Marloes Ruiter
Almere College
Dronten, The Netherlands

Seaweed against world hunger

In 2050, there will be about 9 million people on this earth. Because every single person should get enough healthy food, we must find solutions to solve this World Food Problem. There are already many initiatives for feeding the growing world population. An upcoming hype is eating insects. Insects were originally only eaten in the eastern part of the world, but are slowly getting accepted in the west. Insects do have a lot of benefits. They are very healthy because they contain many proteins (Huis, 2018). They are a very good substitute for the regular meat we consume. However, there is a big downside on consuming insects: many people from western countries do not think insects are very tasty. Even digested in something people already know, like a burger, people are not very fond of it (Onwezen, 2015). This makes it hard to make the consumption of insects the standard. Another possible solution for feeding the growing world population is city farming. The idea of city farming is to grow crops in spacious (non-used) buildings, preferably in the middle of a city as urbanisation demands access to food in the city. This has a lot of benefits. You can adapt the circumstances in the building to conditions that are ideal for the crop you want to cultivate. Besides this, it is also possible to re-use the water on the different levels. Therefore, there the loss of water will be much lower. There is also no need to use pesticides because insects can be kept out of the building. The idea of city farming is very similar to using greenhouses, which is commonly used in my homeland The Netherlands. But the extra benefit of city farming over using greenhouses is that the crops already are at their destination. They do not have to be distributed from the farm to the people in the city. Which makes city farming contributing less to the greenhouse effect and the global warming. Unfortunately, city farming also has some disadvantages. Crops cultivated in a city farm are way more expensive than crops grown on a regular farm. This is because the scale of a city farm is way smaller than the scale of a regular farm and because the building needs lots of modifications before it's suitable for growing crops. Moreover, not every crop is suitable for city farming.

Seaweed does have the potential to contribute to solve hunger and to end world poverty. The big advantage of seaweed is that is does not use precious farmland. Seaweed can grow in deposited areas of the sea, of which nowadays not much is used. Seaweed has the potential to replace meat, but still make the meal contain all the nutrients we need. Seaweed contains lots of proteins and fibres. The specie I studied was *Ulva Lactuca. Ulva Lactuca* contains 58.1 percent of carbohydrates, 28.4 percent of fibres and 13.6 percent of proteins (Rasyid., 2017). Besides all this, *Ulva Lactuca* contains vitamin A, B1, B2 and lots of different minerals. It also contains sodium, potassium, iron and calcium. The quantity of calcium in *Ulva Lactuca* is even 10 times more than the quantity of calcium in milk. These nutrients make *Ulva Lactuca* very suitable for human consumption, for example as a substitute for meat. Nowadays, we get most of our proteins from eating meat. Because seaweed contains so much proteins, it can replace meat in our meal.

In the experiment we did, we concluded that *Ulva Lactuca* can grow under very wide circumstances. We let the seaweed grow by different temperatures, light intensities and different light colours, which is constructed from different wavelengths of light. To test these circumstances, we did three experiments. The first was the temperature. We chose three temperatures, 9 degrees Celsius which was in the refrigerator, 23 degrees Celsius which was just room temperature and 35 degrees Celsius which was the temperature in a hot water bath. In every condition, the light intensity was 9.35 kilolux (klx). Kilolux is an unit for illuminance. All the other conditions were identical in the three different circumstances. The second experiment we executed, tested the effect of variable light intensities. We chose 5

different light intensities: 0.0185 klx (0 lamps), 9.35 klx (1 lamp), 13.973 klx (2 lamps), 16.709 klx (3 lamps) and 28.277 klx (6 lamps). The temperature of the water was 23 degrees Celsius. In this experiment as well, all other conditions were identical. The third experiment had a variety in light colour. We chose the colours red (a wavelength of 692 nm), blue (a wavelength of 470 nm) and white (all wavelengths between 380 and 780 nm). The temperature was 23 degrees Celsisus as well, and the light intensity was 9.35 klx. All other conditions were identical. For 21 days, we observed our seaweed grow. Each condition contained three *Ulva Lactuca* samples of the same surface. Because Ulva Lactua is only one cell layer thin, you can determine the entire growth by only measuring the growth of the surface. During the 21 days of observation there were a few measuring point, and after the three weeks was the final measurement. The conclusions were that by a light intensity of 13.973 (so by using 2 lamps), the surface growth was the biggest. By the experiment with a variety in light colour, the highest growth was found by white light, while the highest activity of photosynthesis was found by red light. By the experiment with different temperatures, there were no valid results found. At all the three temperatures the samples had died. This is probably because the temperature of the hot water bath was way too high, the North Sea never gets this hot. We do not really have an explanation for the dying of the samples by the other temperatures. The overall conclusion was that *Ulva Lactuca* had grown the most by a temperature of approximately 14 klx.

We chose to study *Ulva Lactuca* because it grows in our homeland The Netherlands. But *Ulva Lactuca* does not only grow in The Netherlands, not even only in Europe. The specie is capable of growing in seas anywhere around the world, which makes it available for many people. *Ulva Lactuca* is also a very easy growing specie. You can harvest it 2 times a season, so the profits can be very high. Mainly in eastern countries such as Japan, Korea and China, seaweed is cultivated. When we look at Europe, we see that the cultivation is mainly taking place in France, Ireland and Norway. That's the reason why I chose to look at Norway, to see in what way Norway can contribute to ending world hunger by producing seaweed. Of course Norway is by far not the poorest country in the world, but Norway contains lots of potential for producing seaweed, which can be shipped and sold around the world. Also, Norway is comparable to the circumstances we used in our experiment and therefore the results of our experiment are applicable to Norway.

Norway has about 5 million inhabitants, and a surface of almost 400 000 square kilometres. But only 4 percent of Norwegian surface is cultivated as 45 percent of the surface of Norway is not useable for economic activities. Just a very small part of the country is available for agriculture. The biggest surface of the country does not have the right soil for growing crops. The soil is for example made of stone. Also, the temperatures in the Northern part of the country are too low for growing crops. Therefore, about 50 percent of the food consumed in Norway is imported. The grass fields in the north of the country are used for cattle. The livestock farms in Norway are relatively small (Hove, 2017). The government supports the small scale of family companies in Norway. Compared to other western European countries, the sizes of the farms are a lot smaller. The livestock farming sector in Norway is heavily subsidized. This is done to make it attractive to cultivate the small parts of the country which are available for agriculture. In the southern part of the country are more farms with crops, for example wheat. Fishing is more important than agriculture in Norway. Norway is the world's second largest exporter of seafood. In 2015, 1.38 million tons of salmon and trout were produced in Norway (Akvakultur, 2016), and this number is still growing.

Norway's potential is the over 100.00 kilometres long coast line. It's an extraordinary long coast line for a country of this proportions. But this coastline is not only suitable for fishery, it is also very qualified to be used for producing other aquaculture, such as seaweed. The Atlantic Ocean is the home for over 400 species of seaweed (Rueness, 1998). Seaweed is a fast growing sector in Norway (Pierrick Stévant, 2017-4). For over 50 years, wild seaweed is being harvested in Norway. Although the Norwegian rules for harvesting wild seaweed are

considered to be the best in the world, there are some risks at harvesting wild seaweed. It can for example damage the surrounding ecosystem. There were also some regional conflicts between the seaweed industry and other coastal zone users. The first commercial cultivation permits at sea were delivered in 2014. There are still lots of challenges in this seaweed sector in Norway. Upscaling the current projects requires a good consideration of the advantages and disadvantages of this aquaculturally challenge. For example the impacts of the growth of seaweed on the surrounding ecosystems and threats from climate change. The extra benefit of growing seaweed in a country with a highly developed, and still growing, fishing industry is that the wastes of the fishing sector can be used for the seaweed production. The nutrients from the wastes can be used as a valuable resource for the marine plants production. By using this system, the total production of biomass created at one location can be increased. Another advantage of a country with a highly developed fishing industry is that the infrastructure too is highly developed. This makes it easy to distribute the cultivated seaweed among the world.

It's very important that the harvest of seaweed does not affect the environment and the ecosystem sea/ocean. Therefore it is significant that there will be controls and rules, set up by the government. Norway already has this strict measures, but it is important that in every country were seaweed will be cultivated, this rules will exist. Besides this, it is also very important that the food quality is guaranteed by international rules. Seaweed has the quality to absorb heavy metals from the seawater. Seaweed with a high percentage of heavy metals is not qualified for human consumption. Therefore, it is important that the water quality is tested on a regular basis and that there are strict guidelines for the metal concentration in the seawater, and eventually in the seaweed.

The seaweed consumption in Norway presumably started with the Vikings during the year 1000. They brought seaweed with them on long trips along the sea, because of their high contents of vitamins. This protected them against diseases such as scurvy. Despite the high nutritional value of seaweed, it is not a commonly used ingredient in the Norwegian or the European kitchen. There is still a long way to go before seaweed will have the same role in the diet of western people as it has now in the Asian diet. But I think it is a challenge worth taking. Think about sushi. When this was introduced in the western part of the world last century, people would think it was weird and disgusting. But when you look at sushi now, it is a very popular, commonly eaten delicatecy. This proves that people just need a little time to get used to new foods. There are so many benefits from consuming and producing seaweed, and there are endless possibilities in the way you can integrate it in your meals. By using Norway as a place for finding out what is the best way to grow seaweed without damaging the nature, we can eventually spread this knowledge around the world. So not only the Norwegian population, but the global population can enjoy the benefits of seaweed. We can spread our knowledge around the world just like the way the Vikings travelled around the world.

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