行政院國家科學委員會專題研究計畫 成果報告

應用電解水在芽苗菜培育上之研究 (2)-黃豆芽
研究成果報告(精簡版)

計 畫 類 別 ：個別型
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執 行 單 位 ：國立臺灣大學食品科技研究所

計 畫 主 持 人：許順堯

計畫參與人員： 專科畢-專任助理：楊志萱

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行政院國家科學委員會專題研究計畫成果報告

應用電解水在芽苗菜培育上之研究 (2) -黃豆芽

Studies on applications of electrolyzed water on cultivating sprout and seedling vegetables (2)- soybean sprout

計畫類別：■ 個別型計畫　　□ 整合型計畫
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共同主持人：
計畫參與人員：楊志萱(專任助理)

成果報告類型(依經費核定清單規定繳交)：■精簡報告　□完整報告

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執行單位：國立臺灣大學　食品科技研究所

中　華　民　國　96　年　11　月　27 日

I、Abstract

The purposes of this project are to study the cultivation conditions of soybean sprouts and to investigate efficacy of different methods for eliminating microorganism contaminations of soybean sprouts using NaOCl, electrolyzed oxidizing water (EOW), electrolyzed reducing water (ERW) and hypochlorite soft acid water (HSW).

Results indicated that growth curves of soybean sprout could be well-fitted with Gompertz models. Sprouts cultivated with tap water yielded larger harvest index, maximum growth rate and final size of hypocotyl length than those cultivated with EOW, ERW or HSW. Spraying with 10 ppm ethephon solution on the sprouts once a day did not had significant effect on growth rate and final size of the sprouts probably due to the spraying times of the ethephon and the cultivation water . Sprouts cultivated at 25 ℃ yielded larger sprouts than those at 22 ℃.

Microorganism contamination of soybean sprouts during cultivation was investigated. Results indicated no *Escherichia coli* was found in the sprouts. Viable cell count increased quickly from the starting seed to the 24^{th} hour of cultivation and then increase slowly till the 168^{th} hour of the harvest time of the sprouts. The growth curve followed a Rectangular hyperbola model ($p < 0.001$). Analyses done on yeast and mold indicated that mold is the predominant microorganism of the two. A maximum increase on number of mold appeared at the 117^{th} hour of the cultivation period. The growth curve followed a Gompertz model ($p < 0.001$).

Various protocols had been tested for efficacies of different disinfection methods on the harvest soybean sprouts. 50 ppm and 100 ppm of EOW and HSW solutions, respectively, significantly ($p < 0.01$) decreased 58% ~81% of the viable cell counts on the sprouts. Results indicated that 100 ppm of EOW and HSW solutions significantly ($p < 0.01$) reduced 81% of the viable cells on the sprouts after the sprouts were subjected to a three-minutes of 45 ℃ heat-shock treatment. Results indicated that chilling the disinfectants to 5 ℃ before applying to the sprouts reduced from 51 % to 71% of the viable cell count on the sprouts

Keywords: Electrolyzed water, High chlorite soft acid water, Growth, Disinfection, Soybean sprout

摘要

本計畫目的在探討黃豆芽之培育條件，以及次氯酸鈉水(NaClO)、電解氧化水(EOW)、電解還原水(ERW)和次氯酸根水(HSW)等不同 殺菌及培育方法應用在黃豆芽上之效果和適性。

結果顯示黃豆芽生長曲線可用 Gompertz model 模擬。自來水比 EOW, ERW 或 HSW 水有較高收穫指數、最大生長速和最終下胚軸長度。培育期間每日噴灑一次 10 ppm 之益收生長素對黃豆芽之生長速和最終長度沒有顯著影響，可能與噴藥及灑水之時間有關。25 ℃培育比 22 ℃培育可得到較高大之豆芽。

培育之黃豆芽沒有發現大腸桿菌。生菌數從開始時快速增加至約第 24 小時，然後緩慢

增加至第 168 小時收成時止。生菌數之增長曲線可用 Rectangular hyperbola model 模擬($p < 0.001$)。黴菌與酵母菌檢驗結果顯示黴菌為主，菌數高峰出現在約第 117 小時。黴菌與酵母菌數之增長曲線可用 Gompertz model 模擬($p < 0.001$)。

50 ppm 或 100 ppm 之 EOW 或 HSW 分別可以顯著($p < 0.01$)降低黃豆芽上 58%至 81%之生菌數。100 ppm 之 EOW 或 HSW 分別可以顯著($p < 0.01$)降低先經三分鐘 45℃熱震處理的黃豆芽上 81%之生菌數。預冷至 5℃之 100 ppm 之 NaClO, EOW 或 HSW 可以降低黃豆芽上 51%至 71%之生菌數。

關鍵詞：電解水，次氯酸根水，生長，消毒，黃豆芽

II、Introduction

Living foods lifestyle has drawn attentions of many people who are aware of health; it is becoming more and more popular around the world. Sprouts and seedling vegetables contain abundant amounts of all sorts of nutrients and are healthy and easy cultivating. Consumption of these foods is increasing dramatically each year. Production of the sprouts and seedling vegetables is not very complicated. It can be done in plant factories as well as in common household environment. However, growing conditions suitable for sprouts and seedling vegetables are also good for pathogenic microorganisms. Food poisoning outbreaks caused by consuming sprouts or seedling vegetables happened every year. Therefore, the purpose of this project is to study possible measures for eliminating microorganism contaminations and to improve growth and qualities of sprouts and seedling vegetables using electrolyzed water and disinfection waters, such as NaOCl, electrolyzed oxidizing water (EOW), electrolyzed reducing water (ERW) and hypochlorite soft acid water (HSW).

III、Results and discussion

The project is divided into three main parts. In the first part, effects of cultivation temperature and addition of cultivation adjunct on growth rate, harvest index, and qualities of the soybean sprouts were studied.

Results of the experiments on growth conditions indicated that growth curves of soybean sprouts could be well-fitted with Gompertz models. Sprouts cultivated with tap water yielded higher harvest index than those with reverse osmosis water. Temperature had significant effects on the sprouts. Sprouts grew in higher temperature (25 ℃) were significantly larger in final size (93 mm in average radicle length, 128 mm in average hypocotyl length and 219 mm in average total length) than those grew in lower (22 ℃) temperature (79 mm in average radicle length, 109 mm in average hypocotyl length and 178 mm in average total length). Maximum growth rate of radicle, hypocotyl and total length of the sprouts cultivated in higher temperature (0.82 mm/hr, 1.34 mm/hr, and 2.03 mm/hr, respectively) were also larger than those grown in lower

temperature (0.58 mm/hr, 1.30 mm/hr, and 1.78 mm/hr, respectively). Spraying with 10 ppm ethephon solution on the sprouts once a day reduced maximum growth rate and final size of the sprouts (i.e. from 2.08 mm/hr to 1.73 mm/hr and from 200 mm to 178 mm, respectively) but the differences did not reach a statistical significant levels ($p < 0.05$) probably due to large variation in sampling.

Microorganism contamination of soybean sprouts during cultivation had been investigated. Results indicated that *Escherichia coli* was not found in the sprouts. Viable cell count significantly increased from the starting seed to the 24^{th} hour of the cultivation period and then increase slowly till the 168^{th} hour of the harvest time of the sprouts. The growth curve can be well-fitted by a Rectangular hyperbola model ($p < 0.001$). Analyses done on yeast and mold indicated that mold is the predominant microorganism of the two. The growth curve followed a Gompertz model ($p < 0.001$). The average initial and final viable yeast and mold counts were 2.89 and 4.47 log10 CFU/g respectively. Maximum growth rate of the yeast and mold was 0.013 log10 CFU/hr, which appeared at the 117^{th} hour during the cultivation period. Comparing to the 7.89 log10 CFU/g of average viable cell count, the number of yeast and mold is small. In addition to the above analyses, 12 soybean sprout samples had been purchased from local market places and were tested for the viable cell counts on the sprouts. Results indicated that the average viable cell count was 7.57 ± 0.32 log10 CFU/g.

In the second part of the study, 1 ppm of electrolyzed oxidizing water (EOW), electrolyzed reducing water (ERW) and hypochlorite soft acid water (HSW), respectively, were used to cultivate soybean sprouts. Results indicated that EOW, ERW and HSW all significantly decreased hypocotyl length and total length of the final sprouts and the sizes of the sprouts at the maximum growth rate. The final hypocotyl length and the maximum-rate hypocotyl length of the HSW-cultivated sprouts decreased from 133 mm to 84 mm and from 79 mm to 47 mm, respectively. The final total length and the maximum-rate total length of the HSW-cultivated sprouts decreased from 217 mm to 161 mm and from 130 mm to 97 mm, respectively. The final hypocotyl length and the maximum-rate hypocotyl lengths of the EOW-cultivated and the ERW-cultivated sprouts decreased from 161 mm to 77 mm and 84 mm respectively, and from 99 mm to 48 mm and 53 mm, respectively. The final total length and the maximum-rate total lengths of the EOW-cultivated and the ERW-cultivated sprouts decreased from 314 mm to 141 mm and 175 mm respectively, and from 196 mm to 94 mm and 110 mm, respectively. ERW did not promote growth of the sprouts as expected. However, concentration other than 1 ppm many have different effect.

In the third part of the study, various protocols were designed to compare efficacies of many disinfecting methods on the harvest soybean sprouts. Results of a comparison on 50 ppm and 100 ppm of EOW and HSW solutions indicated that washing and soaking with these disinfectants at the tested concentrations significantly ($p < 0.001$) decreased 58% ~81% of the viable cell counts on the sprouts. Another comparison had been done on the effects of 100 ppm of NaClO, EOW and HSW solutions on soybean sprouts after the sprouts were subjected to a three-minutes of 45 ℃ heat-shock treatment. Results indicated that EOW and HSW significantly ($p < 0.001$) reduce 81% and 81%, respectively, of the viable cells on the sprouts. Another comparison on 100 ppm of

NaClO, EOW and HSW solutions, respectively, were done by chilling the solutions to 5 ℃ before applying to the sprouts. Results indicated that all these chilled disinfectants reduced from 51 % to 71% of the viable cell count on the sprouts but the differences did not reach statistical significant level ($p < 0.05$).

IV、Self-evaluation

The project had not been implemented as planned because cultivating the sprouts with EOW and ERW did not show promising results as expected. But the investigation had been expanded to including some disinfection treatments on the harvest sprouts. Significant progress has been achieved in the study. The experiences gained can be used in the following studies. The results are being published.

V、References

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出席國際學術會議心得報告

計畫編號	NSC 95-2221-E-002-038
計畫名稱	應用電解水在芽苗菜培育上之研究 (2)-黃豆芽
出國人員姓名 服務機關及職稱	許順堯 國立臺灣大學　食品科技研究所　教授
會議時間地點	96 年 7 月 28 日至 8 月 1 日，在美國 Chicago 市舉行
會議名稱	69th Institute of Food Technologist Annual Meeting
發表論文題目	1. Effects of soaking time, water, temperature and growth adjunct on mungbean sprouts. 2. Disinfection of cultivating mungbean sprouts with chlorine waters.

一、參加會議經過

本人於 96 年 7 月 27 日出發至 8 月 2 日回國，順利完成參加會議。會議期間除了在 7 月 30 日與 7 月 31 日各發表論文一篇外，並參觀了兩天之 Poster sessions 及壹場 Oral presentation session。此外也出席了 7 月 29 日開幕時之 Keynote Session 並數次參觀了其規模宏大的 Food Expo。

二、與會心得

本次會議期間曾與來自 USDA 及 Purdue University 的研究人員討論芽苗菜有關之安全問題，覺得美國人對此問題非常關心，但似乎也尚未找到完善之解決辦法。Food Expo 中則看到很多大陸來的商家參展，感覺他們是蠻拼命的。

發表論文一：

Effects of soaking time, water, temperature and growth adjunct on mungbean sprouts.

Shun-Yao Hsu, National Taiwan University, Taipei, Taiwan.; Ting-Wen Hsu, Fu Jen Catholic University, Taipei County, Taiwan; Guoo-Shyng Wang Hsu, Fu Jen Catholic University, Taipei County, Taiwan.

Living food, such as raw sprouts and seedling vegetables, has been highly recommended by hygiene pursuing people due to its vital nutrients, which will be destroyed if it be cooked, and its easy cultivation. We cultivated mungbean sprouts in growth chambers. We used a four factor two level factorial design to compare the effects of soaking time of seeds, cultivation temperature, type of cultivation water, and addition of a cultivation adjunct on sprouting rate, growth rate, harvest index, and qualities of the produce.

We fitted the growth curves with a Gompertz model and then modified the model parameters to those contained biologically relevant parameters. Results of analysis of variance showed that sprout cultivated with tap water had higher harvest index (8.09)、maximum growth rate (1.81 mm/hr) and final size (139 mm) of hypocotyl length than those cultivated with reverse osmosis (RO) water (6.04、0.67 mm/hr and 48 mm respectively). Radicle length of the sprouts cultivated with tap water was larger than those cultivated with RO water (58 mm vs. 36 mm). Spraying a 10 ppm ethephon solution onto the sprouts significantly reduced maximum growth rate and final size of its radicle length (i.e. from 1.11 mm/hr to 0.87 mm/hr and from 52 mm to 43 mm respectively). Sprouts cultivated at 25 ^{o}C yielded higher harvest index than those at 28 ^{o}C (i.e. 8.10 vs. 6.03). The results indicated that mungbean sprouts can be cultivated in common household environment. Tap water, 25 ℃ and 10 hour soaking of the seed before cultivation can produce good quality mungbean sprouts.

發表論文二：

Disinfection of cultivating mungbean sprouts with chlorine waters

Shun-Yao Hsu, National Taiwan University, Taipei, Taiwan.; Ting-Wen Hsu, Fu Jen Catholic University, Taipei County, Taiwan; Wei-Tang Chen, National Taiwan University, Taipei, Taiwan; Chu-Ying Lou Chyr, National Taiwan University, Taipei, Taiwan; Guoo-Shyng Wang Hsu, Fu Jen Catholic University, Taipei County, Taiwan.

Living food, such as raw sprouts and vegetables, has been highly recommended by hygiene pursuing people due to its vital nutrients, which will be destroyed if it be cooked, and its easy cultivation. However, growing conditions suitable for these plants are also fit for microorganisms. We cultivated mungbean sprouts in growth chambers at 25 ^{o}C. We found few molds, while bacteria and yeast being predominant in the plants. No *Escherichia coli* was found. We applied sodium hypochlorite, electrolyzed oxidizing water and hypochlorite soft acid water, respectively, onto the sprouts at different growing stages for different times and by different methods. Average disinfection power of each protocol was evaluated by percentage of viable cell count decreased in harvested produce.

Results indicated that disinfection power of soaking, soaking with bubbling, and spraying were 61%, 37%, and 29% respectively. Disinfection power of soaking for 5, 10, and 15 minutes were 31%, 55%, and 63% respectively. A one-time soaking treatment in the chlorine waters of the growing sprouts on different cultivation day showed that only the one done one hour before the harvest time was effective with 73% of the viable cells eliminated. When increased the treatment time to a three-time or a six-time multiple soaking on the last few days of cultivation, 83% and 89%, respectively, of viable cells were eliminated, but hypocotyl length of the sprouts decreased 26% and 59% respectively. The results indicated that the disinfection methods were not good enough, but the treatments can be modified for further studies.