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South Sudan, Food Spoilage and Waste – (Foodborne Illness)

South Sudan: Killing the Invisible Food Monsters

The sounds of machine guns ring through the air as a country fights war between itself and its neighboring countries, but potentially, the bigger war of food insecurity faces the country of South Sudan. While the country uses machine guns, tanks and other forms of artillery, families fight their own war of food insecurity. The smell of fresh cut steaks grilled alongside steamed vegetables never fills the air for families in this region, rather, the air is filled with the heaviness of worrying where the next safe meal will come from.

While it is difficult for family units in South Sudan to often find food, it is even more challenging for families to find food which is not tainted with some foodborne illness (The City Review, 2021). With South Sudan producing low amounts of its own food, the country imports over 90% of the food consumed in the country (Kiri et al., 2020). Being the youngest country in the world (United Nations, 2023), South Sudan residents are some of the poorest in the world. With a population of just over 11 million, the majority of its population resides in rural areas. While there is a push for urbanization in some areas, the fact that the county is riddled with poor and damaged infrastructure due to its past struggles with wars hinders progress ("South Sudan: Government," n.d.). South Sudan is ranked 187th out of 189 countries on the Human Development Index. The reduction in oil prices has further lowered the economic suffering in the country. Poverty has increased from about 44.7% in 2011 to more than 82.3% now (World Bank, 2022).

The City Review (2021) reported there is a tremendous need for a reduction in illnesses being created by foodborne pathogens. This high foodborne illness level for the country of South Sudan is largely due to the small or inconsistent oversight of the foods being imported from other countries. Since the majority of food must be imported, the government is either not able to inspect or is ignoring the policies in place in order to continue to fulfill food contracts.

Not all areas of the South Sudan are experiencing a lack of quality food. The disparity is quite clear between the haves and have-nots. For the majority, however, most shopping trips mean racing towards a United Nations (UN) helicopter to see what food supplies they can attain for their families (Food for the Hungry, 2021). These "shopping trips" are often attended by the women of the families as they struggle to provide food and security for their families.

The long war for independence in the South Sudan has demolished the public systems such as education, health care, and infrastructure. The continued erratic violent behavior and prolonged uncertainty in many parts of the country have also disrupted the basic social structures (Kane et al., 2016). Economically, according to the World Bank, even though there is potential in the South Sudan, there is a large disparity and poverty, with 51% of the population living below the poverty line. Nearly 72% of the population is under the age of 30 years old; most of them are jobless, untrained, rural, and female (Kane et al., 2016). Approximately 84% of all females cannot read or write. Over half of family units in South Sudan are led by the mothers.

While food shipments from the UN are normally free of foodborne illnesses, shipments from neighboring countries are often not checked for spoilage, old food, or for expired foods. Families often struggle between not eating, and risking eating a meal that may make them sick (Eltigani & Habiballa, 2018). While most foodborne illnesses can be treated in the United States, families in the South Sudan do not have the same access to health care or medical supplies which could prevent or reduce symptoms. Often a simple case of diarrhea in the South Sudan can turn into dehydration, weakness, muscle fatigue and finally death (Cleveland Clinic, 2019).

While there may be a disparity in the roles of getting and cooking the food for the household, the issue of foodborne illnesses effects all members of the family with no respect of the sex of the individual. There is, however, a difference when it comes to age, as foodborne illnesses effect infants and the elderly more than others.

In school, I took a food science class and participated in the meats judging team, where I learned much about reducing contamination to foods from some of the most common microbes associated with foodborne illnesses. As part of my class I was asked to complete research on methods which could be used in order to reduce potential pathogens. I chose to look specifically at something that small households could use to reduce potential pathogens and microbes. I researched ultraviolet -C (UV-C) lighting and how it can be used to reduce microbial growth on raw meats.

It is notable that research by Han (2020) showed there is a risk of pathogens transmitted via raw and prepared foods, especially when not refrigerated properly or when handled by workers which are contagious.

Historically, according to Reed (2010), as early as 1877, scientists Downes and Blunt discovered that sunlight could be used to stop microbial growth. It was not until much later that others proved that factors to inactivate microbes were intensity of sunlight and length of time exposed. During the 1930's, as described by Reed (2010), there was progress which identified ultraviolet (UV) light and that it was measured in nanometers (nm). Much has changed over the last 90 years as scientists have discovered and named three types of UV radiation: A, B, and C. UV-A and UV-B are the two types of radiation that affect things on earth in both good and bad ways (Reed, 2010). In fact, our skin uses UV-A at rates of 320-400 nm to synthesize vitamin D. While UV-A is helpful in the production of Vitamin D, UV-B rays are in the 290-320 nm levels and can cause harm to cellular deoxyribonucleic acid (DNA) (Reed 2010).

Typically, the most damaging rays, UV-C at 200-280 nm, do not make it to the earth and are absorbed by the ozone (Allen, 2001). Allen (2001), suggests that while UV-A and UV-B have the potential for killing microbes, but are not as efficient as UV-C treatments in eliminating microbes on foods. Kim (2016) reflected that UV light covers a spectrum from 10 to 400 nm and that each type of UV serve a specific function within our world. While all UV rays seem to have some germicidal benefits, the UV-C shows the greatest promise for microbial inactivation.

More recently, the Food Drug Administration (FDA) (2020), announced that the primary way UV-C works to inactivate microbes is by direct contact. Therefore, if microbes are hidden in a crevice or fold within a food matrix they may not be effected by the treatment and will continue to reproduce. The FDA goes on to warn of potential hazards if humans also come into direct contact with these UV-C rays. Notably, the FDA (2020) pointed out that while UV-C GT have been used in the food industry for a while, UV-C LEDs are making significant jump in popularity due to their low energy and easy to manufacture status. It seems however, that much of the research concurs that ultimately it is about providing the correct UV rays in the spectrum of 200-280 in order to be effective at inactivating potentially harmful microorganisms. Image 1 (2020) illustrates the light spectrum and the small portion of radiation which is labeled as UV-C radiation at levels of 200-280 nm. Kim (2016) pointed out that UV-C GT does have some limitations in relation to a reduced effectiveness when used in refrigeration because the lamps take longer to warm up, risk dangers of exposing foods to mercury, and typically only stay at 254 nm whereas, UV-C LED's can be adjusted in some equipment to range from 200-280 nm.

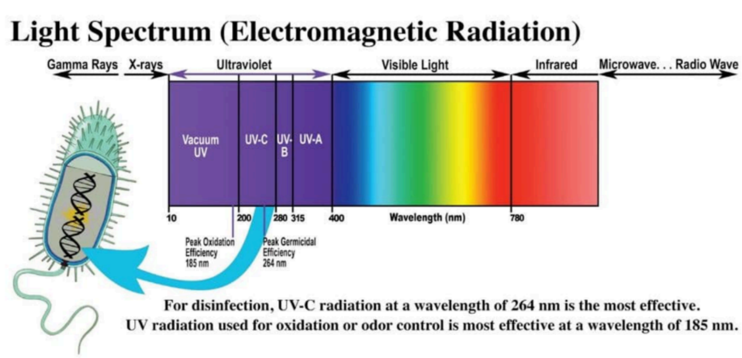
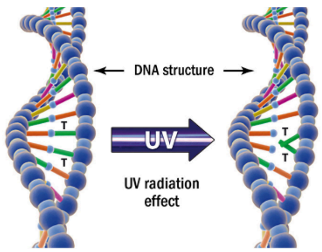


Image 1 - Light Spectrum

Prasad (2020) analyzed the benefits of LEDs, and more particularly, the implications for use in agriculture from plant and animal growth to the inactivation of microbes on food products. Notably, the UV-C LEDs studied on fresh fruits by Prasad (2020), showed variance of results due to temperature, age of fruit, and humidity.

With the establishment from so many sources that the UV-C treatment for both LED and GT type systems were efficient at inactivating microbes, it was necessary to establish an understanding of how each of the treatments worked. According to Birmpa (2014), Herring (2001), and Kebbi (2020), both UV-C LED and UV-C GT work in the same manner by disturbing the DNA structure within the cell to inactivate the microorganism. More specifically, Birmpa (2014) elaborates to include that the mechanism for microbe inactivation lies in the formation of photoproducts within the DNA of the targeted microbe, disturbing both the transcription and translation, ultimately causing death to the organism. Herring (2001) relates the activity within a microbe as it is subjected to UV-C rays as if there is a bubble which forms within the DNA structure causing the building blocks of the DNA to separate, ending the replication of the microbe.



Herring (2001)

Colás-Medà (2021) and Gündüz (2015), conducted research looking at the effectiveness of UV-C treatments on oranges in regard to inactivation of foodborne pathogens commonly found in the industry. It was implied that some of these pathogens can resist thermal pasteurization and treatments commonly used in the agriculture industry.

It was necessary to look for studies analyzing UV-C treatment in chicken meat. McLeod (2017), analyzed the reduction of pathogenic and spoilage causing bacteria on chicken fillets, finding that both UV-C LED and UV-C GT were effective at inactivating microbes on chicken fillets. In the study from McLeod (2017), the methods included using a plastic film over the chicken which was later removed because there was an interaction between the plastic film and the reduction of bacteria.

After conducting my own literature review on UV-C and its effect on meat, I conducted a series of trials to see if a portable LED UV-C lighting could reduce potential pathogens as well as a larger, more secure germicidal tube UV-C device. I used the literature review from above to develop my trials.

I hypothesized that if microbial growth from raw chicken tenders treated with UV-C LED was compared to microbial growth from chicken tenders treated with UV-C GT, then the raw chicken tenders treated with the UV-C GT would have the greatest reduction of microbial growth. A significant level of 95% ($P < 0.05$) was used to form conclusions from the calculated statistical results of ANOVA. Having a P-value less than the $P < 0.05$ shows that there is a significant difference. The calculated probability towards accepting the null hypothesis is 0.0001. Since this value is less than the $P < 0.05$, the null hypothesis is said to be rejected and the alternative hypothesis accepted. This statistical evidence shows that at least for the first treatment of UV-C, the UV-C GT treatment does have significant ability to reduce microbial growth.

These findings are consistent with what McLeod (2017) discussed as far as the importance of time under UV-C treatments for effectiveness. It can be concluded that UV-C LED, with a 95% reduction, and UV-C GT, with a 97% reduction, are both effective at reducing microbial growth on chicken tenders.

I concluded that when comparing the UV-C LED technology and the UV-C GT technology treatments on different types of food, the UV-C technology in general is effective at removing microbes from some food sources, and multiple treatments may be necessary for significantly lowering microbial or bacterial rates. Both UV-C LED equipment, with a 95% reduction, and UV-C GT equipment, with a 97% reduction, were effective at reducing microbial colonies on raw chicken tenders.

My personal research led me to believe that portable LED UV-C devices could be distributed to families in the South Sudan in order to be used to reduce potential pathogens that could be on foods. While my research focused on raw chicken meat, many of the same microbes or pathogens in raw chicken commonly cause some of the most serious cases of foodborne illnesses.

According to Borgen (2018) there are 10 main NGO's serving the South Sudan area. Of those 10 NGO's, I believe the Norwegian Refugee Council (NRC) may be the best fit help fund as well as educate the residents of the South Sudan on UV-C lighting and how to use it. While the NRC may not be the largest or most popular of the NGO's in South Sudan, they have been in South Sudan since the country's independence in 2011. They support education, nutrition, and medical programs, especially in light of the famine and violence that is ravaging the population. I believe their mission makes them the right NGO to help implement LED UV-C LED equipment in order to reduce potential foodborne pathogens on food, therefore reducing the cases of foodborne illnesses in the area.

Sustaining the use of the UV-C technology would have to be researched further. Hopefully the South Sudan government becomes stronger, relationships with allies grow, and the economy of the country begins to increase.

Because the South Sudan is so new of a country, there are many uncertainties about the future for these people and provisions for a safe and pathogen free food source.

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