater-Bi liners at 0.88 mils. The liners showed the following benefits:

- new liners do not clog, plug, increase poly count or contaminate meal

---

<sup>1</sup> IRL Minimum Wage Salary Report, Cornell 2012

- new liners are overwhelmingly preferred by plant managers
- new liners are overwhelmingly preferred by drivers
- new liners overwhelmingly preferred by customers and store managers
- new liners reduce odor, labor and water usage
- new liners saves customers an estimated **\$2.61**/barrel due to reduced water and labor

### **Publications:**

The data outlined in this report will be formatted for the Journal of Animal Physiology and Animal Nutrition and submitted in journal-format in 2014.

### **Outside funding:**

Central-Bi supported this study by doubling the number of liners and facilities in the test. The total additional investment was \$8,800.

An attempted was made to secure \$12,000 in sponsorship from BioBag USA to cover material costs, yet this was declined. However, BioBag USA extended a discount per bag as if we ordered 20+ pallets of liners. The discount saved almost 30% of suggested retail price.

### **Future Work:**

At the moment (8/30/13), a proposal is being considered by FPRF to develop further products (gloves) in addition to securing other prospective suppliers of Mater-Bi materials.

Future work should consider how much time the new liner saves drivers, as this question was not asked of drivers. Secondly, a more thorough study should be conducted to determine the total cost savings for both rendering facilities and clients. Thirdly, it is suggested to determining if reduction in smell is a legitimate attribute of the bag rather than a product of the Hawthorne effect. Lastly, an LCA study should be conducted to show the environmental impact of the bags, which is assumed to be highly positive.

However, it is very important that FPRF qualify the labor and water savings statements prior to disclosing this data to the public.

### **Acknowledgments:**

This study would not have been possible without the help and assistance from David Kirstein and Darling International staff. In addition, the additional funding from Chuck Neece at CentralBi allowed the study to double the amount of liners tested. Last, but not least, Annel Greene and the ACREC staff has been monumental supporters, both professionally and personally of the PI.