

GROWTH AND AGAR CHARACTERISTICS OF SELECTED *Gracilaria*
SPECIES UNDER DIFFERENT CULTIVATION METHODS

FONG CHUEN FAR

MASTER OF SCIENCE
UNIVERSITI MALAYSIA TERENGGANU

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Growth and agar characteristics of selected Gracilaria species
under different cultivation methods / Fong Chuen Far

PERPUSTAKAAN SULTANAH NUR ZAHIRAH
UNIVERSITI MALAYSIA TERENGGANU (UMT)
21630 KUALA TERENGGANU

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Lihat sebelah

HAK MILIK
PERPUSTAKAAN SULTANAH NUR ZAHIRAH UMT

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I certify that an Examination Committee has met on 15th January 2008 to conduct the final examination of Fong Chuen Far on her Master of Science thesis entitled "Growth and Agar Characteristics of Selected *Gracilaria* Species Under Different Cultivation Methods" in accordance with the regulations approved by the Senate University of Malaysia Terengganu. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follow:

Nor Antonina Abdullah, Ph.D.
Faculty of Maritime Studies and Marine Science
Universiti Malaysia Terengganu
(Chairperson)

Siti Aishah Abdullah @ Christine A. Orosco, Ph.D.
Faculty of Maritime Studies and Marine Science
Universiti Malaysia Terengganu
(Member)

Mohd. Azmi B. Ambak, Ph.D.
Professor
Faculty of Agrotechnology and Food Science
Universiti Malaysia Terengganu
(Member)

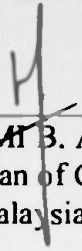
Mohamed Kamil B. Abdul Rashid, Ph.D.
Associate Professor
Faculty of Maritime Studies and Marine Science
Universiti Malaysia Terengganu
(Independent Examiner)



MOHD. AZMI B. AMBAK, Ph.D.
Professor/Dean of Graduate School
Universiti Malaysia Terengganu

Date: 12 June 2008

This thesis submitted to the Senate of Universiti Malaysia Terengganu and has been accepted as fulfillment of the requirement for the degree of Master of Science.

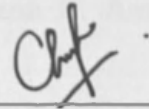


MOHD. AZMI B. AMBAK, Ph.D.
Professor/Dean of Graduate School
Universiti Malaysia Terengganu

Date: 12 June 2008

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UMT or other institutions.



FONG CHUEN FAR

Date: 12 June 2008

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LIST OF ABBREVIATIONS

Ø	diameter
mm	millimeter
cm	centimeter
m	meter
in	inch
cm ⁻¹	per centimeter
cm ⁻²	per square centimeter
m ⁻¹	per meter
m ²	per square meter
mm·s ⁻¹	millimeter per second
wt	weight
Qty	quantity
g	gram
kg	kilogram
t	tonne
g·cm ⁻²	gram per square centimeter
g·m ⁻²	gram per square meter
kg·cm ⁻³	kilogram per cubic centimeter
°C	degree centigrade
°C·min ⁻¹	degree centigrade per minute
min	minute
h	hour
RGR	Relative growth rate
% day ⁻¹	percentage per day
g dry wt ha ⁻¹	gram per dry weight per hectare
kg dry wt·ha ⁻¹	kilogram dry weight per hectare
kg wet wt·ha ⁻¹	kilogram wet weight per hectare
g dry wt·ha ⁻¹ ·yr ⁻¹	gram per dry weight per hectare per year
t dry wt	tonne dry weight
t dry wt·ha ⁻¹	tonne dry weight per hectare
t wet wt·ha ⁻¹	tonne wet weight per hectare
t dry wt·ha ⁻¹ ·yr ⁻¹	tonne dry weight per hectare per year

%	percentage
ppt	part per thousands
mg·l ⁻¹	milligram per liter
ml	milliliter
w/v	weight per volume
μM·m ⁻² ·s ⁻¹	micromolar per square meter per second
DO	Dissolved oxygen
NH ₄ ⁺	Ammonium
NO ₂ ⁻	Nitrite
NO ₃ ⁻	Nitrate
PO ₄ ³⁻	Phosphate
SD	Standard Deviation
NaOH	Sodium Hydroxide
H ₂ SO ₄	Sulfuric Acid
FTIR	Fourier Transformed Infrared
N	large sample size
df	Degree of freedom
P	Power of probability
F	Ratio of between and within group variance
R ²	Power of two Pearson's correlation
r	Pearson's correlation
r _s	Spearman's rank order correlation

Abstract of thesis presented to the Senate of Universiti Malaysia Terengganu in fulfillment of the requirements for the degree of Master of Science

GROWTH AND AGAR CHARACTERISTICS OF SELECTED *Gracilaria* SPECIES UNDER DIFFERENT CULTIVATION METHODS

FONG CHUEN FAR

Jan 2008

Chairperson : Siti Aishah Abdullah @ Christine A. Orosco, Ph.D.

Member : Professor Mohd. Azmi B. Amhak, Ph.D.

Faculty : Maritime Studies and Marine Science

Culture of the commercially important agarophyte, *Gracilaria* using two different approaches was done. Cultivation via vegetative propagation of *Gracilaria* sp. and *G. manilaensis* was conducted in pond in Gelang Patah, Johore, using line and floating – cage methods while natural spore recruitment was implemented in the wild population of *G. changii* in Sandakan, Sabah on fixed – bottom rope and netting substrates with Phase 1 (P1) from June 2004 to June 2005 and Phase 2 (P2) from August 2004 to June 2005. In pond culture, line method supported better growth and productivity of *Gracilaria* sp. and *G. manilaensis*. Monthly monitoring of relative growth rate showed maximum growth of *Gracilaria* sp. in September 2004 ($2.28 \pm 0.63\% \text{ day}^{-1}$) and *G. manilaensis* in November 2004 ($2.88 \pm 1.80\% \text{ day}^{-1}$) with the total production of $72.5 \text{ kg dry wt} \cdot \text{ha}^{-1}$ and $51.2 \text{ kg dry wt} \cdot \text{ha}^{-1}$, respectively. In field culture, P2 ($18.9 \pm 5.7 \text{ cm}^{-2}$) and P1 ($16.7 \pm 3.5 \text{ cm}^{-2}$) fixed – bottom rope substrates showed highest sporeling density in October 2004. Density of sporelings was higher on P2 fixed – bottom netting substrates compared to P1, ranging from $1.1 \pm 0.2 \text{ cm}^{-2}$ to $4.0 \pm 1.6 \text{ cm}^{-2}$. P1 fixed – bottom rope substrates produced a maximum crop of $9.15 \text{ t wet wt} \cdot \text{ha}^{-1}$ while higher biomass production was recorded in P2 fixed –

bottom netting substrates (6.63 t wet wt ha⁻¹). Epiphytism and fouling organisms were major problems in both cultures.

Yield, quality and content of agar extracted with and without alkali treatment from the monthly harvested cultivars in pond culture, and *G. changii* harvested in November 2005 were assessed and compared with commercially available agar strip from China and agar powder from Thailand. Yield of agar alkali treated at 90°C from all *Gracilaria* species ranged from 18.6% to 38.1%. Highest gel strength of agar from *G. manilaensis* (781 g·cm⁻²) and *G. changii* in PI fixed – bottom rope substrates (852 g·cm⁻²) were higher compared to commercial agar strip. Gel strength of agar from *G. manilaensis* in line method was correlated to light intensity. FTIR spectra of 890 cm⁻¹, 930 cm⁻¹, 1370 cm⁻¹ and 1640 cm⁻¹ were detected in all agars extracted from the cultured species. The study showed that line method in pond culture and fixed – bottom rope substrates in field culture had the potential to be applied in commercial production. In terms of species selection, *G. manilaensis* and *G. changii* are appropriate for food grade agar production.

Abstrak tesis yang dikemukakan kepada Senat Universiti Malaysia Terengganu
sebagai memenuhi keperluan untuk ijazah Master Sains

**PERTUMBUHAN DAN CIRI – CIRI AGAR DARIPADA RUMPAI LAUT,
Gracilaria SPESIS DALAM TEKNIK PENKULTURAN YANG BERBEZA**

FONG CHUEN FAR

Jan 2008

Pengerusi : Siti Aishah Abdullah @ Christine A. Orosco, Ph.D.

Ahli : Profesor Mohd. Azmi B. Ambak, Ph.D.

Fakulti : Pengajian Maritim dan Sains Marin

Pengkulturan *Gracilaria*, agarofit yang mempunyai kepentingan komersial, telah dijalankan dengan mengaplikasikan dua pendekatan yang berbeza. Pengkulturan melalui pembiakan vegetatif bagi *Gracilaria* sp. dan *G. manilaensis* telah dijalankan di kolam di Gelang Patah, Johor, dengan menggunakan kaedah tali and sangkar terapung manakala rekrutasi spora secara semulajadi telah diaplikasikan di populasi liar *G. changii* di Sandakan, Sabah dengan substrat tali dan jaring kekal – dasar pada Fasa 1 (P1) dari Jun 2004 hingga Jun 2005 dan Fasa 2 dari bulan August 2004 hingga Jun 2005. Pengkulturan di kolam, kaedah tali menyokong pertumbuhan dan produktiviti *Gracilaria* sp. dan *G. manilaensis* yang lebih baik. Pemantauan bulanan menunjukkan pertumbuhan maximum *Gracilaria* sp. pada bulan September 2004 ($2.28 \pm 0.63\%$ hari⁻¹) dan *G. manilaensis* pada November 2004 ($2.88 \pm 1.80\%$ hari⁻¹) dengan produktiviti keseluruhan masing – masing sebanyak 72.5 kg berat kering ha⁻¹ dan 51.2 kg berat kering ha⁻¹. Pengkulturan di lapangan, P1 (18.9 ± 5.7 cm²) dan P2 (16.7 ± 3.5 cm²) substrat tali kekal – dasar menunjukkan kepadatan spora tertinggi pada bulan Oktober 2004. Kepadatan spora adalah lebih tinggi di substrat jaring kekal – dasar P2 berbanding dengan P1, dengan julat antara 1.1 ± 0.2 cm² dan 4.0 ± 1.6 cm². Substrat tali kekal – dasar P1 mampu menghasilkan tuaian maximum sebanyak 9.15

ton berat basah·ha⁻¹ sementara produktiviti biomass yang lebih tinggi tercatat pada substrat jaring kekal – dasar P2 (6.63 ton berat basah·ha⁻¹). Epifit dan organisma penghalang merupakan masalah yang perlu diatasi dalam kedua – dua kaedah pengkulturan.

Penghasilan, kualiti dan kandungan agar yang diekstrak dengan dan tanpa rawatan alkali daripada tuaian bulanan dari kolam dan *G. changii* yang dituai pada November 2005 telah dinilai dan dibandingkan dengan agar keping dari China dan serbuk agar dari Thailand yang boleh didapati di pasaran. Penghasilan agar daripada semua *Gracilaria* spesis yang dirawat dengan alkali pada suhu 90°C berada dalam julat antara 18.6% dan 38.1%. Nilai tertinggi kekuatan gel agar daripada *G. manilaensis* (781 g·cm⁻²) dan *G. changii* pada substrat tali kekal – dasar PI (852 g·cm⁻²) adalah lebih tinggi berbanding dengan nilai yang diperolehi daripada agar keping komersial. Kekuatan gel agar daripada *G. manilaensis* dari kaedah tali menunjukkan korelasi dengan intensiti cahaya. Spektra FTIR 890 cm⁻¹, 930 cm⁻¹, 1370 cm⁻¹ dan 1640 cm⁻¹ telah dikesan pada semua agar yang diekstrak daripada spesis tanaman. Kajian ini menunjukkan bahawa kaedah tali di pengkulturan kolam dan substrat tali kekal – dasar di pengkulturan lapangan berpotensi untuk diaplikasikan untuk penghasilan secara komersial. Dari segi pemilihan spesis, *G. manilaensis* dan *G. changii* sesuai untuk penghasilan agar gred makanan.