REFERENCES

Abelyan, V.A., Yamamoto,T., and Afrikyan, E.G. 1994. Isolation and characterization of cyclomaltodextrin glucanotransferase using cyclodextrin polymers and their derivatives. *Biochemistry (Moscow).* **59** (6) : 573-579.

Amaizo. 1991. Cyclodextrins USA (Mimeograph).

Amaizo. 1993. Cavitron cyclodextrin : A breakthrough for molecular encapsulation USA (Mimeograph).

Bender , H. 1977a. Cyclodextrin - glucanotransferase von *Klebseilla pneumoniae* 1. Synthase, reinguigung und eigenschschaften des enzymes von *K. pneumoniae* M5 a1. *Arch. Microbiol.* **111**: 271.

Bender , H. 1977b. Cyclodextrin - glucanotransferase von *Klebseilla pneumoniae* 2. Bedetung des enzyme fur den metabolismus der cyclodextrin bei *K. pneumoniae* M5 a1. *Arch. Microbiol.* **113** : 49.

Bender, H. 1986. Production, characterization and application of cyclodextrins. *Adv. Biotech. Proc.* **6** : 31-71.

Bender, H. 1988. Studies on the reaction mechanism of cyclodextrin glycosyltransferase : subsite analysis. In O. Huber and J. Szejtli (eds.), Proceedings of the Fourth International Symposium on Cyclodexrtrins, Munich, Kluwer, Academic Publisher : 19-26.

Binder, H., Huber, O., and Bock, A. 1986. Cyclodextrin glycosyltransferase from *Klebsiella pneumoniae* M5al : Cloning nucleotide sequence and expression. *Gene* **47** : 269-277.

Bollag, D.M. and Edelstein, S.J. 1991. Gel electrophoresis under denaturing condition. Protein methods. New York ; John Wiley & Sons, Inc.

Boonchai, J. 1995. Determination of cyclodextrin glycosyltransferase gene from *Bacillus* sp. A11, Master's Thesis, Faculty of Science, Chulalongkorn University.

Bovetto, L. J., Backer, D. P., Villette, J. R., Sicard, P. J., and Bouquelet, S. J-L. 1992. Cyclomaltodextrin glucanotransferase from *Bacillus circulans* E192 I : Purification and characterization of the enzyme. *Biotechnol. Appl. Biochem.* **15** (1) : 48-58.

Bradford, M. M. 1976. A rapid and sensitive method for the qualitatively of microgram quantities of protein utilizing the principle of protein-dye binding. *Anal. Biochem.* **72** : 248-254.

Casu, B. and Reggiani M. 1979. Methylated cycloamyloses and their inclusion properties. *Carbohydr. Res.* **76** : 59-68.

Depinto, J. A. and Campbell, L. L. 1968. Purification and properties of cyclodextrin glycosyltransferase from an alkalophilic bacteria forming primarily cyclodextrin. In D. Duchhene (ed.), Proceedings of the Fifth International Symposium on Cyclodextrins, Paris, Edition de Sante.: 25-31.

Dubois, M., Gilles, K. A., Hamilton, J. K., Rebers, P. A., and Smith, F. 1956. Colorimetric method for determination of sugars and related substances. *Anal. Chem.* **28** : 350-356.

Englbrecht, A., Harrer, G., Lebert, M., and Schmid, G. 1990. Biochemical and genetic characterization of cyclodextrin glycosyltransferase from an alkalophilic bacteria

forming primarily cyclodextrin. In D. Duchene (ed.), Proceedings of the Fifth International Symposium on Cyclodextrins, Paris, Edition de Sante.: 25-31.

Ensuiko.1993. Information of various cyclodextrin products. Japan (Mimeographed).

Ensuiko.1994. Stabilization of natural colors by cyclodextrin. Japan (Mimeographed).

French, D. and Rundle, R. E. 1942. The molecular weights of the Schardinger alpha and beta dextrin. *J. Am. Chem. Soc.* **64** : 165-172.

French, D., Levine, M. L., Pazur, J. H., and Norberg, E. 1949. Studies on the Schardinger dextrins : The preparation and solubility characteristics of alpha- , beta- , and gamma-dextrins. *J. Am. Chem. Soc.* **71** : 353-359.

Fuwa, H. 1954. A new method for microdetermination of amylase activity by the use of amylase as the substrate. *J. Biochem.* **41** : 583-603.

Hamamoto, T., Kaneko, T. , and Horikoshi , K. 1987. Nucleotide sequence of the cyclomaltodextrin glucanotransferase (CGTase) gene from Alkalophilic *Bacillus* sp. Strain no. 38-2. *Agric. Biol. Chem.* **51** : 2019-2022.

Horikoshi, K. 1971. Production of alkaline enzymes by alkalophilic microorganisms. *Agric. Biol. Chem.* **35** : 1783-1791.

Horikoshi, K. 1979. Production and industrial applications of beta-cyclodextrin. *Proc. Biochem.* **14** : 26-30.

Horikoshi, K.and Akiba, T. 1982. Alkalophilic microorganisms : A new microbial world. Japan Tokyo : Scientific Societies Press : 105-157.

Horikoshi, K. 1988. Enzymology and molecular genetic of CD-forming enzyme. In O. Huber and J. Szejtli (eds.), Proceedings of the Fourth International Symposium on Cyclodextrins, Munich, Kluwer Academic Publisher : 7-17.

Horikoshi, K., Ando, T., Yohida, K., Tokyu, J. P., Nakamura, N., Kunitachi, N. 1982. Enzeugung von cyclodextrin. *Ger Patent DE* 24, 53, 860.

Janssen. 1992. Encapsin HP13 Biotech N. V. Drug Delivery Systems. Belgium (Mimeographed).

Jantarama, J. 1997. Mutation of *Bacillus* sp. A11 for increasing cyclodextrin glycosyltransferase activity. Master's Thesis, Faculty of Science, Chulalongkorn University.

Kaneko, T., Hamamoto, T., and Horikoshi, K. 1988. Molecular cloning and nucleotide sequence of the cyclomaltodextrin glucanotransferase gene from the Alkalophilic *Bacillus* sp. Strain No. 38-2 *J. Gen. Microbiol.* **134** : 97-105.

Kato , T. and Horikoshi, K. 1984. Immobilized cyclomaltodextrin glucanotransferase of an alkalophilic *Bacillus* sp. No. 38-2. *Biotechnol. Bioeng.* **26** : 595-598.

Kim, P. 1996. Purification of cyclodextrin glycosyltransferase by immunoaffinity chromatography, Master's Thesis, Faculty of Science, Chulalongkorn University.

Kimura, K., Kataoka, S., Nakamura, A., Takano, T., Kobayashi, S., and Yamane, K. 1989. Function of the C-terminal region of cyclodextrin glucanotransferase of alkalophilic *Bacillus* sp.# 1011 : Relation to activity and pH stability. *Biochem. Biophys. Res. Com.* **161** : 1273-1279.

Kitahata, S., Tsuyama, N., and Okada, S. 1974. Purification and some properties of the cyclodextrin glycosyltransferase from a strain of *Bacillus* species. *Agric. Biol. Chem.* **38** : 387-393.

Kitahata, S. and Okada, S. 1975. Transfer action of cyclodextrin glycosyltransferase on strach. *Agric. Biol. Chem.* **28** : 2413-2417.

Klein, C. and Schulz, G. E. 1991. Structure of cyclodextrin glycosyltransferase refined at 2.0 A° resolution. *J. Mol. Biol.* **217** : 737-750.

Kobayashi, S., Kainuma, K., and Suzuki, S. 1978. Purification and some properties of *Bacillus macerans* cycloamylose (cyclodextrin) glucanotransferase. *Carbohydr. Res.* **61** : 229-238.

Komitani, T., Tanimoto, H., Nishimera, T., and Okada, S. 1993. A new method for precipitation of various glucosides with cyclodextrin glucanotransferase. *Biosci. Biotech. Biochem.* **57** : 1185-1187.

Komiyama, M. and Bender, M. 1984. Cyclodextrin as enzyme model. The chemistry of enzyme action. Elsvier Science Publisher B.r. : 505-527.

Kuttiarcheewa, W. 1994. Immobilization of cyclodextrin glycosyltransferase on inorganic carriers. Master's Thesis, Faculty of Science, Chulalongkorn University.

Laloknam, S. 1997. Detection of cyclodextrin glycosyltransferase gene by synthetic oligonucleotide probes. Master's Thesis, Faculty of Science, Chulalongkorn University.

Makela, M., Mattsson, P., Schinina, M. E., and Korpela, T. 1988. Purification and properties of cyclomaltodextrin glucanotransferase from an alkalophillic *Bacillus*. *Biotechnol. Appl. Biochem.* **10** : 414-427.

Malai, T. 1992. Development of activity stain for cyclodextrin glycosyltransferase in non-denaturing polyacrylamide gel. Senior project, Faculty of Science, Chulalongkorn University.

Malai, T. 1994. Cyclodextrin production from rice starch. Master's Thesis, Faculty of Science, Chulalongkorn University.

Mattsson, P., Meklin, S., and Korpela, T. 1990. Analysis of cyclomaltodextrin glucanotransferase isoenzymes by isoelectric focusing in immobilized pH gradients. *J. Biochem. Biophys. Methods.* **20** (3) : 237-246.

Matzuzawa, M., Nakamura, N., and Horikoshi, K. 1975. An improve method for the preparation of Schardinger beta-dextrin on an industrial scale by cyclodextrin glycosyltransferase of an alkaphilic *Bacillus* sp. ATCC 21783. *Strach/ Strake.* **27** : 410-413.

Mori, S., Hirose, S., Oya, T., and Kitahata, S. 1994. Purification and properties of cyclodextrin glucanotransferase from *Brevibacterium* sp. No. 9605. *Biosci. Biotech. Biochem.* **11** : 1968-1972.

Nagamoto, S., 1985. Cyclodextrins-expanding the development of their functions and application. *Chem. Econ. Eng. Rev.* **17** : 28-34.

Nakamura, N. and Horikoshi, K. 1976. Characterization and some cultural conditions of a CGTase-producing alkalophilic *Bacillus* sp. *Agric. Biol. Chem.* **40** : 753-757.

Nakamura, N. and Horikoshi, K. 1976. Purification and properties of cyclodextrin glycosyltransferase of an alkalophilic *Bacillus* sp. *Agric. Biol. Chem.* **40** (5) : 935-941.

Nomoto, M., Chen, C. C., and Sheu, D. C. 1986. Purification and characterization of cyclodextrin glucanotransferase from alkalophilic bacterium of Taiwan. *Agric. Biol. Chem.* **50** : 2701-2707.

Okada, S. and Kitahata, S. 1975. Method of purification of cyclodextrin producing enzyme. US Patent 3, 888, 738.

Park, C. S. , Park, K. H., and Kim, S. H. 1988. A rapid screening method for alkaline β-cyclodextrin glucanotransferase using phenolphthalein-methyl orange containing-solid medium. *Agric. Biol. Chem.* **53** : 1167-1169.

Pongsawasdi, P. and Yagisawa, M. 1987. Screening and identification of a cyclomaltodextrin glucanotransferase producing bacteria, *J. Ferment. Technol.* **65** : 463-467.

Pulley, O. A. and French, D. 1961. Studies on the Schardinger dextrins. XI The isolation of new Schardinger dextrins. *Biochem. Biophys. Res Com.* **5** : 11-15.

Rattapat, N. 1996. Effect of some carbohydrates on the induction of cyclodextrin glucanotransferase and cyclodextrin production by *Bacillus* sp. A11. Master's Thesis, Faculty of Science, Chulalongkorn University.

Rojtinnakorn, J. 1994. Preparation of antibody against cyclodextrin glycosyl-transferase from *Bacillus* A11. Master's Thesis, Faculty of Science, Chulalongkorn University.

Rutchtorn, U. 1993. Production of cyclodextrin glucanotransferase in a fermenter and its immobilization on DEAE-cellulose. Master's Thesis, Faculty of Science, Chulalongkorn University.

Saenger, W. 1979. Circular hydrogen bonds in alpha-cyclodextrin hexahydrate *Nature*. **279** : 343.

Saenger, W. 1980. Cyclodextrin inclusion compound in research and industry. *Angew. Chem.*, Int. Ed. Engl., **19** : 344-362.

Saenger, W. 1982. Structure aspect of cyclodextrin inclusion compounds. In J. Szejtli (ed.), Proceedings of the First International Symposium on Cyclodextrins, Budapest, Akademial Kiado : 141-145.

Schardinger, F. 1903. Thermophile bakterien ous ver schiedenen nahrungsmittelu und mich, und die gebldeten produtke, wenn diese baskterien innahrlosungen kultiviert werden, die kohlehydrate enthaten, *Z. Untersuch Nahr Genussm.* **6** : 865-880.

Schardinger, F. 1904. *Bacillus macerans* ein aceton bildender rottebacilluss, *Zbl. Bakter. Parasiten Kande II.* **14** : 772-778.

Schmid, G., Huber, O. S., and Eberle, H-J. 1988. Selective complexing agent for the production of γ-cyclodextrin. Proceedings of the Fourth International Symposium on Cyclodextrins. Munich, Kluwer Academic Publisher : 87-92.

Schmid, G., Huber, O. S., and Eberle, H-J. 1989. Cyclodextrin glucanotransferase production yield enhancement by overproduction of cloned gene. *TIBTECH.* **17** : 244-248.

Siripornadulsilp, S. 1993. Molecular cloning of cyclodextrin glucanotransferase gene from *Bacillus* sp. A11 in *Escherichia coli.* Master's Thesis, Faculty of Science, Chulalongkorn University.

Szejtli, J. 1988. Chapter I : Cyclodextrin Technology., Netherland: Kluwer Academic Publisher.

Szejtli, J. 1990. Cyclodextrins properties and application. Drug Invest. 2 (Suppl. 4) : 11-21.

Szejtli, J., and Paginton, J. 1991. Cholesterol removal with CDs, Cyclodextrin News. May (5) : 1-2.

Takano, T., Fukuda, M., Kobayashi, S., Kainuma, K., and Yamane, K. 1986. Molecular cloning, nucleotide sequencing , and expression in *Bacillus subtilis* cells of *Bacillus macerans* cyclodextrin glucanotransferase gene. *J. Bacteriol.* : 1118-1122.

Techaiyakul, W. 1991. Production and characterization of cyclodextrin glucanotransferase from *Bacillus* spp. Master's Thesis, Faculty of Science, Chulalongkorn University.

Villers, A. 1891. Fermentation de fecute par le ferment butyrique. *Compt. Rend.* **112** : 526-530.

Vittayakitsirikul, V. 1995. Expression of cyclodextrin glycosyltransferase in *Bacillus subtilis* MI111 (RM 125) and *Escherichia coli*. Master's Thesis, Faculty of Science, Chulalongkorn University.

Yamamoto, M., Aritumi, H., Ilie, T., Hirayama, F., and Uekama, K. 1990. Pharmaceutical evaluation of branched β-cyclodextrins as parental drugs carriers. In D. Duchene (ed.), Minutes of the Fifth International Symposium on Cyclodextrins, Paris, Edition De Sante. : 541-544.

Yang, C.P. and Su, C.S. 1989. Study of cyclodextrin production using cyclodextrin glucanotransferase immobilized on chitosan. *J. Chem. Tech. Biotechnol.* **46** : 283-298.

APPENDICES

APPENDIX A : Preparation for polyacrylamide gel electrophoresis

1. Stock reagents

30% Acrylamide, 0.8% bis-acrylamide, 100ml

acrylamide	29.2 g
N,N′-methylene-bis-acrylamide	0.8 g

Adjusted volume to 100 ml with distilled water

1.5 M Tris-HCl pH 8.8

Tris (hydroxymethyl)-aminomethane	18.17 g

Adjusted pH to 8.8 with 1M HCl and adjusted volume to 100 ml with distilled water

2 M Tris-HCl pH 8.8

Tris (hydroxymethyl)-aminomethane	24.2 g

Adjusted pH to 8.8 with 1M HCl and adjusted volume to 100 ml with distilled water

0.5 M Tris-HCl pH 6.8

Tris (hydroxymethyl)-aminomethane	6.06 g

Adjusted pH to 6.8 with 1 M HCl and adjusted volume to 100 ml with distilled water

1 M Tris-HCl pH 6.8

Tris (hydroxymethyl)-aminomethane	12.1 g

Adjusted pH to 6.8 with 1M HCl and adjusted volume to 100 ml with distilled water

Solution B (SDS PAGE)

2 M Tris-HCl pH 8.8	75 ml
10% SDS	4 ml
distilled water	21 ml

Solution C (SDS PAGE)

1 M Tris-HCl pH 6.8	50 ml
10% SDS	4 ml
distilled water	46 ml

2. Non-denaturing PAGE

7.0% Separating gel

30% acrylamide solution	2.33 ml
1.5 M Tris-HCl pH 8.8	2.50 ml
distilled water	5.15 ml
10% $(NH_4)_2S_2O_8$	50 µl
TEMED	5 µl

For preparative gel, 25 µl of 10% $(NH_4)_2S_2O_8$ and 2.5 µl of TEMED were added.

5.0% stacking gel

30% acrylamide solution	1.67 ml
0.5 M Tris-HCl pH 6.8	2.50 ml
distilled water	5.80 ml
10% $(NH_4)_2S_2O_8$	50 µl
TEMED	10 µl

Sample buffer

For analytical gel

1 M Tris-HCl pH 6.8	3.1 ml
glycerol	5.0 ml
1% bromophenol blue	0.5 ml
distilled water	1.4 ml

For preparative gel

0.5 M Tris-HCl pH 6.8	1.0 ml
glycerol	0.8 ml
0.5% bromophenol blue	0.4 ml
distilled water	5.8 ml

One part of sample buffer was added to four parts of sample.

Electrophoresis buffer, 1 litre

(25 mM Tris, 192 mM glycine)

Tris (hydroxymethyl)-aminomethane	3.03 g
Glycine	14.40 g

Dissolved in distilled water to 1 litre. Do not adjust pH with acid or base (final pH should be 8.3).

3. SDS-PAGE

7.5% separating gel

30% acrylamide solution	2.5 ml
solution B	2.5 ml
distilled water	5.0 ml

10% $(NH_4)_2S_2O_8$	50 µl
TEMED	10 µl

5.0% stacking gel

30% acrylamide solution	0.67 ml
solution C	1.0 ml
distilled water	2.3 ml
10% $(NH_4)_2S_2O_8$	30 µl
TEMED	5 µl

Sample buffer

1 M Tris-HCl pH 6.8	0.6 ml
50% glycerol	5.0 ml
10% SDS	2.0 ml
2-mercaptoethanol	0.5 ml
1% bromophenol blue	1.0 ml
distilled water	0.9 ml

One part of sample buffer was added to four parts of sample. The mixture was heated 5 minutes in boiling water before loading to the gel.

Electrophoresis buffer, 1 litre

Tris (hydroxymethyl)-aminomethane	3.0 g
Glycine	14.4 g
SDS	1.0 g

Adjusted volume to 1 litre with distilled water (pH should be approximately 8.3).

APPENDIX B : Preparation for phenol-sulfuric acid (PAS) staining solution

Fixative solution

Ethanol	200 ml
Glacial acetic acid	20 ml

Adjust volume to 500 ml with distilled water

Schiff 's reagent

1. Dissolve 10 g of basic fuchsin in 21 ml of distilled water with heating. Cool in ice-bath to 50°C (not below 40°C).

2. Add 200 ml of I N HCl. Mix, and cool to 25°C.

3. Add 17 g of sodium metabisulfite. Mix, and let sit overnight at 4°C in the dark.

4. Add 20 g of HCl washed charcoal, and centrifuge charcoal to avoid contact with filter paper. Filter the supernatant through glass wool to remove remaining harcoal, the filtrate should be clear and colorless.

5. Stored in a brown bottle at 4°C.

0.7% Periodic acid solution

Periodic acid	1.4 g
5% Acetic acid	200 ml

0.2% Sodium metabisulfite

Sodium metabisulfite	0.4 g
5% Acetic acid	200 ml

APPENDIX C : Preparation for isoelectric focusing gel electrophoresis

Monomer-ampholyte solution

30% Acrylamide solution	0.9 ml
1.0% Bis-acrylamide solution	1.25 ml
Ampholyte pH 5-7	0.243 ml
Distilled water	1.39 ml
50% Sucrose	1.186 ml
TEMED	2 µl
0.02 M $(NH_4)_2S_2O_8$	39.5 µl

Fixative solution, 100 ml

Sulfosalicylic acid	4 ml
Trichloroacetic acid	12.5 g
Methanol	30 ml

Immerse gels in this solution for 30 minutes.

Staining solution, 100 ml

Ethanol	27 ml
Acetic acid	10 ml
Coomassie brilliant blue R-250	0.04 g
$CuSO_4$	0.5 g
Distilled water	63 ml

Dissolve the $CuSO_4$ in water before adding the alcohol. Either dissolve the dye in alcohol or add it to the solution at the end.

Immerse the gel in the stain for approximately 1-2 hours.

Destaining solution

First destaining solution

Ethanol	12 ml
Acetic acid	7 ml
$CuSO_4$	0.5 g
Distilled water	81 ml

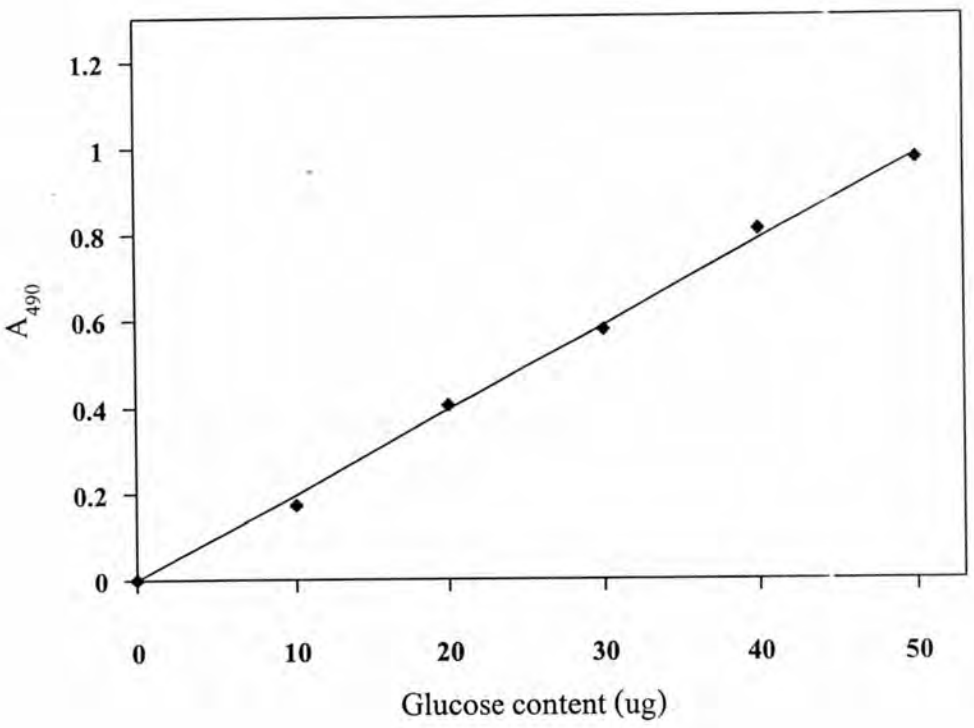
Dissolve the cupric sulfate in water before adding the alcohol. Immerse the gel in two or three changes of this solution until the background is nearly clear.

Second destaining solution

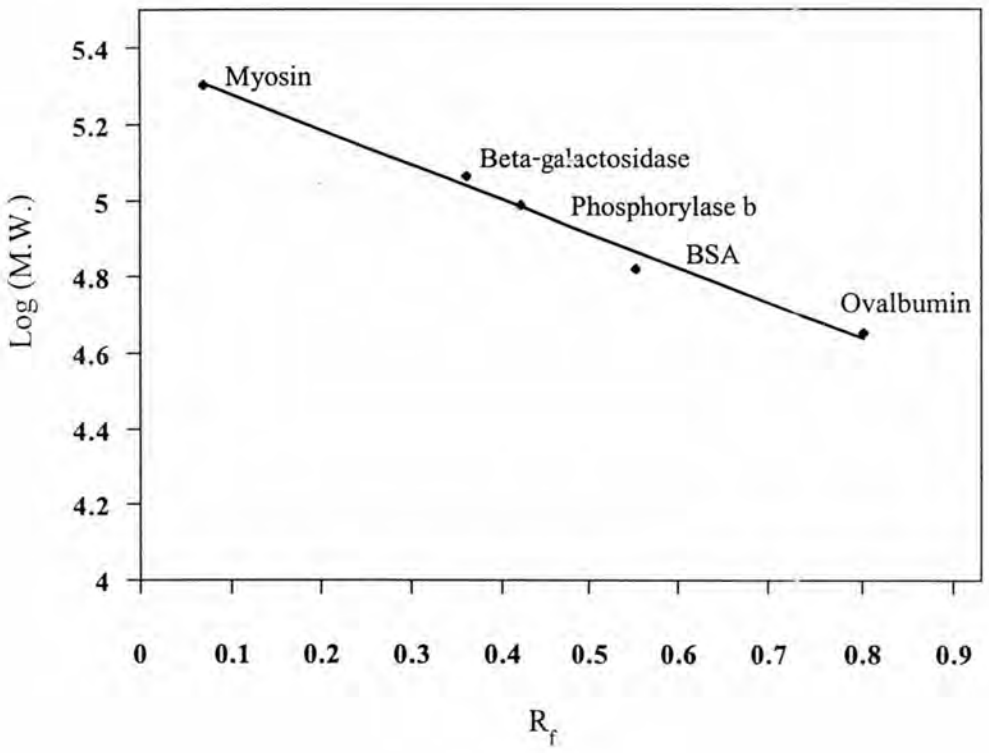
Ethanol	25 ml
Acetic acid	7 ml
Distilled water	68 ml

Immerse the gel in this solution to remove the last traces of stain and $CuSO_4$.

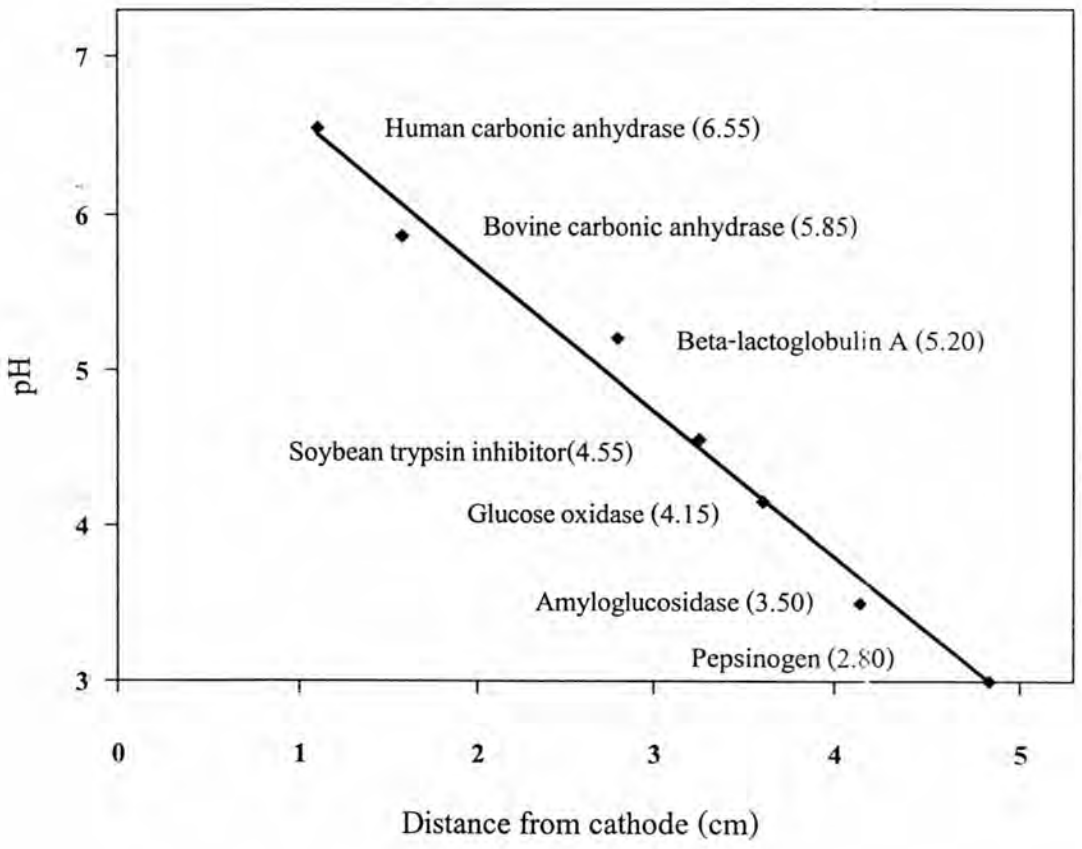
APPENDIX D : Standard curve of glucose by Phenol-sulfuric acid method



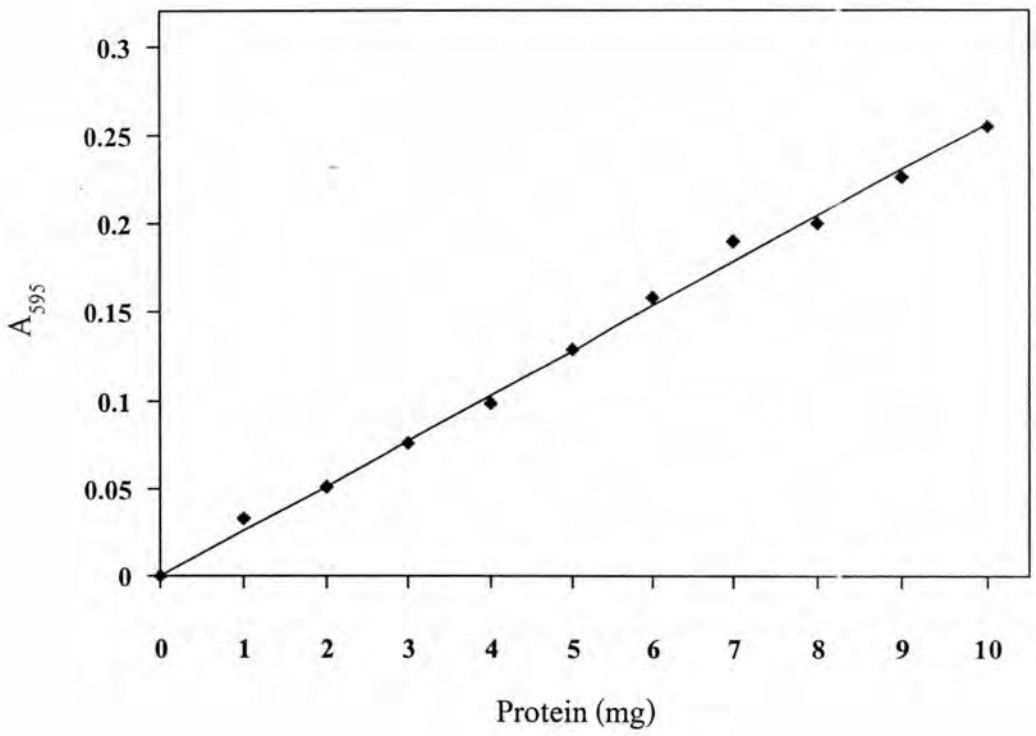
APPENDIX E : Molecular weight calibration curve of standard protein on 7.5% SDS-PAGE



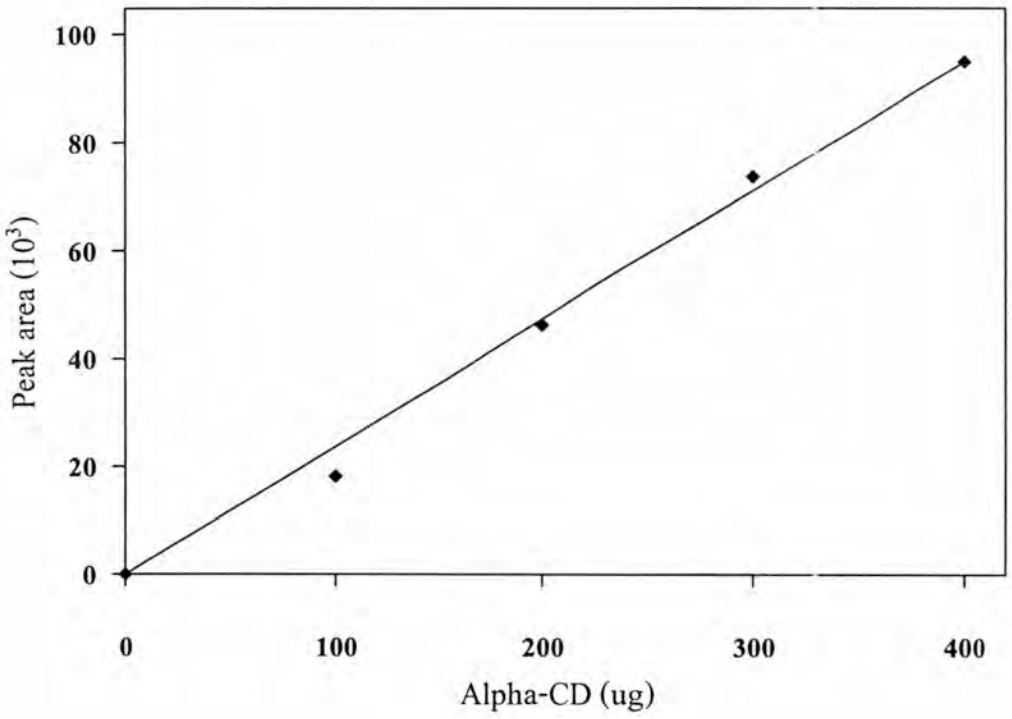
APPENDIX F : Standard pI calibration curve (pI 2.5-6.5)



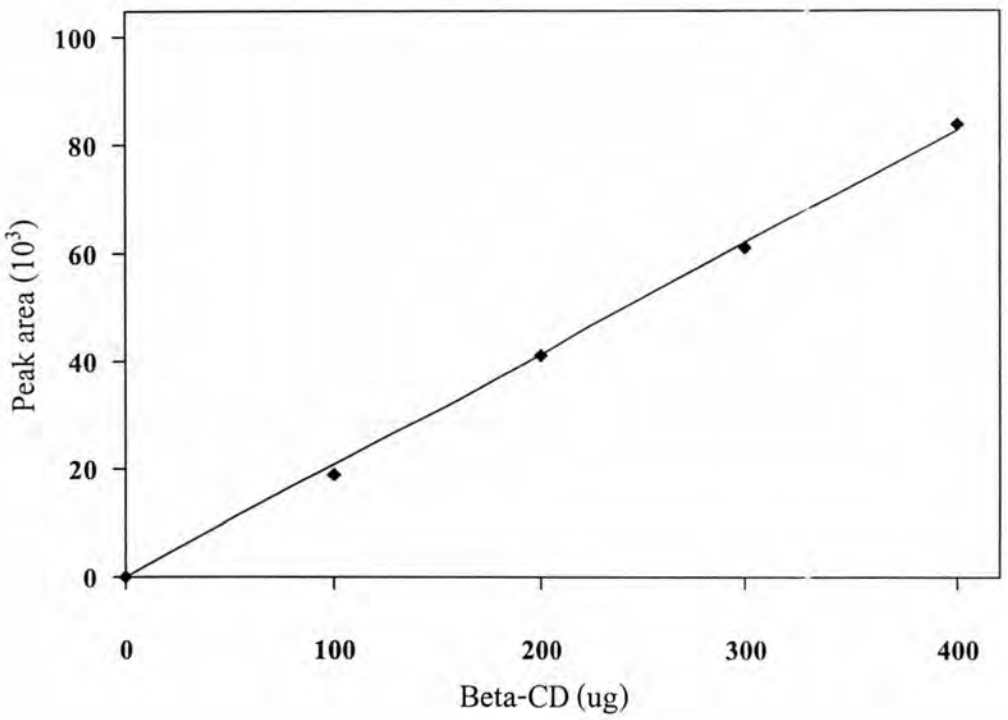
APPENDIX G : Standard curve for protein determination by Bradford's method



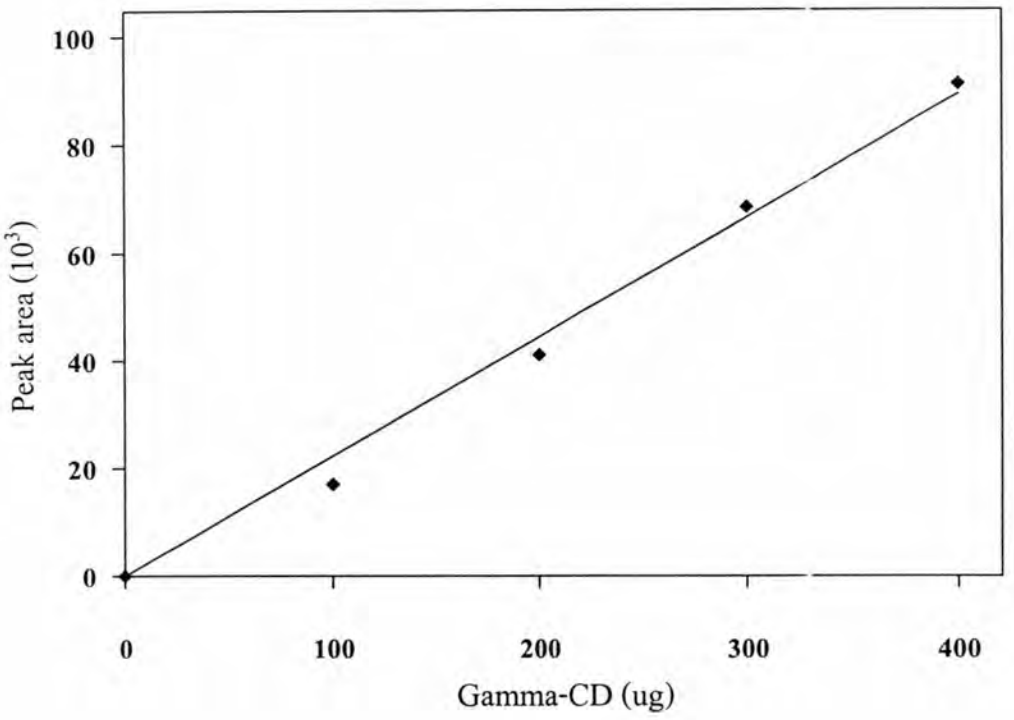
APPENDIX H : Standard curve of Alpha-CD by HPLC method



APPENDIX I : Standard curve of Beta-CD by HPLC method



APPENDIX J : Standard curve of Gamma-CD by HPLC method



BIOGRAPHY

Miss Kannika Kaskangam was born on Nov. 4, 1974. She graduated with the Bachelor Degree of Science in Radiation Technology with the first class honor from Mahidol University in 1995 and continued studying for Master in Biotechnology Program.