

atau hiosiamina terjadi setelah fase stasioner dicapai. Karena fase stasioner lebih lambat dicapai, akibatnya saat kalus dipanen, alkaloid atropina dan atau hiosiamina belum banyak disintesis.

Dengan demikian, medium paling efektif untuk produksi atropina dan atau hiosiamina adalah medium S₄₀N₀ dengan kadar atropina dan atau hiosiamina sebesar 250,45 ± 25,26 µg/g kalus kering. Namun demikian, hasil yang dicapai pada kultur kalus ini masih jauh di bawah kadar atropina dan atau hiosiamina dalam daun tanaman asal, yaitu sebesar 458,45 ± 28,28 µg/g daun kering, sehingga perlu dicari upaya lain untuk lebih meningkatkan kadar atropina dan atau hiosiamina melalui teknik kultur jaringan ini.

DAFTAR PUSTAKA

- Backer, C.A. and Bakhuizen van den Brink, R.C. 1963. *Flora of Java*. Vol. I. N.V. P. Noordhoff, Groningen, Netherlands.
- Backer, C.A. and Bakhuizen van den Brink, R.C. 1965. *Flora of Java*. Vol. II. N.V. P. Noordhoff, Groningen, Netherlands.
- Bajaj, Y.P.S., Furmanowa, M., dan Olszowska, O. 1988. Biotechnology of the micropropagation of medicinal and aromatic plants. Dalam: *Biotechnology*

in agriculture and forestry 4. Ed. Bajaj, Y.P.S. Springer-Verlag. Berlin. Heidelber. New York. London. Paris. Tokyo. P. 60-103

Balandrin, M.F., Klocke, J.A., 1998, Medicinal, Aromatic, and Industrial Materials from Plants, dari Bajaj, Y.P.S. (ed), *Biotechnology in Agriculture and Forestry*, 4, Springer-Verlag, Berlin, Heidelber, New York, London, Paris, Tokyo, , 3 - 35.

Becker, H and Sauerwein, M. 1990. Manipulating the biosynthetic capacity of plant cell cultures. Dalam: *Secondary products from plant tissue culture*, 43-53. Charlwood, B.V., and Rhodes, M.J.C., (Eds.) Clarendorn Press. Oxford.

Berlin, J, 1998, Formation of secondary metabolites in cultured plant cells and its impact on pharmacy, dari Bajaj, Y.P.S. (ed), *Biotechnology in Agriculture and Forestry*, 4, Springer-Verlag, Berlin, Heidelber, New York, London, Paris, Tokyo, 37.

Bhojwani, S.S. dan Rhazdan, M.K. 1983. *Plant tissue culture theory and practice*. Elsevier. Amsterdam. Oxford. Tokyo. p 287-372

Bold, and Harold, P. 1960. *The Plant Kingdom*. Prentice Hall Inc. New Jersey.

Cordell, G.A. 1981. *Introduction to Alkaloid, A Biogenetic Approach*. John Wiley and Sons Inc. New York.

Carew, D.P. and Krueger, R.J. 1977. *Catharanthus roseus* tissue culture: the effect of medium modifications on growth and alkaloid production. *J. Nat. Prod.* 40: 326-336.

Crocomo, O.J., Aquarone, E., and Gottlieb, O.R. 1981. Biosynthesis of secondary product *in vitro*. Dalam: *Plant tissue culture methods and applications in agriculture*. Ed. Thorpe, T.A. Academic Press. New York. London. Toronto. Sydney. San Fransisco.

Decendit, A., Liu, D., Ouelhazi, L., Doireau, P., Merillon, J.M. dan Rideau, M. 1992. Cytokinin-enhanced accumulation of indole alkaloids in *Catharanthus roseus* cell cultures factors affecting the cytokinin response. *Plant Cell Rep.* 11: 400 – 403.

Deus, B. dan Zenk, M.H. 1982. Exploitation of plant cells for the production of natural compounds. *Biotech. And Bioeng.* 24: 1965 – 1974.

Dixon, R.A. and Paiva, N.L. 1995. Stress-induced phenylpropanoid metabolism. *The Plant Cell*, 7: 1085 – 1097.

- Etika, T. 2000. Kalus dan kandungan kurkumin kalus temulawak (*Curcuma xanthorrhiza* Roxb.) pada kadar sukrosa yang berbeda dalam medium MS. *Skripsi*. 45. Fakultas Biologi Universitas Gadjah Mada Jogjakarta.
- Evans, W.C. 1989. *Trease and Evans Pharmacognosy*. 13th Ed. Bailliere Tindall The Alden Press, Oxford, Great Britain. p. 206.
- Flick, C.E., Evans, D.A. dan Bravo, J.E. 1983. Organogenesis. Dalam: *Handbook of plant cell culture*. Vol. I. Eds. Evans, D.A. MacMillan Publishing Co. New York. p 13-81
- Fowler, M.W. 1983. Commercial application and economic aspects of mass plant cell culture. In: *Plant biotechnology*. Mantell, S.H. and Smith, H. (Eds). Cambridge Univ. Press. London. p.3-38
- Fujita, Y., Hara, Y., Suga, C. and Marimoto, T. 1981. Production of Shikonin derivates by cell suspension cultures of *Lithospermum erythrorhizon*. Effect of nitrogen sources on the production of shikonin derivates. *Plant Cell Reports*. 1. 59-60.
- George, E.F. and Sherington, P.D. 1984. *Plant Propagation by Tissue Culture, Handbook and Directory of Commercial Laboratories*. Exergetics Limited, London.
- Harborne, J.B. 1996. *Metode fitokimia. Penuntun cara modern menganalisis tumbuhan*. Penerjemah: Padmawinata, K. Penerbit ITB Bandung.
- Heinstein, P. F. 1985. Future approaches to the information of secondary natural products in plant cell suspension cultures. *J. Nat. Prod.* 48: 1-9.
- Hilton, M.G. and Wilson, P.D.G. 195. Growth and The Uptake of Sucrose and Mineral Ions by Transformed Root Cultures of *Datura stramonium*, *Datura candida x aurea*, *Datura wrightii*, *Hyoscyamus muticus* and *Atropa belladonna*. *Planta Medica* 61 : 345-350.
- Kurata, H., Seki, M., Furusaki, S. 1994. Light effect to promote secondary metabolite production of plant cell culture. Dalam: *Advances in plant biotechnology*. Eds. Ryu, D.D. Y. dan Furusaki, S. Elseiver. Amsterdam. New York. London. Tokyo. P. 103-151.
- Ohlsson, A.B., Bjork, L. dan Gatenbeck, S. 1983. Effect of light on cardenolide production by *Digitalis lanata* tissue cultures. *Phytochemistry* 22: 2447-2450.

- Oksman-Caldentey, K.M., Sevon, N., Vanhala, L., dan Hiltunen, R. 1994. Effect of nitrogen and sucrose on primary and secondary metabolism of transformed root cultures of *Hyoscyamus muticus*. *Plant Cell, Tissue and Organ Culture*. 38: 263-272.
- Polard, J.W. and John, M.W. 1990. *Plant Cell and Tissue Culture, Methods in Molecular Biology* 6. Humana Press Clifton, New Jersey.
- Pramono, S., Gunawan, D. Dan Soegihardjo, C.J. Editor 1987. *Risalah Seminar Nasional Metabolit Sekunder*. PAU Biotek UGM.
- Prihastanti, E. 1998. Kultur suspensi sel mesofil daun pegagan (*Centella asiatica* (I) dan analisis kualitatif senyawa asiakotida. *Tesis*.40. Program Pascasarjana Program Studi Ilmu Biologi, Universitas Gadjah Mada Jogjakarta.
- Robinson, T. 1991. *Kandungan organik tumbuhan tinggi*. Penerjemah: Padmawinata, K. Penerbit ITB. Bandung.
- Rokem, J. S., Tal, B. dan Goldberg, I. 1985. Methods for increasing diosgenin production by *Dioscorea* cells in suspension cultures. *J. Nat. Prod.* 48: 210-222.
- Sahai, O. P. dan Shuler, M.L. 1984. Environmental parameters influencing phenolics production by batch cultures of *Nicotiana tabacum*. *Biotech. Bioeng.* 26: 111-120.
- Salisbury, F.B. dan Ross, C. W. 1992. *Plant Physiology*. Wadsworth Publishing Company. California.
- Samuelsson, G. 1999. *Drugs of Natural Origin. A textbook of Pharmacognosy*. 4th revised edition. Swedish Pharmaceutical Society, Swedish Pharmaceutical Press. Stockholm, Sweden.
- Schripsema, J. 1991. Factors involved in the alkaloid production of *Tabernaemontana divaricata* plant cell suspension cultures. *Dissertation*. Rijks Universiteit, Leiden. The Netherland.
- Sikuli. N.N. and Demeyer, K. 1997. Influence of The Medium on Alkaloid Production by hairy Roots of *Datura stramonium*. *Plant Cell, Tissue and Organ Culture* 47 : 261-267
- Simola, L. K. dan Neiminen, S. 1988. Tropane alkaloids from *Atropa belladonna*. Part II. Interaction of origin, age, and environment in alkaloid production of callus cultures. *J. Nat. Prod.* 51: 234-242

- Sumardi, I. 2001. Teknik kultur jaringan sebagai alat untuk penemuan produk alam sebagai obat baru. *Makalah*. Seminar sehari peranan produk alam dalam penemuan obat baru. Fakultas Farmasi Universitas Gadjah Mada. Jogjakarta.
- Taiz, L. and Zeiger, E. 1998. *Plant Physiology*. Second edition. Sinauer Associates Inc. Publisher. Massachusetts.
- Tyler, V.E., Brady, L.R. and Robbers, J.E. 1988. *Pharmacognosy*. Ninth edition. Lea & Febiger, Philadelphia.
- Yeoman, M.M. dan MacLeod, A.J. 1977. Tissue (callus) culture technique, dalam *Plant tissue and cell culture*. Ed. Street, H.E. Blackwell Scientific Publications. Oxford. London. Edinburgh. Melbourne. P31-59
- Yun, D.J., Hashimoto, T., and Yamada, Y. 1992. Metabolic Engineering of Medical Plants: Transgenic *Atropa Belladonna* With An Improved Alkaloid Composition. *Proc. Natl. Acad. Sci. USA Dec. 15; 89 (24) : 11799-11803*.

Lampiran 1. Komposisi media Murashige-Skoog (MS)

A. Elemen Makro	Mg/l
NH ₄ NO ₃	1650
KNO ₃	1900
CaCl ₂ .2H ₂ O	440
MgSO ₄ .7H ₂ O	370
KH ₂ PO ₄	170

B. Elemen Besi