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The Food Industry and Chemical Engineering Solutions

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Abstract: **The issues that have arisen from the food industry is much more serious than realized at a surface-level. One of the main issues seems to stem from not knowing what to do with high volumes of wasted food. With products from the food industry being produced at high quantities and perishing in short period of time, food waste has began to take a major toll on the Earth's environment. However, food in it of itself is a material consisting of complex chemical compounds, and thus the chemicals themselves can be observed, utilized, and even manipulated. It is within these 'manipulations' by which chemical engineering comes into aid. If one were to list the failures of the food industry, then the first and foremost failure is not having enough adequate chemical engineers. For food industries that have succeeded, studies show an integration of chemical engineering principles being implemented. This research will study the negative consequences and results of the food industry lacking in chemical engineers, as well as food industries from other countries, such as Europe, implementing chemical engineers with favorable outcomes.**

Keywords: **Chemical Engineering, Food Wastage, Food Industry.**

I. INTRODUCTION

The problems caused by the food industry is most likely due to the lack of coalescence and integration between the food industry and the chemical engineering world. These problems can be fixed once the food industry begins to coalesce and integrate more chemical engineers into the industry. If not, then the many problems will continuously get worse in a matter of time. In order to prove these points, a background on food wastage will be explained. Next, a section on the environmental damage done by the food industry will be shown with sub-sections on greenhouse gas emissions and water wastage. Furthermore, a section on the lack of chemical engineering in the food industry will be talked about with sub-sections explaining the lack of profession and education for chemical engineering in regards to the food industry. Then, it will transition to various chemical engineering solutions that have worked in the food industry such as chemical ecology and other specific examples of research done by chemical engineers. And lastly, another solution for the problem will be explained under the section of utilization of chemical engineers in the food industry with sub-sections exhorting for more job recruitment and formal education for chemical engineers in the food industry.

II. BACKGROUND

A. Food Wastage

One of the major problems in the Earth's environment has been caused by an unexpected consequence: food wastage. Unfortunately, the detriment on the environment caused by food wastage is astoundingly high. While there are many reasons as to why food wastage affects the environment, one of the main reasons why food wastage negatively affects the Earth is because food is being wasted at an incredibly high rate. The United Nations Environmental Programme made a report showing the staggering numbers of food wastage in the UK alone. The report shows, "In the UK, 8.3 million tonnes of food and drink are thrown away every year with a carbon impact exceeding 20 million tonnes of $CO2$ equivalent emissions" (Kosseva, 2013). According to the report, one of the ways food wastage influences the earth's environment in a negative manner is the rise of $CO2$. This is because spoiled and wasted food increase the carbon dioxide in the air. And according to the report, the CO2 emission level caused by food wastage is highly staggering. Maria Kosseva, a researcher who wrote an article called *Introduction: Causes and Challenges of Food Wastage*, states that making food that are not eaten not only causes carbon dioxide to rise, but also lowers the economic value. Kosseva states this sentiment by saying, "Producing food that will not be consumed leads to unnecessary CO2 emissions in addition to loss of economic value of the food produced" (Kosseva, 2013). Therefore, food losses represent a waste of resources used in several inputs, especially the economy.

The UN report also showed the specific numbers of each food category being wasted in the UK. The report showed, "860,000 tonnes of fresh vegetables and salads, 870,000 tonnes of drink, 680,000 tonnes of bakery, 660,000 tonnes of home made and pre-prepared meals, 500,000 tonnes of fresh fruit, 290,000 tonnes of meat and fish, 530,000 tonnes of dairy and eggs, 190,000 tonnes of cakes and desserts, 67,000 tonnes of confectionery and snacks " (Kosseva, 2013). In the end, this shows that most, if not all, the food categories are being wasted at an exceedingly high level. Another report shows that in Japan alone, an excruciating number of food waste is being trashed. The amount of food being wasted in Japan in terms of dollars are in the trillions. Kosseva stated that, "in Japan approximately 20 million tonnes food garbage is generated every year. This means that as much as f11 trillion worth of food is lost to waste annually" (Kosseva, 2013). The US has also contributed in harming the Earth's environment through food wastage. However, the US has contributed even more to damaging the environment by trying to take care of the food waste problem through the utilization of landfills. Although landfills can be used as an energy source, significant amount of food waste is buried in landfills, which damages the environment. According to the US Environmental Protection Agency, "Currently in the USA, over 97% of food waste is estimated to be buried in landfills. When food is disposed in a landfill it quickly rots and becomes a significant source of methane—a potent greenhouse gas with 21 times the global warming potential of carbon dioxide" (Kosseva, 2013). Landfills, and the methane developed from them, have been mainly found and emanated from the US. The US Environmental Protection Agency stated that, "Landfills are a major source of human-related methane in the USA, accounting for more than 20% of all methane emissions, which can be used as an energy source". (Kosseva, 2013).

The issues and concerns of food wastage are multi-faceted. However, one of the main reasons that the number of food wastage is so high is because of the lack of coalescence between chemical engineering and the food industry. This lack of coalescence, and the wastage apparently caused by it, was so noticeable that even the former presidents of chemical engineering organizations issued a 'call-to-arms'. This 'call-to-arms' was recognizing, "Chemical engineers have a key role to play" (Darton et. al., 2014). The former presidents direly stated that a cohesive and connected system was needed in order to pinpoint the technical problems and propose different business models for the food industry. But the key for the former presidents and engineers was connecting and integrating, or in other words, coalescing. The presidents stated, "Our profession will need to work very closely with others" (Darton et. al., 2014). As for food wastage, the problems are much more complex and deeper than people simply throwing away food in high volumes. While people and the contribution of the mass and fast production from the food industry, have thrown away food in high volume, studies have shown that this problem damages the earth's environment tremendously.

III. ENVIRONMENTAL DAMAGE

A. Greenhouse Gas Emissions

One of the consequences of food wastage can be seen in the cause and effect of greenhouse gas emissions. First of all, food waste consequently has increased greenhouse gas emissions, thus affecting the Earth's environment, but also a substantial product that is part of the food industry: animal feed. The reports show, "The combined carbon impacts in the UK of food and packaging waste in the supply chain totals 10 million tonnes of CO2 eq, and in the household 26 million tonnes CO2 eq. In addition, the greenhouse gas impacts associated with by-product going to animal feed is 3.7 million tonnes of CO2 eq" (Kosseva, 2013). The greenhouse gas emissions will continue to increase unless people recognize the problem and try to prevent environmental damages. A surprisingly high number was reported from a research stating, "The greenhouse gas emissions of avoidable food waste from Finnish households roughly correspond to the emissions of 100,000 cars" (Kosseva, 2013).

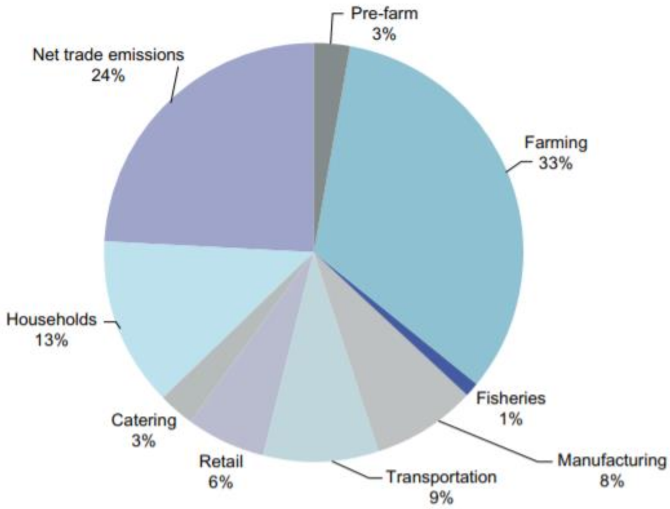

Figure 1: Greenhouse gas emissions associated with the UK food chain by sector in 2006.

From WRAP (2010) (Kosseva, 2013).

According to a graph for greenhouse gas emissions correlated from the UK food chain in 2006, 33% of greenhouse gas emitted from the food chain the UK is due to farming. As stated earlier, this is due to production, consumption, and wastage of animal feed.

B. Water Wastage

In addition, a great deal of water is used for the food waste. A research supported this statement by saying, "Globally, the amount of water withdrawn every year to produce the lost and wasted food could fill a lake of 1,300 km3, about half the volume of Lake Victoria" (Kosseva, 2013). It is important to note that water waste is categorized into food waste. This is not simply due to water being a material consumed by the human body, but also because water is used in many ways for the production and development of food. And as one can correlate, much water is wasted in food production.

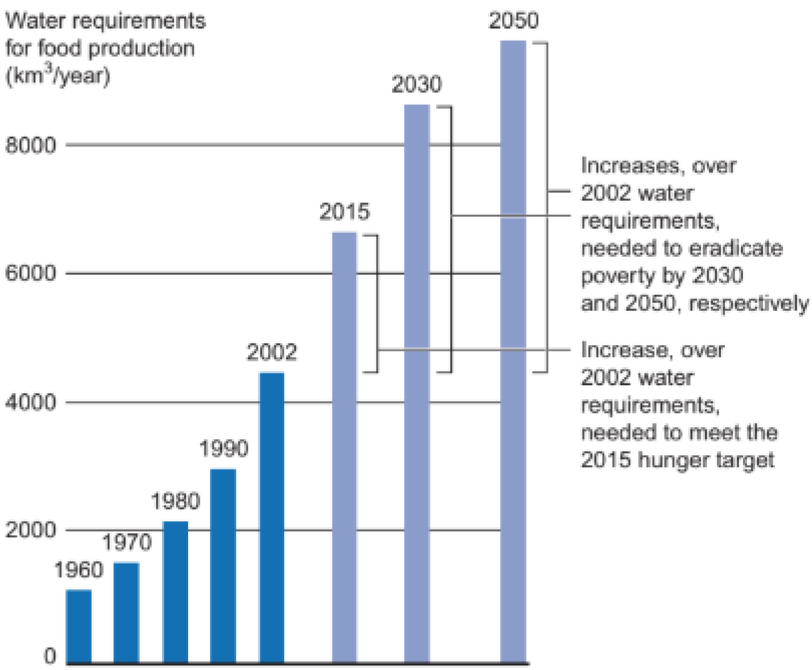

Figure 2: Historic and Projected Changes in Water Consumption for Food Production

From Nordpil (2009) (Kosseva, 2013).

As seen by the graph, there has been a constant and significant increase in water consumption for food production. There has been a drastic increase of water requirements from the years 2002 to 2015. It was within this millennium in which water requirements of food production has increased the highest of 2000 billion cubic meters. By the year 2030 and 2050, water consumption and wastage from the food industry will be over max capacity, by which over 8000 billion cubic meters of water will be wasted in the year 2030 and 10000 billion cubic meters of water by 2050. It should be noted that this is water used for food production alone.

IV. LACK OF CHEMICAL ENGINEERING IN THE FOOD INDUSTRY

A. Lack of Chemical Engineers for the Food Industry

For many years now, the food industry has seen the need as well as the lack of chemical engineers involved in food production. Chemical engineers, food scientists, ecologists, and even the food industry have repeated this sentiment. A guest editorial on the article, *Advances in the Application of Chemical Engineering Principles in Food Industry*, reminiscences a ground-breaking chemical engineering technique for milk fouling by Professor Peter Fryer from Cambridge University (Chen, 2007). This chemical engineering technique for milk fouling left such an impact in both the chemical engineering world and the food industry, chemical engineers and food production specialists have sought ways to correlate chemical engineering with food production. However, both have realized that there is still much work to be done in terms of implementing chemical engineering principles into the food industry.

Even so, the lack of chemical engineers in the food industry has been a growing concern. Chemical engineers have expressed this need for the food industry by stating, “The food industry has need for engineers, which it fills with a variety of hires, including chemical engineers (CEs), food engineers (FEs) and agricultural engineers” (Saguy et. al., 2013). But the refusal to do so has caused many problems to arise in detrimental effects. In an ironic turn, these problems can only be solved through engineers with a chemical engineering background.

Xiao Dong Chen, a professor in the Department of Chemical Engineering at Monash University, stated, “There is an ever increasing demand in the food industry that chemical engineers should work with the food scientists and technologists to bring the functionality based food design (formulation) to a practical outcome, i.e. the food products that have substantial retention of the functions that were intended at the formulation stage” (Chen, 2007). In essence, Chen is stating that bringing in more chemical engineers into the food industry will in effect cause a much more sustainable and efficient food production system. This will thus prevent many of the problems, whether ecologically or health-wise, caused by the food industry.

B. Lack of Education for the Food Industry

However, as stated earlier, there is also a lack of coalescence between chemical engineering and anything related to food as an education. Daryl B. Lund, a former chemical engineer, outlined the reasons and consequences to this problem in his article, *Who Would Have Thought? The Story of a Food Engineer*. Lund, now a food engineer is interested in applying food science with chemical engineering science. In his article, Lund states how little research there was during his time as a food engineer. Lund noticed, “The food industry has reduced internal funds for research” (Lund, 2017). However, this is not the only issue that Lund has realized. Lund has noticed that there was also a lack of formal and training in regards to chemical or food engineering in universities. Lund writes, “Another looming issue is the training and education requirements for employees in the food industry. Many of the jobs in the industry require technical knowledge but not necessarily a university four-year degree” (Lund, 2017). The issue that concerns Lund is that most universities teach cognitive and analytical knowledge and not so much ‘hands-on’ skills. Technical skills are needed in the field of chemical engineering, and such skills cannot be taught in a standard four-year program. But what makes the situation even more dire is that engineers with technical skills are greatly needed since food wastage is increasing and health problems caused by food is rising. There is already a lack of cohesion between chemical engineering and food production while concerning matters from the food industry are on-going. And if the universities are also not providing the education in order to properly train students to take jobs in these matters, then it may make matters even worse. Lund also states that there has been a lack and decrease of funding for research in food engineering science. Thus, Lund theorizes,“Given the decrease in research funding, there may also be a reduction in the number of universities offering MS and PhD programs in food science and technology” (Lund 2017). Again, this is a problem as for Lund, food is very much a science. But, it is a science that involves engineering.

V. CHEMICAL ENGINEERING SOLUTIONS FOR THE FOOD INDUSTRY

A. Chemical Ecology

It is important to reduce food waste and develop methods to valorise unused co-products and improve the management of wastes that cannot be reused or recycled. Kosseva stated that investing and focusing on the function, structure, and model of the food market would decrease food spoilage as well as increase the efficiency of food production. Kosseva writes, “Public investment in transport infrastructure would reduce the opportunities for spoilage, whereas better functioning markets and the availability of capital would increase the efficiency of the food chain” (Kosseva, 2013). One of the ways to do this is for chemical engineers to utilize the concepts of chemical ecology.

Chemical ecology is developing with new technologies for sustainable food production. It helps in the global population and climate change. However, food sustainability is an issue as crops are lost to pests, diseases, and other harmful elements. New approaches are needed to provide plant nutrients as crop losses leads to harm the environment and the farm profits by the carbon footprint. The solution is, “By introducing nitrogen fixation into a wider range of crops, or into their rhizospheres, we can expect to harness allelopathy to reduce losses of fixed nitrogen as the powerful noxious greenhouse gas, nitrous oxide” (Pickett, 2012). By regulating the production of methane and various, crucial agrogenic greenhouse gases, the geographic regions could be more acceptable. Therefore, chemical ecology can provide both a framework and solution to the problem of food and crop preservation. This can be done through the ‘ethos’ of chemical ecology which is to synthesize both high science and agricultural application together. Therefore, the synthesization of two different worlds, science and agriculture, can provide a viable solution to the problem of food waste. The world of agriculture and farming should apply the rules and methods of high science, while the science community should be intentional in working within the agricultural and farming world. According to J.A. Pickett, a chemical ecology researcher, he argues that, “We must show the way through high quality science and thereby persuade the world of the contribution that chemical ecology can make to sustainable intensification of food production” (Pickett, 2012). Coalescing both the chemical engineering world and the agricultural world can be one viable solution to the food wastage and greenhouse gas emission problems.

B. Examples of Chemical Engineering Solutions

There are many examples of chemical engineering principles that have worked in solving issues caused by the food industry such as health and wastage. These are a few examples by which chemical engineering techniques have helped in those regards.

(a) Reduction of Beauvericin from Cereal Products

One of the ways in which chemical engineers have helped the food industry is by making sure the products on the shelves are healthy and non-toxic. However, not every food product on the shelves of markets are regulated for health safety. Such is the case with grain and flour products. According to a research done by food chemists and toxicologists, researchers discovered that many of the cereal products had high concentration of beauvericin (BEA). BEA is considered a contaminant for grain and cereal products and thus toxic and unhealthy when consumed. However, researchers have noticed, “The presence of BEA in food and feed commodities has been reported in several countries of south and north Europe (Finland, Norway, Spain, Slovakia, Croatia, Switzerland and Italy), and also in USA, South Africa” (Luciano et. al., 2013). Therefore, researchers have sought ways to decrease the level of BEA in cereal products by utilizing chemical engineering techniques. One of the ways by which this was done was to separate and utilize two chemical compounds called BITC and PITC. The researchers explain that, “BITC and PITC are common isothiocyanates with strong reactive capacity” (Luciano et. al., 2013). With strong reactive capabilities, researchers hypothesized that both BITC and PITC can eliminate the high levels of BITC, thus working as an organic ‘fumigation’ system. After experiment and study, the researchers have found this method to be successful.

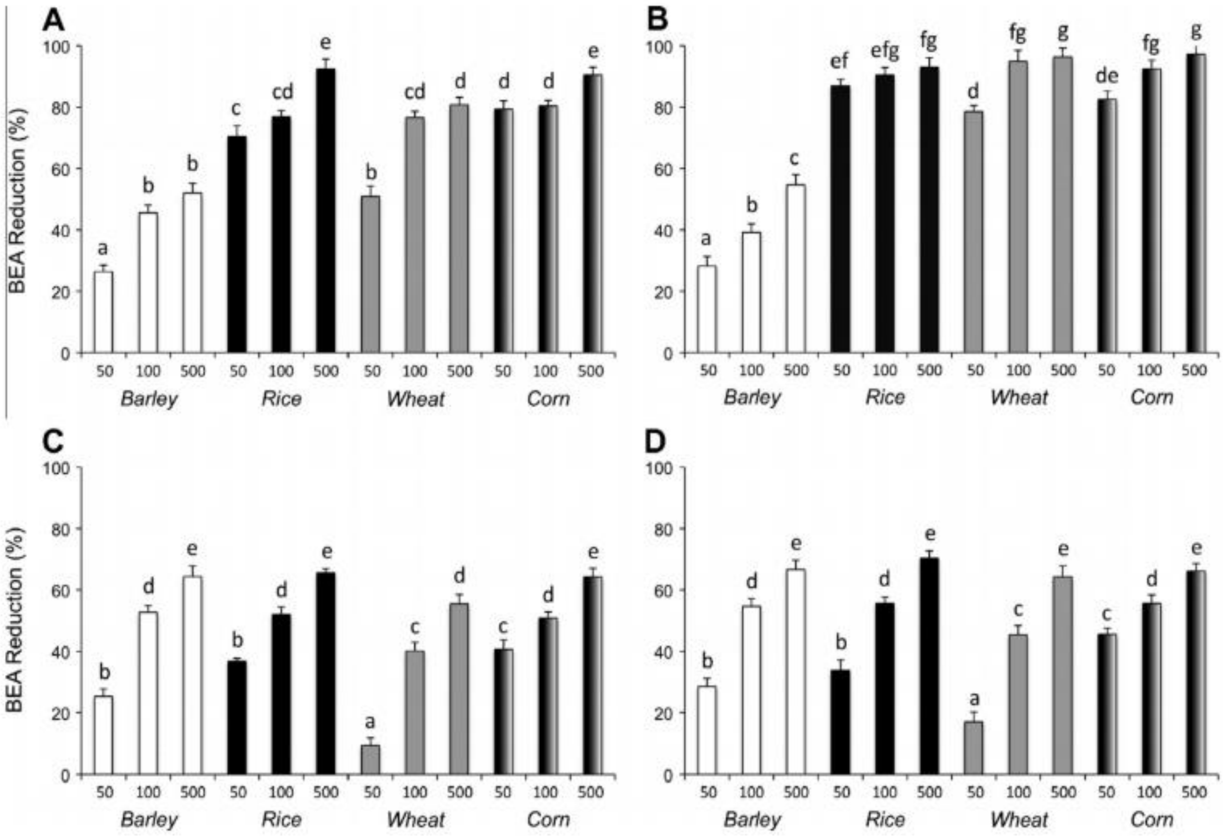

Figure 3: Reduction of BEA (%) when utilizing BITC (A and C) and PITC (B and D)

(Luciano et. al., 2013).

This graph shows the reduction percentage of BEA when using BITC and PITC in barley, rice, wheat, and corn. The graph points out that, "Among the crops, corn was the vehicle where BEA was mostly affected by the action of the ITCs, followed by wheat and rice, and lastly barley" (Luciano et. al., 2013). Corn is one of the highest grown and consumed crops in the world. However, natural compounds such as PITC and BITC can reduce the levels of BEA and the risk associated with the ingestion of the minor fusarium mycotoxin.

(b) Benzyl Isothiocyanate for Tomatoes

BITC (benzyl isothiocyanate) has also known to have properties to prevent perishing and mold infestation. This is known to be the case especially for tomatoes. BITC is known as a strong antifungal compound, which controls Alternaria alternata growth. Resh weight loss were measured by monitoring respiration rate. Tomatoes are highly perishable and had large post-harvest losses. Tomatoes are most frequently infected by Alternaria alternata. As a solution, researchers conducted an experiment by exposing tomatoes to BITC in a low-density polyethylene bag for 15 days at 20 degrees celsius. Doing so decreased the damages done by Alternaria alternata significantly. Researchers have found and concluded that, "BITC merits special attention as a naturally occurring substance that can control the spread of A alternata infections" (Troncoso-Rojas et. al., 2005). One of the main concerns for the researchers was the inadequate preservation procedures managed by crop companies. Consequently, a large number of tomato crops have been wasted. Researchers express this concern by saying, "Among the factors responsible for these losses are poor harvest and handling techniques as well as infections produced mainly by fungi" (Troncoso-Rojas et. al., 2005). And so, the researchers call for more research of chemical engineering preservation techniques, such as utilizing BITC against tomato mold infestation.

(c) Utilization of Waste Bread

One food product that is particularly responsible for high level of food waste is bread. Usually, bread is simply wasted. The problem with this is that bread is produced in high levels while also perishing in a fast amount of time. This in effect has been the source for the high level of food wastage in the environment. But the real issue is that the food industry does not utilize the waste bread as researchers have found various ways in which waste bread can be used. Colin Webb, a researcher who addresses the food wastage problem, has noted, “One of the major untapped resources for such processes is waste cereal-based foods and, in particular, bread” (Kosseva and Webb, 2013). Waste bread, through chemical engineering methods, can be used to manufacture other products.

One way in which this was found was by several researchers from the Department of Chemical and Biomolecular Engineering at Hong Kong University. They found, “Utilisation of food waste as the renewable feedstock in biorefinery for chemicals and energy production becomes a promising option to target both solid waste problem and the over-dependence on petroleum as the major source of chemicals and energy” (Leung et. al., 2012). Through chemical and biomolecular engineering techniques, waste bread can be used to produce fermentative succinic acid which can be used as a nutritious feedstock. In this manner, the researchers hope that this will reduce the food wastage and environmental pollution problems.

Another utilization of waste bread was to produce strong enzymes by which the waste bread going under solid state fermentation (SSF) is able to produce. Webb observes that bread undergoing the process of SSF, “Enhances the thermostability of the enzyme significantly” (Kosseva and Webb, 2013). This is important since these enzymes can be used to produce ethanol. By this process, Webb describes waste bread as a, “Much cheaper alternative for bioethanol production” (Kosseva and Webb, 2013).

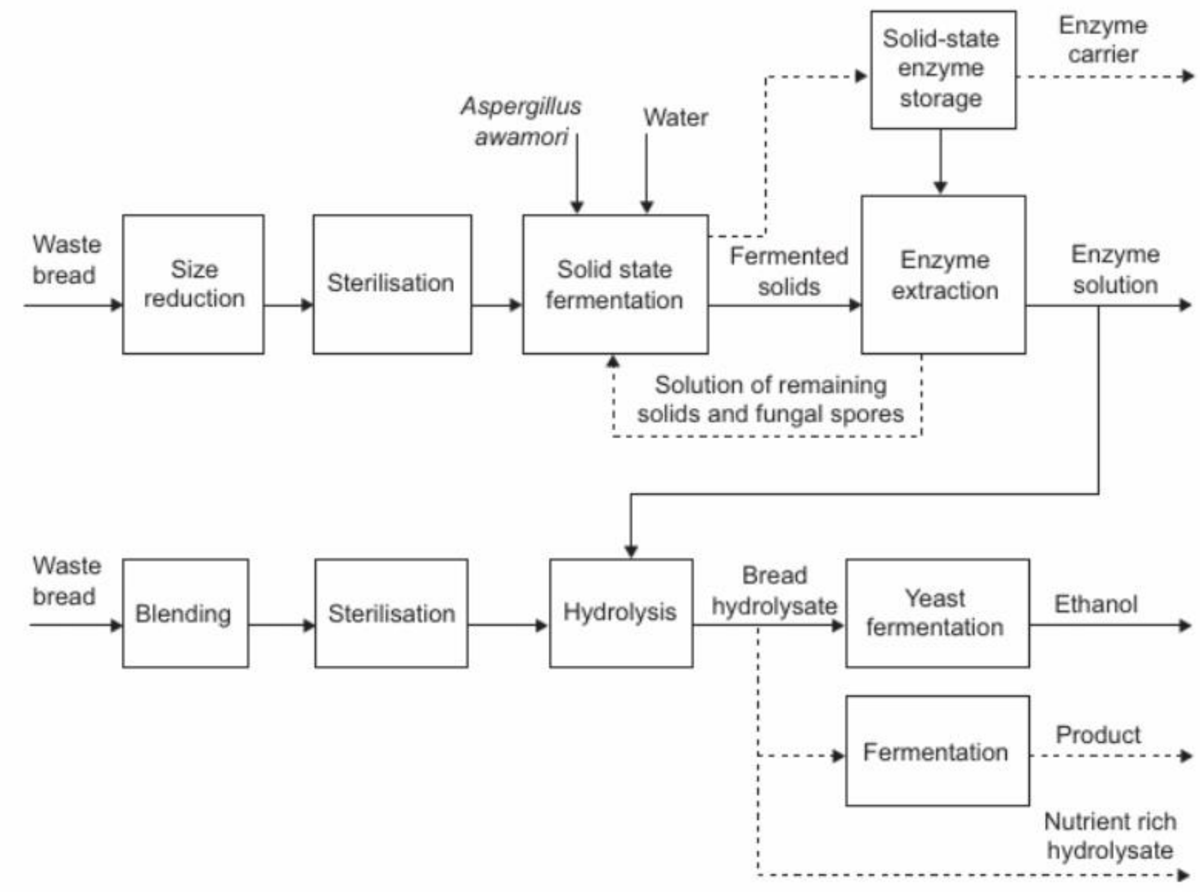

Figure 4: Process and production of waste bread undergoing solid-state fermentation (SSF) into ethanol

(Kosseva and Webb, 2013).

Another positive result is that the number of bread waste can significantly decrease. And as the waste decreases, the manufacturing of other products, particularly ethanol, will significantly rise. This in turn will have economic benefits as well since, “300 million liters of ethanol, with a current market value of over 100 million euros, could be produced annually in the UK alone if all of the waste bread could be recovered and processed in this way” (Kosseva and Webb, 2013).

(d) Genomics on Crops for Various Other Industries

Oil was considered the main source for energy, but it has also raised greenhouse gases to drastic levels and caused global warming. Maggie Smallwood, a researcher at the Department of Biology in New York echoes these claims. While Smallwood acknowledges that industries have used oil as a primary source of energy through fossil fuel manipulation, there have been negative consequences on the environment due to its overuse. Smallwood states, "It has also raised greenhouse gases to levels that are unprecedented in pre-history" (Smallwood, 2006). However, the overuse of fossil fuel has not only affected the environment but also the food industry. Smallwood writes, "These issues have driven increasing interest and investment in the use of agricultural products and residues for transport fuel and industrial feedstocks" (Smallwood, 2006). Oil is a limited source and thus, the economics and environment are changing. Scientists are working to find other resources that would not harm the environment and deplete natural reserves. "Oil will not last forever," Smallwood writes, "Reserves falling and this together with political instability in countries rich in oil is already driving price rises" (Smallwood, 2006). Smallwood proposes the art of chemical science and genomics as alternatives to the ensuing problems. For example, scientists can manipulate the plant family of arabidopsis, as it has complete genome sequences and a depth of resources for transcripting protein. As a result, it can be used for, "Rapid manipulation of the output characteristics of agricultural feedstocks for diverse industrial applications" (Smallwood, 2006). Diverse industrial applications meaning an alternative for fossil fuel. Smallwood proposes that plant species not only be used for food consumption, but for other industries in order to combat the fossil fuel problem. Smallwood writes, "Most of our domesticated plant species have been bred for food applications. With increasing interest in the use of these same feedstocks for industrial purposes, prompt tailoring of existing food crops as well as domestication of novel crops will be needed" (Smallwood, 2006). Therefore, an input and coalescence is necessary between the food and oil industries with chemical engineering as the bridge.

(e) Analysis of Starch under Human Consumption

Another means in which chemical engineering principles can coalesce and benefit is in the nutritional health world. A group of researchers who study the science of nutrition and diabetes in King's College London, have studied the chemical compounds and enzymes of starch going through the human digestive system. They did so by using hydrocolloids and starches together in order to, "Modify the rheological properties with the aim to enhance the starch tolerance to processing conditions" (Shaari et. al., 2017). As a result, researchers have found that the properties of starch are altered by the hydrocolloids. This research was done to simply understand how cornstarch is ingested by the human body. And while it may seem minute and miniscule, the researchers exhort, "This can be important in understanding how dietary starch is digested with relevance to diabetes, cardiovascular health and cancer" (Warren et. al., 2012). And so, there is a coalescence necessary with chemical engineering not just with food as an industry, but also as a means to research and improve health through understanding food digestion.

(f) Hybrid Method of Chemical Engineering for Water

Water, according to Yasuyuki Konishi and Masayoshi Kobayashi, is an integral part of food, as food is comprised of water by over 70%. Also, water is very much used for the production and cooking of food. Konishi and Kobayashi, two chemical engineers working for technological institutes in Hokkaido, Japan, have found that water highly impacts the food quality and taste. Konishi and Kobayashi have found this through via chemical engineering techniques. In their report, they note, "As a chemical engineering technique, the water activity parameter (aw) has frequently been used to evaluate quality and taste of foods" (Konishi and Kobayashi, 2013). As a method to overcome the difficulties to design products in food engineering, Konishi and Kobayashi used a hybrid method of various chemical engineering methods in order to separate various water 'species' and then retain and differentiate the species amongst various fish jerkies such as squid, sardines, and salmon (Konishi and Kobayashi, 2013). This research is important in understanding the role of chemical engineers within the food industry, as chemical engineering techniques are shown vital for testing the quality and taste of food. This can impact the food industry in effective and practical ways, but it should be recognized that more chemical engineers are needed within the food industry to perform such research.

(g) Food Packaging

Lastly, the positive impact of chemical engineers on food packaging will be examined. In London, chemical engineer techniques increased the use of products. For example, "Recent trends in flexible food packages here in Britain indicate increasing use of multiwall paper sacks, transparent film packages, single serving packs, and vacuum- and gas-filled flexible containers" (Journal of Agricultural and Food Chemistry, 1954). The development in the chemical engineering methods of 1954 in London had improved and thus the food packaging also improved. Many chemical engineers in London at the time were optimistic about the application of chemical engineering techniques in packaging (Journal of Agricultural and Food Chemistry, 1954). Even now, the developed food packagings are still used to this day in various products. This is because the British chemical engineers have used a chemical engineering method that uses vacuum or gas packaging in order to prevent the "deteriorative effect of oxygen" to invade the food (Journal of Agricultural and Food Chemistry, 1954).

It is significant to use the proper packaging to extend the shelf life of food products. Products such as bread requires certain temperature and condition to store longer. According to Settakorn Upasen and Piyachat Wattanachai, who are both chemical engineers, claimed that, "Bakery products usually have a short shelf life of only a few days at room temperature due to their high water activity. Refrigerating storage of these types of products is not applicable to their texture and taste change with temperature" (Upasen and Wattanachai, 2018). And thus, refrigeration is not enough for prolonging bread life. Rather, improvements in the packaging techniques are needed in order to extend the life period of the bread.

VI. UTILIZATION OF CHEMICAL ENGINEERS IN THE FOOD INDUSTRY

A. Job Recruitment of Chemical Engineers

One of the ways to solve the issues caused by the food industry is to simply recruit more chemical engineers. In Britain, chemical engineers have helped solve the problems of food wastage. According to the Agricultural and Food News, "Two to three million tons of water are imported in foods into the United Kingdom each year. Lockspeiser revealed that satisfactory dehydration techniques have been worked out for reducing this by 80%" (Journal of Agricultural and Food Chemistry, 1954). The techniques in chemical engineering even developed certain fields. The reporter stated, "Engineering techniques in the flour milling industry has been the main postwar development in flour milling technique which increased the use of bulk storage and delivery" (Journal of Agricultural and Food Chemistry, 1954). Chemical engineers not only assisted in the actual materials, but also the industry as a whole. The reporter claimed that, "The sugar industry is benefiting from improved materials and has been successful that at the bulk deliveries amount to about 1000 tons per week" (Journal of Agricultural and Food Chemistry, 1954).

Chemical engineers should collaborate and work in the food industry to bring a better and practical outcome for a more functional and sustainable food production system. Chemical engineering can contribute to a development in the food processing in a number of ways. Chen exhorts this by saying, "The non-chemical engineers or technologists are becoming more aware of what chemical engineering can contribute to a fruitful and successful outcome of many developments that have to involve good manufacturing practice" (Chen, 2007). According to Chen, chemical engineers were the ones to have both realized and solved the problems that were unique to the food industry. However, these were problems that involved much technical complications, yet chemical engineers were able to solve them "rather creatively" (Chen, 2007). But right now both fields are not completely connected to each other. This can all change if the food industry decides to start recruiting more chemical engineers. And based upon the evidence stated earlier, doing so can produce beneficial results in fruitful effect.

B. Formal Education for Chemical Engineering

The 'interest' for the field of food engineering however is indeed rising. And thus, a few universities are starting to offer more courses in the subject. Even so, certain challenges still exist that may need improvement as the courses still retains to the four-year degree program and even lacks the proper funding, equipment, and network. According to various researchers comprised of agriculturalists and chemical engineers, food engineering education should, "Keep pace with the extraordinary expansion of knowledge, the availability of virtual tools, diminishing funding and laboratory resources, and the possibility of creating partnerships between industry and academia" (Saguy et. al., 2013).

One of the ways this can happen is for the universities to realize that food is an actual science. As mentioned earlier, Lund has been concerned and alarmed by the lack of technical teaching in the science field at top universities. But Lund is concerned by the lack of technical teaching in the subject matter of food. Lund argues, "Our knowledge of food science and technology has transformed food and the art of preservation and cooking via scientific understanding" (Lund, 2017). Yet, there are certain countries that understand this link between science and food. In Australia and New Zealand, food education is understood as science education. This is because both Australia's and New Zealand's economy is heavily dependent on the food industry (Chen, 2007). Therefore, both countries have developed an education system by which chemical engineering students are formally trained to work in the food industry. Much of the system was adopted by the

British chemical engineering education system since there was much success seen in the coalescence of chemical engineering and the British food industry. But what makes this system works is that those under this formal education system can easily transition into employment in the food industry (Chen, 2007). In general, chemical engineers look to Europe for formal and robust education systems that can lead students into the actual industries. For example, “The European Master’s degree program is an excellent example of how collaborations between universities, with industrial support, can result in an effective educational experience for students” (Saguy et. al., 2013). Also, the industries that have recruited such students have been conscientious about ‘mentoring’. The European food industries who have been intentional on recruiting chemical engineers, have also been intentional in hiring college graduates with a chemical engineering degree and placing them under veteran engineers. Young future engineers placed under older veterans have shown to display, “Probability of higher success” (Saguy et. al., 2013). Other programs such as the ‘Marie Curie’ program have also shown much success. This program allows students to study at other countries for a PhD degree. The purpose of studying in another country has also served another purpose however. Students under the ‘Marie Curie’ program have been described as, “Very employable – speaking multiple languages as well as being technically qualified” (Saguy et. al., 2013). It was due to the foreign studies by which students were able to discover various engineering skills, develop capable expertise in research, and learn another language. If the food industry and the education board can offer such programs by and large, then the issues that have arisen from the food industry can hopefully begin to diminish.

VII. CONCLUSION

In conclusion, the problems that have arisen and have been caused by the food industry can be fixed if the industry decides to properly and adequately work with chemical engineers. Many problems have arisen as food wastage have reached overwhelmingly high numbers which have contributed to the increase of greenhouse gases and water wastage. The lack of having chemical engineers in the industry may be due to the industry not offering many positions for engineers as well as universities not teaching many courses on engineering. However, this should all change as chemical engineering principles have shown to benefit the industry of food such as reducing the time period of tomatoes perishing or utilizing waste bread for ethanol production. In any case, there needs to be more job recruitment for chemical engineers that are provided by the food industry and also an implementation of chemical engineering education programs that can help students transition to work for the food industry. By doing so, this may perhaps help create a cleaner world and provide a healthy unity between both food and science.

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