AC 2008-494: BRIDGING HEALTH AND FOOD SCIENCE TO ELECTRONIC ENGINEERING

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Bridging Health and Food Science To Electronic Engineering

ABSTRACT:

The primary focus of most engineering programs is on teaching students the technical aspects of the field without much emphasis on how to incorporate that knowledge in real world situations. Technological advancements in today's society are bringing many fields of study (which previously had little or no correlation) closer together. In order to help our students become well-rounded engineers for the future, it is important to bridge the gap between traditional engineering curriculums and non-technical fields and, as a result, create an engineering discipline that is more holistic. In line with this view, the two following issues from the health and food science fields were investigated in the laboratory section of the Photonics course:

1. Does the color of glass make a difference in bottled beer quality? If so, which color of glass provides tastier and fresher beer?
2. Does this apply to other consumer beverages such as milk? If so, which type of plastic milk container keeps milk fresher and healthier?

This paper intends to show how these two experiments were developed and outline the results of the experiment.

INTRODUCTION:

The Electronic and Computer Engineering Technology (ECET) curriculum at ……………. University has a heavy emphasis on "hands on" laboratory experiments and projects. Every technical course, either core or elective, has a laboratory section that complements it. Photonics is an upper division elective course focused on fiber-optics/light theory and their applications. The laboratory experiments in this course are collection of experiments in geometry/wave optics, fiber optics, and optical communications. This course holds many related applications in fields such as: physics, energy consumption, economy, and in both food, and health science etc.

The way students connected Photonics to food and health science was the result of a television advertisement that directly related the “crisp freshness” of beer to the composition and color of the glass it was bottled in. The advertisement continued in making a comparison of their glass beer bottles compared to those of the competition to show that one brand keeps beer fresher for longer time. This was an inferred reference towards the fact that there is a relationship between the many ways light can affect the quality of bottled beverages. The students also extended the range of the experiment to milk containers to test a beverage/container that most people are familiar with. The final goal was to develop a series of laboratory experiments to investigate the accuracy of these claims with equipment provided in the laboratory.

PROCEDURE & DATA:

Part 1:Milk Containers

The first containers analyzed were the plastic milk containers since they were readily available and easy to manipulate for the purposes of this experiment. This experiment was conducted in order to investigate how different types of common plastic milk containers react to the light they are exposed to in the grocery store.

Two high-density polyethylene (HDPE) #2 plastic milk containers from two different dairy companies were considered for this experiment. The first regular plastic container had very thin, transparent walls so that the level of the milk could be observed from the outside. The second plastic container had thicker walls so that the milk level could not be seen from the outside; this company marketed their bottle as the “light block” container.

Prior to beginning the experiment it was noted that fluorescent light bulbs were the universal light source in many grocery stores (this includes refrigeration units and general store areas). In order to be consistent, the same Buffalo Brand fluorescent “energy-saver” bulb was used for both plastic containers to simulate the light sources found in most grocery stores. Due to this fact, the brand or specifications of the light source had no effect on the results of the experiments whatsoever.

The Integrating Sphere

Students use the "Integrating Sphere" system to find the light spectrum emitted from a number of light sources. This system is a spherical test machine that encompasses a light source completely to capture the emitted spectrum of light and other related information such as radiation, luminous flux, and radiant flux. To collect all this information, the Integrated Sphere is connected to a spectrometer and a computer. The "Labsphere Spectral Lamp Measurement System" software processes the above-mentioned information.

For the experiment, the light bulb was placed inside the sphere and each plastic container was placed over the light bulb (one at a time) through a hole that was made at the bottom of each plastic container.

Figures 1, and **2** show the spectrums emitted through each container and **Table 1** shows all related information for the light emitted in each case. The particular light source chosen shows a maximum intensity around "orange-red" part of the spectrum. This, again, should be noted as a characteristic of the light bulb only which had no effect on the results of this experiment.

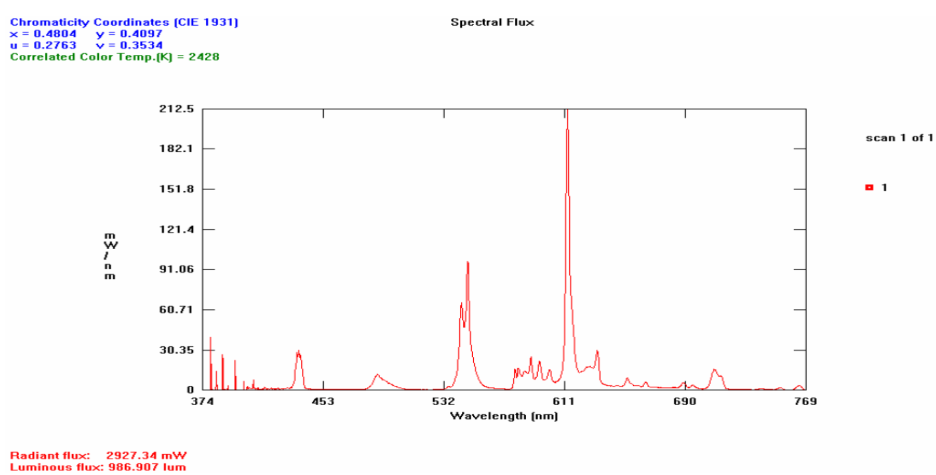

Figure 1 – Light spectrum emitted from Buffalo Brand bulb inserted in "light block" milk container.

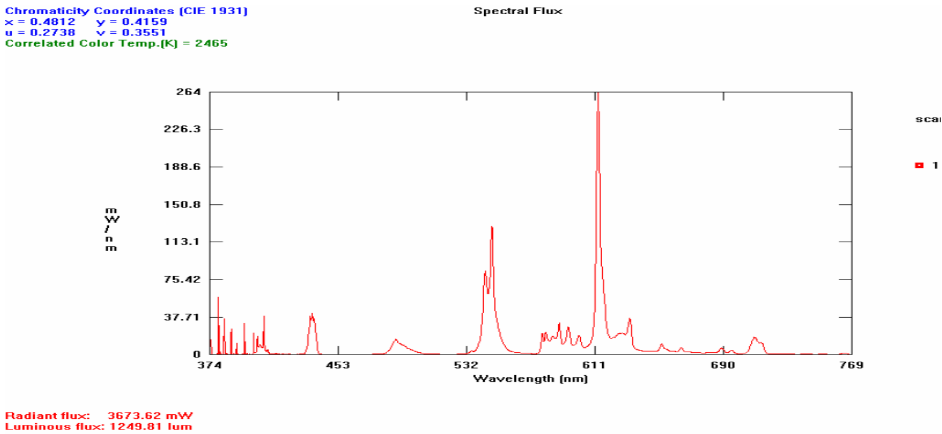

Figure 2 - Light spectrum emitted from Buffalo Brand bulb inserted in regular milk container.

Type of milk bottle	Max. Power (mw/nm)	Radiant flux (mw)	Luminous Flux (lum)
Light block	212	2927.34	986.907
Regular	264	3673.62	1249.81

Table 1 – Data Comparison of two plastic milk bottles.

Light Power Detector

To gain a better understanding of how these plastic containers reacted to the light source, a light power detector measured the light power coming through each container from the light source. First, the light detector was installed (one at a time) through the previously cut hole inside of each bottle. Next, the light power was measured with the light source placed at a distance of one, two, three, four, and five inches from the container. This was done to provide better accuracy through a linear graph. **Figure 3** and **Table 2** show the comparison of the light power emitted through each of the plastic containers.

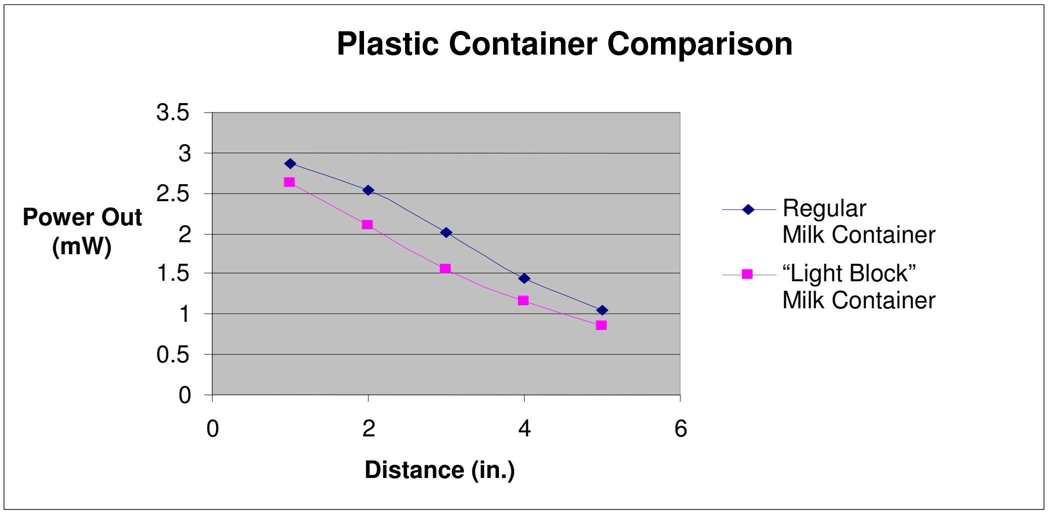

Figure 3 - Comparison of light power emitted from the two plastic containers versus distance.

Regular Milk Container		“Light Block” Milk Container	
Distance **(in.)**	Power Out **(mW)**	Distance **(in.)**	Power Out **(mW)**
1	2.86	1	2.63
2	2.54	2	2.09
3	2.01	3	1.56
4	1.44	4	1.17
5	1.06	5	0.85

Table 2 – Light power emitted from the two plastic containers from in various distances.

Further Research on the Lights Effects on Milk

All of the above figures and tables help illustrate the results of this experiment which proved that light penetrated less in the “light block” plastic container than with the regular plastic container. Unfortunately, there was no equipment available to test the effects of light radiation on milk.

However, Kathryn Chapman’s research has shown that: “Light exposure causes chemical reactions in milk that can modify the proteins and fats that are present to produce many negative flavors, ranging from burnt protein (burnt feathers or hair) to cardboard or metallic flavors. The resulting off-flavors are dependent upon various factors such as exposure time, intensity and wavelength of light, and composition of the milk."[1]. Researchers at Cornell University also found that the florescent light radiation has negative impact on the milk’s proteins and fats: “Light-oxidized defects develop in milk as a result of its exposure to sunlight or to fluorescent lighting (wavelengths below 620 nm) common in store dairy cases. Light initiates a chemical reaction in milk that modifies specific proteins and fats, resulting in the characteristic off-flavors. Certain vitamins (i.e. riboflavin and vitamin A) are also susceptible to light-induced degradation in a similar manner."[2] More specifically for vitamin A: "Fluorescent lighting in retail dairy display cases induces vitamin A degradation and 'light-oxidized' flavor defects in milk products packaged in light-transmissible (i.e. high-density polyethylene - HDPE) containers."[3]

This experiment proved that light penetrated less through the “light block” milk container than the regular container. With the information and data acquired through this experiment it is evident that to ensure quality, freshness, or taste milk should be stored in the thicker “light block” plastic containers.

Part 2: Beer Containers

The second experiment was conducted in order to investigate how glass bottles of varying colors reacted to light exposure received in the store. This part of the lab was done last because each glass bottle had to have their bottom removed.

Four glass bottles of varying colors were selected: clear, green, light brown, and dark brown. As mentioned before, the bottom of each bottle was cut from them so that the same light source from the first experiment could be inserted.

The Integrating Sphere

The Integrating Sphere was used again to collect the light spectrums from each individual bottle. **Figures 4**, **5**, **6**, and **7** show the light spectrum emitted from each respective bottle using the same florescent light bulb.

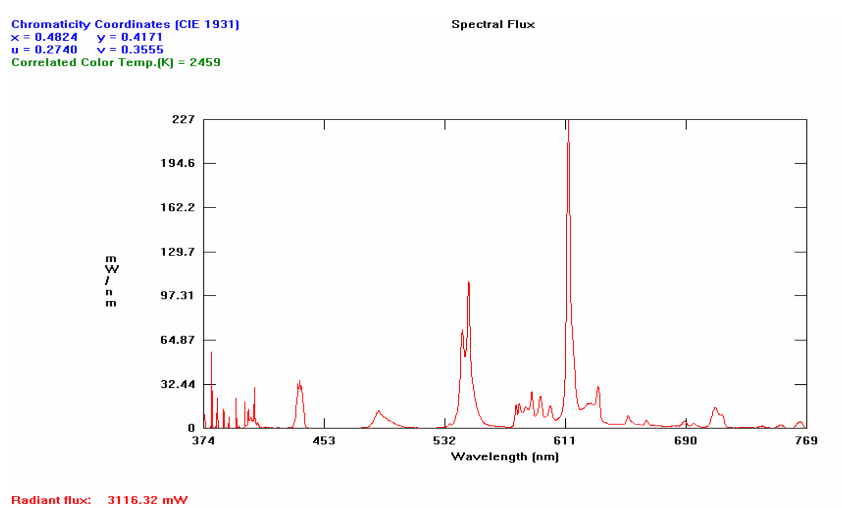

Figure 4 - Light spectrum emitted from Buffalo Brand bulb inserted in clear glass bottle.

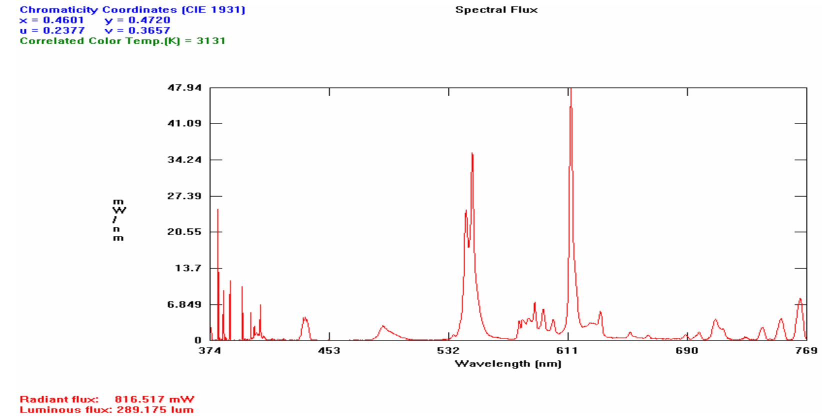

Figure 5 - Light spectrum emitted from Buffalo Brand bulb inserted in green glass bottle.

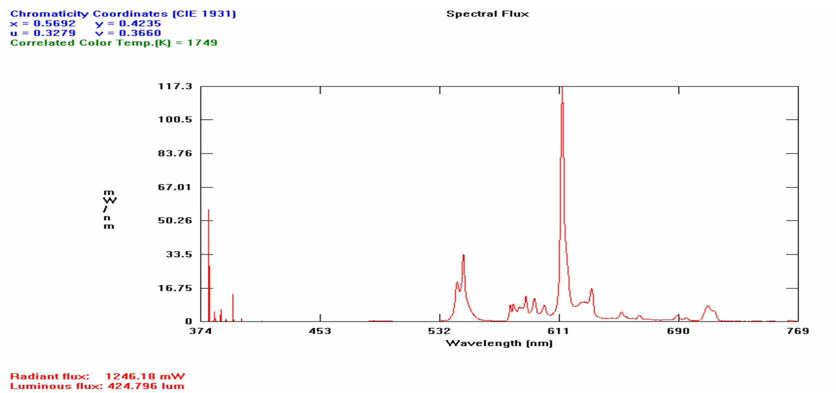

Figure 6 - Light spectrum emitted from Buffalo Brand bulb inserted in light brown glass bottle.

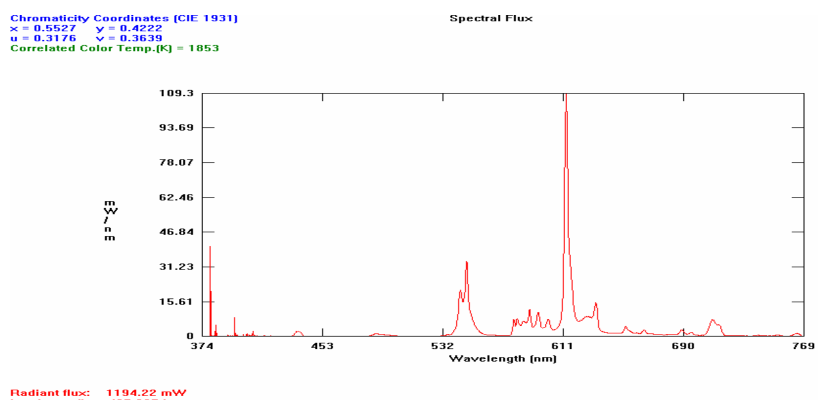

Figure 7 - Light spectrum emitted from Buffalo Brand bulb inserted in dark brown glass bottle.

Light Power Detector

The light detector used in the first part of the experiment was inserted (one at a time) into each bottle. Next, the light power was measured with the light source placed at a distance of one, two, three, four, and five inches from the container. **Figure 8** and **Table 3** show the comparison of the effects of the lights power through the glass bottles.

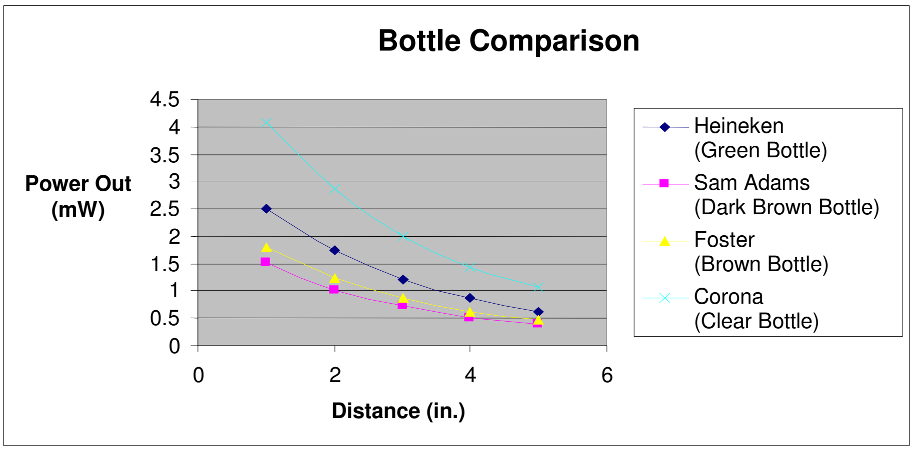

Figure 8 - Comparison of light power in the four different glass bottles versus distance.

Sam Adams (Dark Brown Bottle)		Fosters (Light Brown bottle)		Heineken (Green Bottle)		Corona (Clear Bottle)	
Distance **(in.)**	Power Out **(mW)**	Distance **(in.)**	Power Out **(mW)**	Distance **(in.)**	Power Out **(mW)**	Distance **(in.)**	Power Out **(mW)**
1	1.51	1	1.79	1	2.5	1	4.07
2	1.01	2	1.24	2	1.74	2	2.86
3	0.72	3	0.86	3	1.2	3	2.01
4	0.52	4	0.63	4	0.87	4	1.44
5	0.39	5	0.47	5	0.63	5	1.06

Table 3 - Light power data from the four glass bottles at various distances.

Further Research on the Lights Effects on Milk

Again, the required equipment to study the effects of light on beer were unavailable. However, Promolux lighting International company studies have shown that the radiation of light has directly effects the organic compounds of beer: “Ultraviolet and harmful visible spectrum radiation from the sun or from retail display case lighting initiates a photochemical reaction in beer that produces mercaptans, a group of organic compounds that includes the chemical skunks spray on their enemies. Beer that has been “light struck” tastes and smells like skunk spray, and is often referred to as skunky” [4]. They also fund that the clear glass offers no protection when beer exposed to the light radiation: “Clear glass offers no protection against the light struck effect, and amber glass reduces the effect only slightly” [5].

This experiment illustrated that light is radiated less through dark brown glass bottles than any other colored glass. Additionally, it is recommended that beer be kept in a dark brown glass bottles as opposed to a clear, green, or light brown glass bottles.

CONCLUSION

Advancement in technology allows engineering students to measure and test many non-technical subjects in an engineering related laboratory. The above experiments are an example of how students can use technology to prove advertised claims as true or false. By learning these applications and conducting these experiments engineering students can help people in other fields (i.e. nutritionists, food marketing) to choose the right container to keep foods or drinks safer, fresher, or tastier etc. The above experiments have shown how milk can be exposed to the light radiation much less if it’s kept in a “light block” plastic bottle that has walls that are much thicker than regular plastic bottles. They also have shown that in order to keep light radiation away from beer, it is better to keep it in a brown preferably darker brown glass bottle than clear or green bottle.

REFERENCES

1. Chapman, Kathryn: " New study validates light blocking efforts: teens taste light-oxidation in milk" *Dairy Foods,* Sept. 2002.
2. Cornell University: " Light-oxidized flavor defect of milk" *Dairy Science Facts 2002*.
3. Cornell University: " Studies of light induced defects in fluid milk: vitamin A loss & light oxidized off flavor". *Dairy Science Facts 2002*.
4. Promolux Lighting International company study report. http://www.promolux.com/english/retail_beverage_display
5. Promolux Lighting International company study report http://www.promolux.com/english/retail_beverage_display.