Technical Report

Functional Vegetables Production Plant Factory Utilizing Deep Sea Water

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Abstract

Focus on deep sea water (DSW) to enable stable production of nutritious functional vegetables in artificial light-type plant factories, we have worked with DHC Corporation and Kyoto University for research and development of their culture technologies. This project was selected as a “Program for promoting global agricultural-commercial-industrial collaborations” in FY2015 by METI. In this project, a plant factory with daily capacity of 1000 roots of leaf lettuce was located by the HANEDA Airport to spread the vegetables above widely to inside/outside of Japan. This report will give outlines of the work.

Keywords: plant factory, deep sea water (DSW), functional vegetable, LED, hydroponics

1. Introduction

The plant factories have been more often reported by the media in few years and have been widely known to the consumers. On the other hand, vegetables cultivated in the plant factories have not yet reached the point as to be differentiated against vegetables grown outdoors or by protected horticulture. So, we focus on attention to DSW which has the abundant minerals and a potential to improve westernized eating habits of Japanese people and those of Western people, thus we have continued researching for cultivation technologies with addition of DSW to hydroponic solution in a plant factory. The artificial light-type plant factories has features enable systematic vegetable production without being influenced by the weather, and low-bacteria/pesticide-free farming by extensive hygiene control. The artificial light-type plant factories is drawing attention in overseas as well as in Japan, because it would be built at any location including non-farmland such as a warehouse or an open space in a urban zone close to a consumption area. In particular, Hawaii, Micronesia Islands such as Guam, and the Pacific Rim area of North America, which are our target areas, are surrounded by the Pacific and are easy to access to DSW. American countries to the world largest consumer of fresh vegetables and supplements while Hawaii and Micronesia Islands such as Guam produce fresh vegetables only at limited areas and depend most to import from the mainland America. Potential demand for vegetable production in these areas utilizing the location requirement is very high.
2. Why DSW?

DSW is defined as clean seawater is pumped up from deep sea at the depth of 200 m or more. Facilities pumped up DSW are in operation at more than 10 locations in Japan. Though depending on depth of water drawing, DSW has stable low temperature (5–10°C) and research on commercialization of ocean thermal energy conversion is conducted in Kumejima of Okinawa Pref, Japan and state of HI, U.S. as one of the next-generation clean energies. In addition, because DSW contains abundant minerals and is almost bacteria free, it is widely used for aquaculture or the like. For example, prawns and sea grapes are cultured in Kumejima above and abalones are cultured in Hawaii, both contributing to local industries. In contrast, the number of cases of DSW to agriculture is small yet.

As three parties, Especmic Corporation, DHC Corporation and Kyoto University, have been working on research of culture technologies of functional vegetables using DSW, one of the facts that lies in the background of this research is that the eating habits of western countries has been penetrating into Japan (westernization of eating habits) and one of its impacts considered is increase of mortality from ischemic heart disease to a comparable level as in the western countries. One of the factors in the above is considered as follows. According to the research by KARPPANEN et al. focusing on calcium/magnesium ratio, the ratio 1:1 is most desirable. Until about 1970s, the Japanese has taken meals close to the ratio above by taking more seafood. But along with the westernization of eating habits, intake of calcium increased and intake of magnesium decreased, disrupting the balance of the ratio and increasing the mortality from ischemic heart disease.

As DSW contains much minerals, magnesium in particular, new high value-added nutritious vegetables with calcium/magnesium ratio closer to 1 and more abundant in minerals compared with vegetables from conventional plant factories, are expected to be produced by adding DSW to hydroponic solutions in the plant factories. New markets are expected to be developed by supplying these vegetables to overseas as well as to the domestic markets in Japan.
3. Outline of the work for the “Program for promoting global agricultural-commercial-industrial collaborations”

The theme of our work in this program is “Construction of a demonstration model for high value-added vegetable production using DSW in an airport-side plant factory, and deployment program of branded vegetables in Hawaii, Micronesia Islands such as Guam, and North America”.

This project had ESPEC as the project implementing body and organized a consortium with Kyoto University, DHC Corporation and other members (refer to Figure 1).

In November, 2016, we built an artificial light-type plant factory for functional vegetable production using deep seawater with daily capacity of 1000 roots of leaf lettuce close to HANEDA Airport. There, DSW drawn from offshore Izu Akazawa facility operated by DHC is used for vegetable culture. As stated above, basic technologies for stable production of leaf lettuce while adding DSW to the hydroponic solution have been established through the culture tests so far and demonstration of functional vegetable production such as baby leaves and herbs besides leaf lettuce is underway. The project already started to demonstrate extensive sales of functional vegetables grown using DSW to inside and outside of Japan.

In this program, following 5 items were prioritized.

Figure 1. Program scheme
3.1 Establishment of a facility at the HANEDA Airport for production demonstration of vegetables grown using DSW, and the production demonstration.

An artificial light-type plant factory for production demonstration as well as for showroooming of vegetables grown using DSW with daily capacity of 1000 roots of leaf lettuce was established on the entire 2nd floor (ca. 300 m²) of near to HANEDA Airport, and production of frilly lettuces or the like using deep seawater is continuously made since January, 2016. (Figure 2).

![Image](image_url)

Figure 2. Plant factory in HANEDA, Tokyo

3.2 Increase of items of produced vegetables, study of usage as supplements, and evaluation by the market through mail order

Market research on increase of items of functional vegetable grown using DSW and culture test of various leaf vegetables using DSW have been conducted. Among them in particular, ice plant showed a result where its minerals are doubled. Concerning the usage of vegetables grown using DSW for supplements, DHC ran test production of the supplements using roots of a vegetable (frilly lettuce) grown using DSW. Analysis of the specimen indicates that in addition to abundant dietary fibers, many minerals especially magnesium are contained. Tasting was not held this time because preparation of clinical data is essential before tasting of a supplement by general consumers. Instead, vegetables produced in Haneda plant factory using DSW were served at a hotel next to the DSW drawing facility in Izu Akazawa where many mail-order customers of DHC visit. The result of survey after the tasting showed that most of the customers rated the vegetable grown using DSW this time (frilly lettuce) delicious and that many would purchase it immediately.
3.3 Promotion of usage of vegetable products at the HANEDA Airport and demonstration of logistics to Hawaii, Guam and North America

We have a promotion event late in November, 2015 at the international terminal of the HANEDA Airport. We exhibited a mini vegetable plant (Plant Cellar), distributed brochures introducing our project and collected survey on vegetables grown using DSW. Among responses from over 400 people, many had favorable images for the vegetables grown using DSW and many showed interest to buy them.

3.4 Establishment of a showroom facility for sales promotion in Hawaii and sales promotion activities

We established a mini vegetable plant (Plant Cellar) in the JTB Plaza Honolulu in the Waikiki District, Honolulu, Oahu Island of Hawaii, and performed sales promotion activities of vegetables grown using deep seawater until the end of January, 2016(Figure 3).

![Figure 3. A scene from the promotion event in Hawaii](image)

During the period, the surveys were conducted similarly as in HANEDA Airport and samples of the supplements were exhibited. Many people of Japanese ancestry residents in Hawaii requested to continue production of fresh vegetables in the plant factory and showed intention to purchase vegetables grown using DSW because they are familiar with the DSW itself due to a DSW drawing facility on the Hawaii Island, which is the only one place can get DSW in the U.S.
3.5 Establishment of a showroom facility for sales promotion in Los Angeles and sales promotion activities

In North America, we established a mini vegetable plant (Plant Cellar) in MARUKAI Market in Gardena, suburb of Los Angeles, and performed sales promotion activities of vegetables grown using deep seawater similarly as in Hawaii from the middle to the end of January this year. Over 200 people responded to the survey there, as well. As the degree of recognition there of plant factory and hydroponics is as high as 50% or more, and health consciousness is strong, mineral-rich vegetables grown using deep seawater were mostly favorably accepted. As for purchasing, more than half of the respondents showed intention to purchase.

4. Future prospect

Working on using of DSW for agriculture have been made extensively but application of DSW to a large-scale culture in artificial light-type plant factories is rarely seen so far. Once the possibility of wide acceptance by the consumer of our functional vegetables grown using DSW is verified, then we would like to work for the proliferation of the vegetables with an eye toward cooperation with DSW drawing facilities located inside/outside Japan and existing artificial light-type plant factories.

References

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