

## REFERENCES

- Aga, H., Yoneyama, M., Sakai, S. and Yamamoto, I. (1991). "Synthesis of 2-O- $\alpha$ -D-glucopyranosyl L-ascorbic acid by cyclomalto-dextrin glucanotransferase from *Bacillus stearothermophilus*." *Agricultural and Biological Chemistry* **55**: 1751-1756.
- Alting, A. C., van de Veld, F., Kanning, M. W., Burgering, M., Mulleners, L., Sein, A. and Buwalda, P. (2009). "Improved creaminess of low-fat yoghurt: The impact of amylo-maltase-treated starch domains." *Food Hydrocolloids* **23**: 980-987.
- Aramsangtienchai, P., Chavarisi, W., Ito, K. and Pongsawasdi, P. (2011). "Synthesis of epicatechin glucosides by a  $\beta$ -cyclodextrin glycosyltransferase." *Journal of Molecular Catalysis B: Enzymatic* **73**: 27-34.
- Baek, H. H., Kim, D. H., Kwon, S. Y., Rho, S. J., Kim, D. W. and Choi, H. G. (2012). "Development of novel ibuprofen-loaded solid dispersion with enhanced bioavailability using cycloamylose." *Archives of Pharmacal Research* **35**: 683-688.
- Baek, H. H., Kwon, S. Y., Rho, S. J., Lee, W. S., Yang, H. J., Hah, J. M., Choi, H. G., Kim, Y. R. and Yong, C. S. (2011). "Enhanced Solubility and Bioavailability of Flurbiprofen by Cycloamylose." *Archives of Pharmacal Research* **34**: 391-397.
- Baetrix Serrano, L. (1980). "Preliminary investigation of the inhibitory effect of maltotriose on the Bacterium *Erwinia carotovora*." *Master's Thesis Food Science, Faculty of Science, The University of Manitoba*.
- Barends, T. R. M., Bultema, J.B., Kaper, T., van der Maarel M.J.E.C., Dijkhuizen, L., and Dijkstra, B.W. (2007). "Three-way stabilization of the covalent intermediate in amylo-maltase, an  $\beta$ -amylase-like transglycosylase." *The Journal of Biological Chemistry* **282**: 17242-17249.
- Bender, H., Lehmanh, J. and Wallenfels, K. (1995). "Pullulan, an extracellular glucan from *Pullularia pullulans*." *Biochimica et Biophysica Acta* **36**: 309-316.
- Bhuiyan, S. H., Kitaoka, M. and Hayashi, K. (2003). "A cycloamylose-forming hyperthermostable 4- $\alpha$ -glucanotransferase of *Aquifex aeolicus* expressed in *Escherichia coli*." *Journal of Molecular Catalysis B: Enzymatic* **22**: 45-53.
- Bollag, M. D. and Edlestein, J. S. (1996). "Protein Methods." *John Wiley & Sons, Inc. New York*. : 95-142.
- Boos, W. and Shuman, H. (1988). "Maltose/maltodextrin system of *Escherichia coli*: transport, metabolism, and regulation." *Microbiology and Molecular Biology Reviews* **62**: 204-229.



200506181

- Bradford, M. M. (1976). "A rapid and sensitive method for quantitation of microgram quantities of protein utilizing the principle of protein-dye binding." *Analytical Biochemistry* **72**: 248-254.
- Chotipanang, K., Bhunthumnavin, W., and Prousoontorn, M.H. (2011). "Synthesis of alkyl glycosides from cyclodextrin using cyclodextrin glycosyltransferase from *Paenibacillus* sp. RB01." *The Journal of Inclusion Phenomena and Macrocyclic Chemistry* **70**: 359-368.
- Colleoni, C., Dauville'e, D., Mouille, G., Morell, M., Samuel, M., Slomiany, M. C., Lie'nard, L., Wattebled, F., Hulst, C. and Ball, S. (1999). "Characterization of the *Chlamydomonas reinhardtii*  $\alpha$ -1,4 glucanotransferase supports a direct function in amylopectin biosynthesis." *Plant Physiology* **120**: 1005-1014.
- Critchley, J. H., Zeeman, S. C., Takaha, T., Smith, A.M. and Smith, S.M. (2001). "A critical role for disproportionating enzyme in starch breakdown is revealed by a knock-out mutation in Arabidopsis. ." *The Plant Journal* **26**: 89-100.
- Dawson, R. M. C., Elliott, D. C., Elliott, W. H. and Jones, K. M. (1986). "Data for biochemical research." *Data for biochemical research, New York* **3**.
- Dominguez, A. L., Rodrigues, L. R., Lima, N. M. and Teixeira, J. A. (2014). "An Overview of the Recent Developments on Fructooligosaccharide Production and Applications." *Food and Bioprocess Technology* **7**: 324-337.
- Donnelly, B. J., Fruin, J. C. and Scallet, B. L. (1973). "Reaction of oligosaccharides. III. Hygroscopic properties." *Anheuser-Busch, Inc.*
- Doudoroff, M., Hassid, W. Z., Putman, E. W. and Potter, A. L. (1949). "Direct utilization of maltose by *Escherichia coli*." *The Journal of Biological Chemistry* **179**: 921-934.
- Dubois, M., Gilles, K. A., Hamilton, J. K., Rebeers, P. A. and Smith, F. (1956). "Colorimetric method for determination of sugars and related substance." *Analytical Chemistry* **28**: 350-356.
- Endo, T., Zheng, M. and Zimmermann, W. (2002). "Enzymatic synthesis and analysis of large-ring cyclodextrins." *Australian Journal of Chemistry* **55**: 39-48.
- Felley, C. P., Corthesy-Theulaz, I., Rivero, J. L. B., Sipponen, P., Kaufmann, M., Bauerfeind, P., Wiesel, P. H., Brassart, D., Pfeifer, A., Blum, A. L. and Michetti, P. (2001). "Favourable effect of an acidified milk (LC-1) on *Helicobacter pylori* gastritis in man." *European Journal of Gastroenterology & Hepatology* **13**: 25-19.
- French, D. (1957). "The Schardinger Dextrins." *Advances in Carbohydrate Chemistry* **12**: 189-260.



- Fujii, K., Minagawa, H., Terada, Y., Takaha, T., Kuriki, T., Shimada, J. and Kaneko, H. (2005). "Protein engineering of amyloamylase from *Thermus aquaticus* with random and saturation mutageneses." *Biologia, Bratislava* 16: 97-102.
- Gessler, K., Usón, I., Takaha, T., Krauss, N., Smith, S. M., Okada, S., Sheldrick, G. M. and Saenger, W. (1999). "V-amylose at atomic resolution: X-ray structure of a cycloamylose with 26 glucose residues (cyclomaltohexaicosaoase)." *Proceedings of the National Academy of Sciences* 96: 4246-4251.
- Gibson, G. R. and Mc Cartney, A. L. (1998). "Modification of the gut flora by dietary means." *Biochemical Society Transaction* 26: 222-228.
- Goda, S. K., Eissa, O., Akhta, M. and Minton, N. P. (1997). "Molecular analysis of a *Clostridium butyricum* NClMB 7423 gene encoding 4- $\alpha$ -glucanotransferase and characterization of the recombinant enzyme produced in *Escherichia coli*." *Microbiology and Molecular Biology Reviews* 143: 3287-3294.
- Gupta, R., Gigras, P., Mohapatra, H., Goswami, V. and Chauhan, B. (2003). "Microbial  $\alpha$ -amylase: a biotechnological perspective." *Process Biochemistry* 38: 1599-1616.
- Hansen, M. R., Blennow, A., Pedersen, S., Norgaard, L. and Engelsen, S. B. (2008). "Gel texture and chain structure of amyloamylase-modified starches compared to gelatin." *Food Hydrocolloids* 22: 1551-1566.
- Hansen, M. R., Blennow, A., Pedersen, S., Norgaard, L. and Engelsen, S. B. (2009). "Enzyme modification of starch with amyloamylase results in increasing gel melting point." *Carbohydrate Polymers* 78: 72-79.
- Harata, K. (1981). "Induced circular dichroism of cycloamylose complex with meta- and para-disubstituted benzenes." *Bioorganic Chemistry* 10: 255-265.
- Herrero-Martínez, J. M., Schoenmakers, P. J. and Kok, W. T. (2004). "Determination of the amylose-amylopectin ratio of starches by iodine-affinity capillary electrophoresis." *Journal of Chromatography A* 1053.
- Israilides, C., Smith, A., Scanlon, B. and Barnett, C. (1999). "Pullulan from agro-industrial wastes." *Biotechnology & Genetic Engineering Reviews* 16: 309-324.
- Jeon, B. S., Taguchi, H., Sakai, H., Ohshima, T., Wakagi, T. and Matsuzawa, H. (1997). "4- $\alpha$ -glucanotransferase from the hyperthermophilic archaeon *Thermococcus litoralis* enzyme purification and characterization, and gene cloning, sequencing and expression in *Escherichia coli*." *European Journal of Biochemistry* 248: 171-178.



200306181

- Jeon, Y. and Kim, S. K. (2000). "Production of chitooligosaccharides using an ultrafiltration membrane reactor and their antibacterial activity." *Carbohydrate Polymers* **41**: 133-141.
- Jung, T. Y., Seo, D. H., Yoon, S. M., Choi, H. C., Park, B. C., Park, C. S. and Woo, E. J. (2011). "Structural and functional analysis of substrate recognition by the 250s loop in amyloamylase from *Thermus brockianus*." *Proteins* **79**: 633-644.
- Takefuda, G. and Duke, S. H. (1989). "Characterization of pea chloroplast D-enzyme (4- $\alpha$ -D-Glucanotransferase)." *Plant Physiology* **91**: 136-143.
- Kangouri, K., Namili, S., Nagate, T., Hara, H., Sugita, K. and Omura, S. (1982). "Study on the  $\alpha$ -glucoside hydrolase inhibitor, adiposin. III  $\alpha$ -glucoside hydrolase inhibitor activity and antimicrobial activity IN VITRO." *The Journal of Antibiotics* **1160-1166**.
- Kaper, T., Leemhuis, H., Uitdehaag, J. C. M., van der Veen, B. A., Dijkstra, B. W., van der Maarel, M. J. E. C. and Dijkhuizen, L. (2007). "Identification of acceptor substrate binding subsites +2 and +3 in the amyloamylase from *Thermus thermophilus* HB8." *Biochemistry* **46**: 5261-5269.
- Kaper, T., Talik, B., Ettema, T. J., Herman, B., van der Maarel, M. J. E. C. and Dijkhuizen, L. (2005). "Amyloamylase of *Pyrobaculum aerophilum* IM2 produces thermoreversible starch gels." *Applied and environmental microbiology*: 5098-5106.
- Kasemsuwan, T., Jane, J., Chen, Y. Y., Lee, L. F., McPherson, A. E., Wong, K. S. and Radosavljevic, M. (1999). "Effects of amylopectin branch chain length and amylose content on the gelatinization and pasting properties of starch." *Cereal Chemistry* **76**: 629-637.
- Katelakha, K. (2012). "Transglycosylation reaction of cyclodextrin glycosyltransferase from *Paenibacillus* sp. RB01 for the synthesis of medium-chain alkyl glycosides. Master's Thesis Biochemistry, Faculty of Science, Chulalongkorn University.
- Kim, J. H., Wang, R., Lee, W. H., Park, C. S., Lee, S. and Yoo, S. H. (2011). "One-pot synthesis of cycloamyloses from sucrose by dual enzyme treatment: Combined reaction of amylosucrase and 4- $\alpha$ -glucanotransferase." *Journal of Agricultural and Food Chemistry* **59**: 5044-5051.
- Kim, M. G., Kim, C. H., Lee, J. S., Song, K. B. and Rhee, S. K. (2000). "Synthesis of methyl  $\beta$ -D-fructoside catalyzed by levansucrase from *Rahnella aquatilis*." *Enzyme and Microbial Technology* **27**: 646-651.



- Kim, Y. M., Kim, B. H., Ahn, J. S., Kim, G. E., Jin, S. D., Nguyen, T. H. and Kim, D. (2009). "Enzymatic synthesis of alkyl glucosides using *Leuconostoc mesenteroides* dextranucrase." *Biotechnology Letters* **31**: 1433-1438.
- Kitahata, S. (1988). "Cyclomaltodextrin glucanotransferase." *Handbook of Amylases and Related Enzymes by The Amylase Research Society of Japan*: 154-164.
- Kitahata, S., Hara, K., Fujita, K., Nakano, H., Kuwahara, N. and Koizumi, K. (1992). "Acceptor specificity of cyclodextrin glycosyltransferase from *Bacillus stearothermophilus* and Synthesis of  $\alpha$ -D-Glucosyl O- $\beta$ -D-galactosyl-(1 $\rightarrow$ 4)- $\beta$ -D-glucoside." *Bioscience, Biotechnology and Biochemistry* **56**: 1386-1391.
- Kitahata, S., Murakami, H., Sone, Y. and Misaki, A. (1989). "The acceptor specificity of amyloamylase from *Escherichia coli* IFO 3806." *Agricultural Biological Chemistry* **53**: 2661-2666.
- Kobayashi, R., Takisada, M., Suzuki, T., Kirimura, K. and Usami, S. (1997). "Neoagarobiose a novel moisturizer with whitening effect." *Bioscience, Biotechnology, and Biochemistry* **61**: 162-163.
- Kometani, T., Terada, Y., Nishimura, T., Nakae, T., Takii, H. and Okada, S. (1996). "Acceptor specificity of cyclodextrin glucanotransferase from an alkalophilic *Bacillus* species and synthesis of glucosyl rhamnose." *Bioscience, Biotechnology and Biochemistry* **60**: 1176-1178.
- Kometani, T., Terada, Y., Nishimura, T., Takii, H. and Okada, S. (1994). "Transglycosylation to hesperidin by cyclodextrin glucanotransferase from an alkalophilic *Bacillus* species in alkaline pH and properties of hesperidin glycosides." *Bioscience, Biotechnology and Biochemistry* **58**: 1990-1994.
- Laboratories, B.-R. (2000). "Bio-Gel® P Polycrylamide Gel Instruction Manual."
- Lalitha, M. K. (2004). "Manual on Antimicrobial Susceptibility Testing." *Department of Microbiology, Christian Medical College*. .
- Lin, T. P. and Preiss, J. (1988). "Characterization of D-Enzyme (4- $\alpha$ -Glucanotransferase) in Arabidopsis Leaf." *Plant Physiology* **86**: 260-265.
- Lirdprapamongkol, K. and Svasti, J. (2000). "Alkyl glucoside synthesis using Thai rosewood  $\beta$ -glucosidase." *Biotechnology Letters* **22**: 8189-1894.
- Machida, S., Ogawa, S., Xiaohua, S., Takaha, T., Fujii, K. and Hayashi, K. (2000). "Cycloamylose as an efficient artificial chaperone for protein refolding." *FEBS Letters* **486**: 131-135.
- Manderson, K., Pinart, M., Tuohy, K. M., Grace, W. E., Hotchkiss, A. T., Widmer, W., Yadhav, M. P. G., Gibson, R. and Rastall, R. A. (2005). "In vitro determination of prebiotic properties of oligosaccharides derived from an orange juice



- manufacturing by-product stream." *Applied and Environmental Microbiology* **71**: 8383-8389.
- Manners, D. J. and Rowe, K. L. (1969). "Studies on carbohydrate-metabolizing enzymes. The  $\alpha$ -glucosidase and D-enzyme activity of extracts of carrots and tomatoes." *Carbohydrate Polymers* **9**: 441-500.
- Markosyan, A. A., Abelian, L. A., Adamian, M. O., Ekazhev, Z. D., Akopian, Z. I. and Abelian, V. A. (2007). "Production of fructooligosaccharide syrup from sucrose in combination with palatinose and trehalose." *Applied Biochemistry and Microbiology* **43**: 383-389.
- Martin, T. M., Alcalde, M., Plou, F. J., Dijkhuizen, L. and Ballesteros, A. (2000). "Synthesis of malto- oligosaccharides via the acceptor reaction catalyzed by cyclodextrin glycosyltransferases." *Biocatalysis and Bioformation* **19**: 21-25.
- Mertens, J. A. and Skory, C. D. (2007). "Isolation and characterization of a second glucoamylase gene without a starch binding domain from *Rhizopus oryzae*." *Enzyme and Microbial Technology* **40**: 874-880.
- Monod, J. and Torriani, A. M. (1950). "Amylomaltase of *Escherichia coli*." *Annales de l'Institut Pasteur (Paris)* **76**(65-77).
- Moon, Y. H., Lee, J. H., Ahn, J. S., Nam, S. H., Oh, D. K., Park, D. H., Chung, H. J., Kang, S., Day, D. F. and Kim, D. (2006). "Synthesis, structure analyses, and characterization of novel epigallocatechin gallate (EGCG) glycosides using the glucansucrase from *Leuconostoc mesenteroides* B-1299CB." *Journal of Agricultural and Food Chemistry* **54**: 1230-1237.
- Mun, S., Rho, S. J. and Kim, Y. R. (2009). "Study of inclusion complexes of cycloamylose with surfactants by isothermal titration calorimetry." *Carbohydrate Polymers* **77**: 223-230.
- Nakakuki, T. (1993). "In Oligosaccharides, production, properties, and applications." *Jornal of Biotechnology* **3**: 1-24.
- Nielsen, S. S. (2010). "Phenol-sulfuric acid method for total carbohydrates." *Food Science Texts Series*: 44-53.
- Nimpiboon, P., Nakapong, S., Pichyangkura, R., Ito, K. and Piamsook, P. (2011). "Synthesis of a novel prebiotic trisaccharide by a type I  $\alpha$ -glucosidase from *B. licheniformis* strain TH4-2." *Process Biochemistry* **46**: 448-457.
- Okita, T. W., Greenberg, E., Kuhn, D. N. and Preiss, J. (1979). "Subcellular localization of starch degradative and biosynthetic enzymes of spinach leaves." *Plant Physiology* **64**: 187-192.



- Palcic, M. (1999). "Biocatalytic synthesis of oligosaccharides." *Current Opinion Biotechnology* **10**: 616-624.
- Pandey, A., Nigam, P., Soccol, C. R., Soccol, V. T., Singh, D. and Mohan, R. (2000). "Advances in microbial amylases." *Biotechnology and Applied Biochemistry* **31**: 135-152.
- Papadoyannis, I. N. and Samanidou, V. F. (2005). "Ion-exclusion chromatography." *Encyclopedia of Chromatography DOI: 10.1081/E-ECHR-120040026* **2**.
- Park, J. H., Kim, K. J., Kim, Y. H., Cha, H., Kim, Y. W., Kim, T. J., Kim, Y. R. and Park, K. H. (2007). "The action mode of *Thermus aquaticus* YT-1 4- $\alpha$ -glucanotransferase and its chimeric enzymes introduced with starch binding domain on amylase and amylopectin." *Carbohydrate Polymers* **67**: 164-173.
- Peat, S., Whelan, W. J. and Ress, W. R. (1956). "The enzymic synthesis and degradation of starch. Part XX. The disproportionating enzyme (D-enzyme) of the potato." *Journal of the Chemical Society*: 44-53.
- Przylas, I., Terada, Y., Fujii, K., Takaha, T., Saenger, W. and Sträter, N. (2000). "X-ray structure of acarbose bound to amyloamylase from *Thermus aquaticus*. Implications for the synthesis of large cyclic glucans." *European Journal of Biochemistry* **267**: 6903-6913.
- Rani, B., and Khetarpaul, N. (1998). "Probiotic fermented food mixture: possible applications in clinical anti-diarrhoea usage." *The Journal of Nutrition Health and Aging* **12**: 97-105.
- Reddy, N. S., Nimmagadda, A. and Sambasiva Rao, K. R. S. (2003). "An overview of the microbial  $\alpha$ -amylase family." *African Journal of Biotechnology* **2**: 645-648.
- Rudeekulthamrong, P., Sawasdee, K. and Kaulpiboon, J. (2013). "Production of long-chain isomaltooligosaccharides from maltotriose using the thermostable amyloamylase and transglucosidase Enzymes." *Biotechnology and Bioprocess Engineering* **18**: 778-786.
- Saehu, W., Srisimarath, W., Prousoontorn, M. H. and Pongsawasdi, P. (2013). "Transglucosylation reaction of amyloamylase for the synthesis of anticarcinogenic oligosaccharides." *Journal of Molecular Catalysis B: Enzymatic* **88**: 77-83.
- Sauer, J., Singurskjold, B. W., Christensen, U., Frandsen, T. P., Mirgorodskaya, E., Harrison, M., Roepstorff, P. and Svensson, B. (2000). "Glucoamylase: structure/function relationships and protein engineering. ." *Biochimica et Biophysica Acta* **1543**: 275-293.



- Schmitt, J., Hess, H. and Stunnenberg, H. G. (1993). "Affinity purification of histidine-tagged proteins." *Molecular Biology Reports* 18: 223-230.
- Schuman, B., Alfaro, J. A. and Evans, S. V. (2007). "Glycosyltransferases structure and function." *Topics in Current Chemistry* 272: 217-257.
- Shin, K. D., Lim, S. K. and Son, H. (1988). "Effect of organic acids on the hygroscopicity and browning of sucrose candies." *Food Science and Technology* 7: 107-111.
- Srisimarat, W. (2010). "Characterization of a novel amylomaltase from *Corynebacterium glutamicum* ATCC 13032." *Doctoral's Thesis Biochemistry, Faculty of Science, Chulalongkorn University.*
- Srisimarat, W., Powviriyakul, A., Kualpiboon, J., Krusong, K., Zimmermann, W. and Pongsawasdi, P. (2011). "A novel amylomaltase from *Corynebacterium glutamicum* and analysis of the large-ring cyclodextrin products." 70: 369-374.
- Stassi, D. L., Lopez, P., Espinosa, M. and Lacks, S. A. (1981). "Cloning of chromosomal genes in *Streptococcus pneumoniae*." *Proceedings of the National Academy of Sciences (USA.)* 11.
- Tachibana, Y., Takaha, T., Fujiwara, S., M., T. and Imanaka, T. (2000). "Acceptor specificity of 4- $\alpha$ -glucanotransferase from *Pyrococcus kodakaraensis* KOD1, and synthesis of cycloamylose." *Journal of Bioscience and Bioengineering* 90: 406-409.
- Takaha, T. and Smith, S. M. (1999). "The functions of 4- $\alpha$ -glucanotransferases and their use for the production of cyclic glucans." *Biotechnology and Genetic Engineering Reviews* 16: 257-280.
- Takaha, T., Yanase, M., Takata, H., Okada, S. and Smith, S. M. (1988). "Cyclic Glucans produced by the intramolecular transglycosylation activity of potato D-enzyme on amylopectin." *Biochemical and Biophysical Research Communications* 247: 493-497.
- Takaha, T., Yanase, M., Takata, H., Okada, S. and Smith, S. M. (1996). "Potato D-enzyme. catalyzes cyclization of amylose to produce cycloamylose, a novel cyclic glucan." *The Journal of Biological Chemistry* 271: 2902-2908.
- Takahashi, N., Fukushi, E., Onodera, S., Nishimoto, T., Kawabata, J. and Shiomi, N. (2007). "Isolation and identification of novel tri- and tetra-saccharides synthesized by *Thermoanaerobacter Brockii* Kojibiose phosphorylase." *The Journal of Applied Glycoscience* 54: 195-200.
- Taylor, G. R. J. and Williams, C. M. (1998). "Effects of probiotics and prebiotics on blood lipids." *British Journal of Nutrition* 80: 225-230.





- Terada, Y., Fujii, K., Takaha, T. and Okada, S. (1999). "Thermus aquaticus ATCC 33923 amyloamylase gene cloning and expression and enzyme characterization: production of cycloamylose." *Applied and environmental microbiology*: 910-915.
- Thoma, J. and Stewart, L. (1965). "Cycloamyloses." *Starch Chemistry and Technology*: 209-249.
- Trincone, A. and Giordano, A. (2006). "Glycosyl hydrolases and glycosyltransferases in the synthesis of oligosaccharides." *Current Organic Chemistry* 10: 1163-1193.
- Tzortzis, G. and Vulevic, J. (2009). "Galacto-oligosaccharide prebiotics." *Prebiotics and Probiotics Science and Technology*: 207-244.
- van der Maarel, M. J. E. C., Caprona, I., Euverinka, G. J. W., Bosa, H. T., Kaper, T., Binnema, D. J. and Steenekena, P. A. M. (2005). "A novel thermoreversible gelling product made by enzymatic modification of starch." *Starch* 57: 465-472.
- van der Maarel, M. J. E. C., Van der Veen, B., Uitdehaag, J. C. M., Leemhuis, H. and Dijkhuizen, L. (2002). "Properties and applications of starch-converting enzymes of the  $\alpha$ -amylase family." *Journal of Biotechnology* 94: 137-155.
- van der Veen, B. A., Leemhuis, H., Kralj, S., Uitdehaag, J. C. M., Dijkstra, B. W. and Dijkhuizen, L. (2001). "Hydrophobic amino acid residues in the acceptor binding site are main determinants for reaction mechanism and determinants for reaction mechanism and cyclodextrin-glycosyltransferase." *Journal of Biological Chemistry* 276: 44557-44562.
- van der Veen, B. A., van Alebeek, G. W. M., Uitdehaag, J. C. M., Dijkstra, B. W. and Dijkhuizen, L. (2000). "The three transglycosylation reaction reactions catalyzed by cyclodextrin glycosyltransferase from *Bacillus circulans* (strain 251) proceed via different kinetic mechanisms." *European Journal of Biochemistry* 267: 658-665.
- von Mering, C., Huynen, M., Jaeggi, D., Schmidt, S., Bork, P. and Snel, B. (2003). "A database of predicted functional associations between proteins." *Nucleic Acids Research* 32: 258-261.
- Weijers, A. G. M. C., Franssen, C. R. M. and Visser, G. M. (2008). "Glycosyltransferase-catalyzed synthesis of bioactive oligosaccharides." *Biotechnology Advances* 26: 436-456.
- Wong, C. H., Haynie, S. L. and Whitesides, G. M. (1982). "Enzyme-catalysed synthesis of N-acetyllactosaminr with in situ regeneration of uridine 5'-diphosphate



200306181

- glucose, and 5'-diphosphate galactose." *The Journal of Organic Chemistry* **47**: 5416-5418.
- Wongsangwattana, W. (2000). "Specificity of glucosyl acceptor in coupling and transglucosylation of cyclodextrin glycosyltransferase from *Bacillus circulans* A11." *Master's Thesis Biochemistry, Faculty of Science, Chulalongkorn University*.
- Wongsangwattana, W., Kaulpiboon, J., Ito, K. and Pongsawasdi, P. (2010). "Synthesis of cellobiose-containing oligosaccharides by intermolecular transglucosylation of cyclodextrin glycosyltransferase from *Paenibacillus* sp. A11." *Process Biochemistry* **45**: 947-953.
- Wrolstad, R. E. (2011). "Sugar composition of foods." *Food Carbohydrate Chemistry* **1**: 22-33.
- Xu, Y., Zhou, X., Baid, Y., Wang, J., Wu, C., Xu, X. and Jin, Z. (2014). "Cycloamylose production from amylo maize by isoamylase and *Thermus aquaticus* 4- $\alpha$ -glucanotransferase." *Carbohydrate Polymers* **102**: 66-73.
- Yanase, M., Takata, H., Takaha, T., Kuriki, T., Smith, S. M. and Okada, S. (2002). "Cyclization reaction catalyzed by glycogen debranching enzyme (EC 2.4.1.25/EC 3.2.1.33) and its potential for cycloamylose production." *Applied and Environmental Microbiology* **68**: 4233-4239.
- Yang, S. C., Chen, J.-Y., Shang, H.-F., Cheng, T.-Y., Tsou, S. C. and Chen, J.-R. (2005). "Effect of synbiotics on intestinal microflora and digestive enzyme activities in rats." *The World Journal of Gastroenterology* **11**: 7413-7417.
- Zhang, R. G., Kim, Y., Skarina, T., Beasley, S., Laskowski, R., Arrowsmith, C., Edward, A. and Joachimiak, A. (2002). "Crystal structure of *Thermotoga maritima* 0065, a member of the ICLR transcriptional factor family." *The journal of Biological Chemistry* **277**: 18183-18190.



APPENDIX



**Appendix A Preparation of stock solution for SDS-PAGE****1. 2.0 M Tris-HCl, pH 8.0**

Tris (hydroxymethyl)-aminomethane 9.1 g

Adjusted pH to 8.8 with 1 M HCl and adjusted volume to 50 ml by distilled water.

**2. 1.0 M Tris-HCl, pH 6.8**

Tris (hydroxymethyl)-aminomethane 6.0 g

Adjusted pH to 6.8 with 1 M HCl and adjusted volume to 50 ml by distilled water.

**3. 10% (w/v) SDS**

Sodium dodecyl sulfate 5.0 g

Adjusted volume to 50 ml by distilled water.

**4. 10% (w/v) ammonium persulfate**

Ammonium persulfate 1.0 g

Adjusted volume to 10 ml by distilled water.

**5. 50% (v/v) glycerol**

Glycerol 5.0 ml

Added 5.0 ml distilled water

**6. Solution A**

2.0 M Tris-HCl, pH 8.8 37.5 ml

10% (w/v) SDS 2 ml

Distilled water 10 ml

**7. Solution B**

1.0 M Tris-HCl, pH 6.8 25 ml

10% (w/v) SDS 2 ml

Distilled water 23 ml



**Appendix B Working solution for SDS-PAGE****7.5% separating gel**

40% acrylamide	1.41 ml
Solution A	2.50 ml
Distilled water	3.48 ml
10% (w/v) ammonium persulfate	60 $\mu$ l
TEMED	6 $\mu$ l

**5.0% stacking gel**

40% acrylamide	0.32 ml
Solution B	0.50 ml
Distilled water	1.652 ml
10% (w/v) ammonium persulfate	25 $\mu$ l
TEMED	3 $\mu$ l

**Sample buffer**

Solution B	0.6 ml
50% (v/v) glycerol	5.0 ml
10% (w/v) SDS	2.0 ml
2-mercaptoethanol	0.5 ml
1% (w/v) bromophenol blue	1.0 ml
Distilled water	0.9 ml

Mixed sample with sample buffer (4:1) and heated for 5 minutes before loading to the gel.



## Appendix C Preparation for buffer solution

## 1. 0.5 M phosphate buffer, pH 6.0

$K_2HPO_4$	87.09 g
------------	---------

$KH_2PO_4$	68.05 g
------------	---------

Adjusted pH to 6.0 by  $KH_2PO_4$  and added water to 1 L.

## 2. 0.5 M phosphate buffer, pH 7.4

$K_2HPO_4$	87.09 g
------------	---------

$KH_2PO_4$	34.02 g
------------	---------

Adjusted pH to 6.0 by  $K_2HPO_4$  and added water to 1 L.

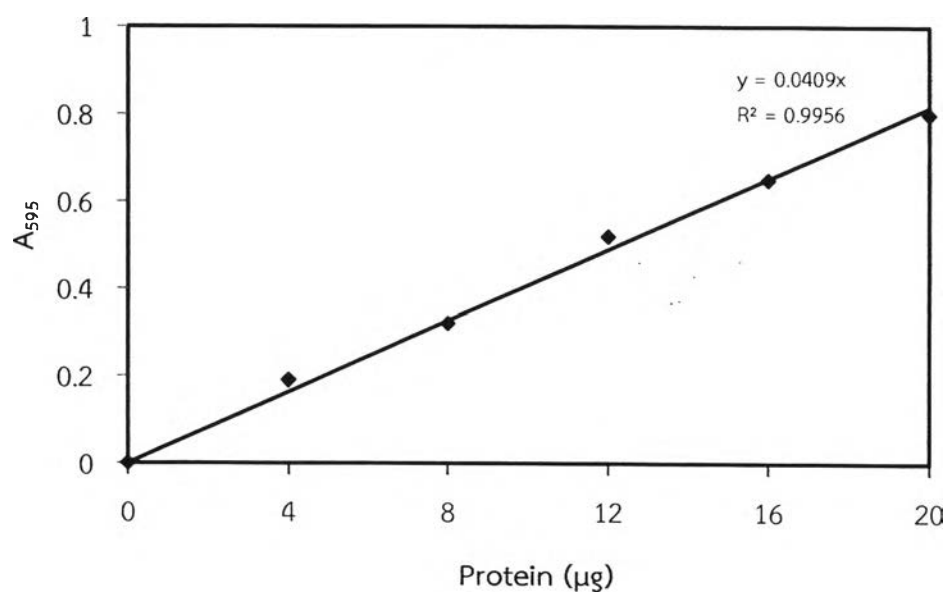
## 3. 50 mM sodium acetate, pH 6.0

$CH_3COONa$	4.10 g
-------------	--------

Adjusted pH to 6.0 by 1 M glacial acetic acid and added water to 1 L.

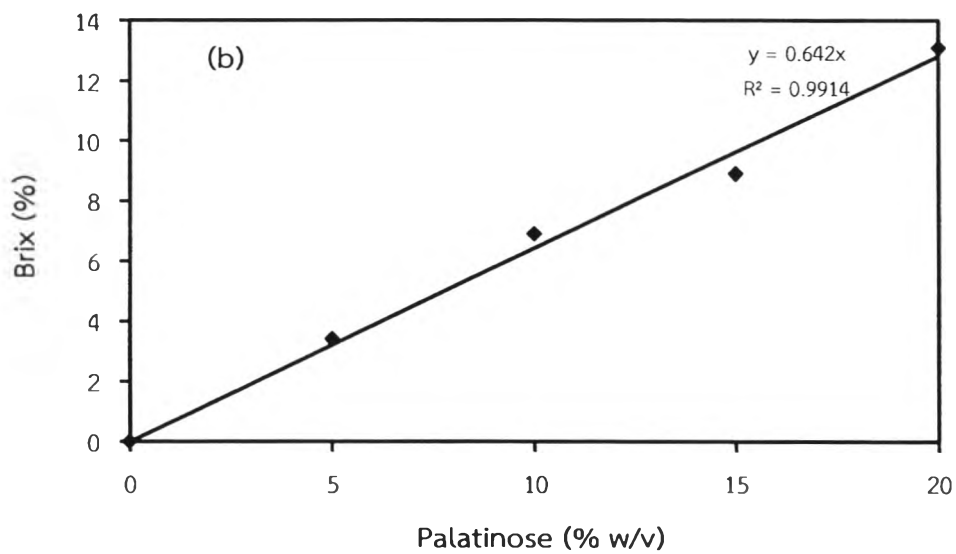
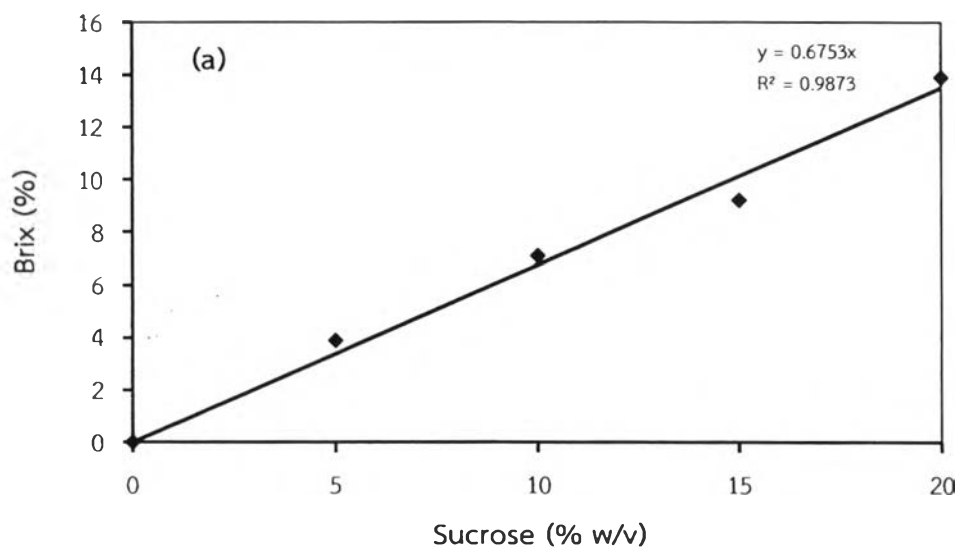


Appendix D BSA standard curve for protein determination by  
Bradford method



## Appendix E Standard curve of sucrose (a) and palatinose (b)

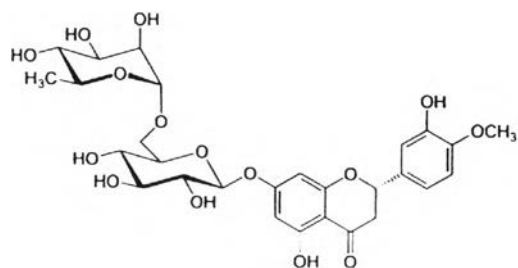
for sweet test



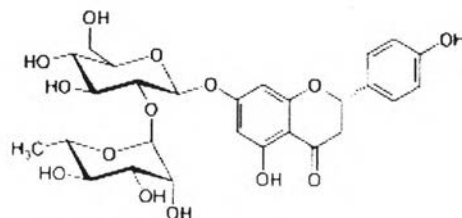
200306181



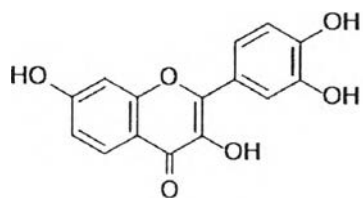
## Appendix F Structure of flavonoid acceptors



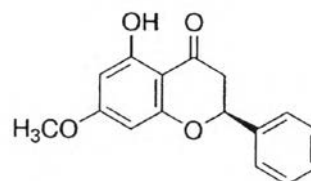
Hesperidin



Naringin



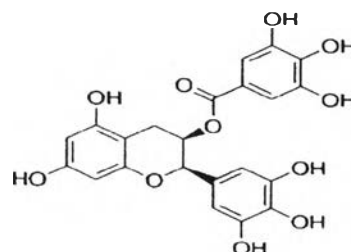
Pinostrobin



Fisetin



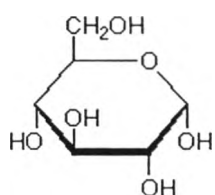
Epicatechin



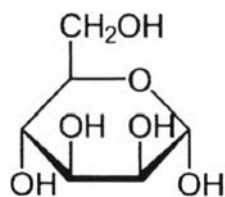
Epigallocatechin gallate



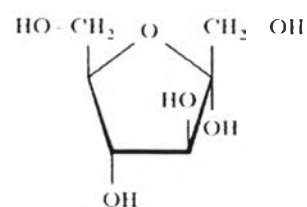
## Appendix G Structure of saccharide acceptors



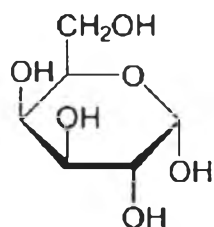
Glucose



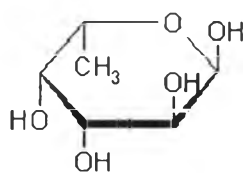
Mannose



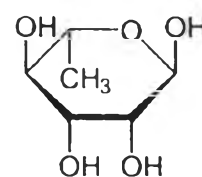
Fructose



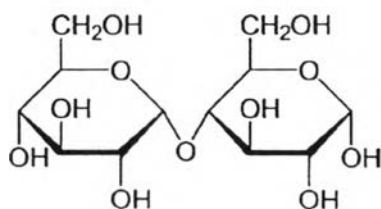
Galactose



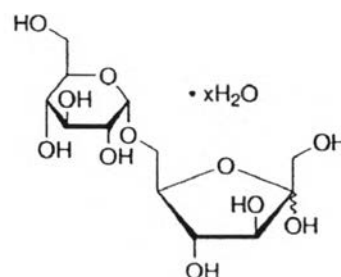
Fucose



Rhamnose

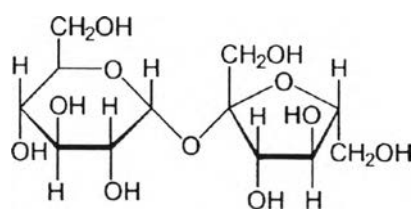


Maltose

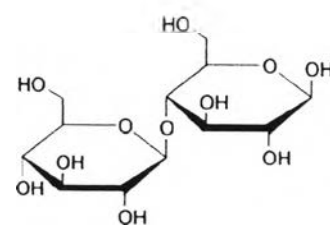


Palatinose

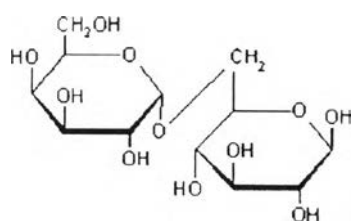




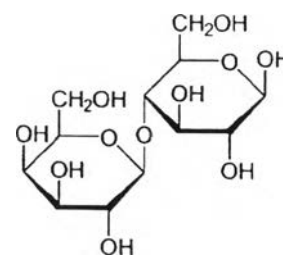
Sucrose



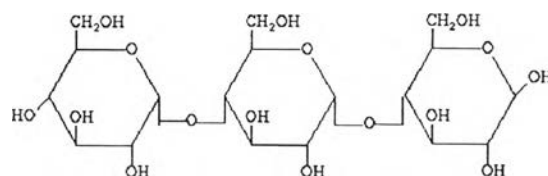
Cellobiose



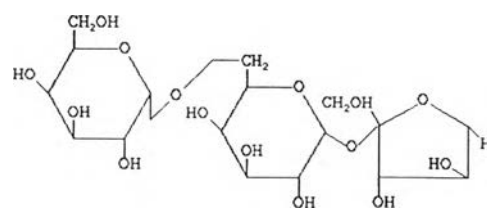
Melibiose



Lactose



Maltotriose



Galactose

Glucose

Fructose

Raffinose



## VITA

Miss Wachiraporn Naumthong was born on October 9th, 1988. After she graduated with the Bachelor of Science in Biochemistry from the Department of Biochemistry, Faculty of Science, Chulalongkorn university in 2010, she continues studying for Master degree in Biochemistry and Molecular Biology. In April 2014, she had orally presented her work at the 4th International Biochemistry and Molecular Biology Conference, with the full article published in the Proceedings of the Conference.

## Publication

Naumthong, W., and Pongsawasdi, P. 2014. Acceptor specificity and transglucosylation reaction of amyloamylase from *Corynebacterium glutamicum*. Proceeding of The 4th International Biochemistry and Molecular Biology Conference, 2-3 April 2014, Rama Gardens Hotel and Resort, Bangkok, 247-252.

