REFERENCES

Ahn, J., Jung, J., Hyung, W., Haam, S., and Shin, C. 2006. Enhancement of *Monascus* Pigment Production by the Culture of *Monascus* sp. J101 at Low Temperature. Biotechnol. Prog. 22: 338-340.

Alberts, A. W. 1988. Discovery, Biochemistry and Biology of lovastatin. *The American Journal of Cardiology*. 62: 10J-15J.

Alberts, A.W., Chen, J., Kuron, G., Hunt, V., Huff, J., Hoffman, C., Rothrock, J., Lopez, M., Joshua, H., Herris, E., Patchett, A., Monaghan, R., Currie, S., Stapley, E., Alber-Schonberg, G., Hensens, O., Hirshfield, J., Hoogsteen, K., Liesch, J., and Springer, J. 1980. Mevinolin: A highly potent competitive inhibitor of hydroxymethylglutaryl-coenzyme A reductase and a cholesterol-lowering agent. *Proceeding of the National Academy of Sciences*. 77(7): 3957-3961.

Aniya, Y., Ohtani, I. I., Higa, T., Miyagi, C., Gibo, H., Shimabukuro, M., Nakanishi, H., and Taira, J. 2000. Dimerumic acid as an antioxidant of the mold, *Monascus anka*. *Free Radical Biology & Medicine*. 6: 999–1004.

Blanc, P.J., Laussac, J.P., Bars, J.L., Bars, P.L., Loret, M.O., Pareilleux, A., Prome, D., Prome, J.C., Santerre, A.L., and Goma, G. 1995. Characterization of monascidin A from *Monascus* as Citrinin. International Journal of Food Microbiology. 27: 201-213.

Carels, M. and Shepherd, D. 1975. Sexual Reproductive Cycle of Monascus in Submerged Shaken Culture. Journal of Bacteriology. 122(1): 288-294.

Carvalho, J.C., Pandey, A., Oishi, B. O., Brand, D., Rodriguez-L´eon, J. A., and Soccol, C. R. 2006. Relation between growth, respirometric analysis and biopigments production from *Monascus* by solid-state fermentation. Biochemical Engineering Journal. 29: 262–269.

Chang, Y.,Huang, J., Lee, C., Shih, I., and Tzeng, Y. 2002. Use of response surface methodology to optimize culture medium for production of lovastatin by *Monascus rubber*. *Enzyme and Microbial Technology*. 30: 889–894.

Chung, C., Chen, H., and Hsieh, P. 2007. Application of the taguchi method to optimize *Monascus* spp. culture. Journal of Food Process Engineering. 30: 241-254.

Chen, F., and Hu, X. 2005. Study on red fermented rice with high concentration of monacolin K and low concentration of citrinin. *International Journal of Food Microbiology*. 103: 331– 337.

Cicero, A.F.G., Brancaleoni, M., Laghi, L., Donati, F., and Mino, M. (2005). Antihyperlipidaemic effect of a *Monascus purpureus* brand dietary supplement on a large sample of subjects at low risk for cardiovasculardisease: A pilot study. *Complementary Therapies in Medicine*. 13: 273-278.

Comerio, R., Pinto, V., Vaamonde, G. 1998. Influence of water activity on *Penicillium citrinum* growth and kinetics of citrinin accumulation in wheat. International Journal of Food Microbiology. 42: 219–223.

Damoglou, A.P., Downey, G.A., Shannon, W., 1984. The production of ochratoxin and citrinin in barley. *J. Sci. Food Agric*.35: 395–400.

Dhale, M.A., Divakar, S., Kumar, S. U., and Vijayalakshmi, G. 2007. Isolation and

Characterization of dihydromonacolin-MV from *Monascus purpureus* for antioxidant properties. *Appl Microbiol Biotechnol*. 73: 1197–1202.

Endo, A. 1979. Monacolin K, a new hypocholesterolemic agent produced by a *Monascus* species. *The journal of antibiotics*. 32(8): 852-854.

Endo, A. 1980. Monacolin K, a new hypocholesterolemic agent that specifically inhibits 3-hydroxy-3-methylglutaryl coenzyme A reductase. *The journal of antibiotics*. 33(3): 334-336.

Endo, A. 1985. Compactin (ML-236B) and related compounds as potential cholesterol lowering agents that inhibit HMG-CoA reductase. *Journal of medicinal chemistry*. 28(4): 401-405.

Endo, A. 1988. Chemistry, Biochemistry, and Pharmacology of HMG-CoA Reductase Inhibitors. *Klin Wochenschr*. 66: 421-427.

Endo, A and Hasumi, K. 1985. Dihydromonacolin L and monacolin X, new metabolites those inhibit cholesterol biosynthesis. *The journal of antibiotics*. 38(3): 321-327.

Endo, A., Hasumi, K., and Negishi, S. 1985. Monacolins J and L, new inhibitors of cholesterol biosynthesis produced by *Monascus ruber*. *The journal of antibiotics*. 38(3): 420-422.

Endo, A.; Kuroda, M.; and Tanzawa, K. 1976. Competitive inhibitor of 3-hydroxy-3-methylglutaryl coenzyme A reductase by ML-236A and ML-236B fungal metabolites, having hypocholesterolemic activity. *FEBS letters*. 72(2): 323-326.

Endo, A., Negishi, Y., Iwashita, T., Mizukawa, K., and Hirama, M. 1985. Biosynthesis

of ML-236B (compactin) and monacolin K. *The journal of antibiotics*. 38(3): 444-448.

Gheith, O., Sheashaa, H., Abdelsalam, M., Shoeir, Z., and Sobh, M. 2008. Efficacy and safety of *Monascus purpureus* Went rice in subjects with secondary hyperlipidemia. *Clin Exp Nephrol*. 12:189–194.

Hajjaj, H., Klaebe, A., Loret, M., Goma, G., Blance, P., and Franc, J. 1999. Biosynthetic Pathway of Citrinin in the Filamentous Fungus *Monascus ruber* as Revealed by 13C Nuclear Magnetic Resonance. Applied and environmental microbiology. 65(1): 311–314

Hawksworth, D.L. and Pitt, J.T. 1983. A new taxonomy for *Monascus* species based on cultural and Microscopical characters. *Australian Journal of Botany*. 31: 51-56.

Heber, D., Lembertas, A., Lu, Q., Bowerman, S., and Go, V.L.W. 2001. An analysis of nine proprietary Chinese red yeast rice dietary supplements: implications of variability in chemical profile and contents. *The Journal of Alternative Complementary Medicine*. 7(2): 133-139.

Heber, D., Yip, I., and Ashley, J.M., 1999. Cholesterol-lowering effects of a proprietary Chinese red-yeast-rice dietary supplement. *Am J Clin Nutr*. 69(2): 231-236.

Journoud, M. and Jones, P.J.H. 2004. Red yeast rice: a new hypolipidemic drug. *Life Sciences*. 74: 2675–2683.

Juzlova, P., Martinkova, L., and Kren, V. 1996. Secondary metabolites of the fungus *Monascus:* a review. *Journal of Industrial Microbiology*. 16: 163-170.

Kane, J.P., and Malloy, M.J. 1990. Treatment of Hyperlipidemia. *Annual Review*

Med. 41: 471-482.

Lee, C., Tsai, T., Wang, J., and Pan, T. 2005. In vivo hypolipidemic effects and safety of low dosage *Monascus* powder in a hamster model of hyperlipidemia. *Applied Microbioloy and Biotechnology.*

Li, C., Zhu, Y., Wang, Y., Zhu, J., Chang, J., and Kritchevsky, D. 1998. *Monascus purpureus* – Fermented rice (red yeast rice): a natural food product that lowers blood cholesterol in animal models of hypercholesterolemia. *Nutrition Research.* 18(1): 71-81.

Li, Y., Liu, H., and Wang, Z. 2005. A validated stability-indicating HPLC with photodiode array detector(PDA) method for the stress tests of *Monascus purpureus* fermented rice, red yeast rice. *Journal of Pharmaceutical and Biomedical Analysis.* 39: 82–90.

Li, Y., Zhang, F., Wang, Z., and Hu, Z. 2004. Identification and chemical profiling of monacolins in red yeast rice using high-performance liquid chromatography with photodiode array detector and mass spectrometry. *Journal of Pharmaceutical and Biomedical Analysis.* 35: 1101–1112.

Liu, B., Wu, T., Su, M., Chung, C., and Yu, F. 2005. Evaluation of Citrinin Occurrence and Cytotoxicity in *Monascus* Fermentation Products. *J. Agric. Food Chem.* 53: 170-175.

Ma, J., Li, Y., Ye, Q., Li, J., Hua, Y., Ju, D., Zhang, D., Cooper, R., and Chang, M. 2000. Constituents of Red Yeast Rice, a Traditional Chinese Food and Medicine. *J. Agric. Food Chem.* 48:5220-5225.

Manzoni, M., and Rollini, M. 2002. Biosynthesis and biotechnology production of

statins by filamentous fungi and application of these cholesterol-lowering drugs. *Applied Microbiology and Biotechnology*. 58: 555-564.

Miyake, T., Mori, A., Kii, T., Okuno, T., Usui, Y., Sato, F., Sammoto, H., Watanabe, A., and Kariyama, M. 2005. Light effects on cell development and secondary metabolism in *Monascus*. *Journal of Industrial Microbiology and Biotechnology*. 32: 103–108.

Miyake, T., Uchitomi, K., Zhang, M., Kono, I., Nozaki, N., Sammoto, H., and Inagaki, K. 2006. Effects of the principal nutrients on lovastatin production by *Monascus pilosus*. *Biosci. Biotechnol. Biochem*. 70(5): 1154-1159.

Monica, S., Roel, F.M., Johanna, F.G. 1999. Mutagenicity of commercial *Monascus* fermentation products and the role of citrinin contamination. Mutat Res. 444:7–16.

Ng, C. and Shyu, Y. 2004. Development and production of cholesterol-lowering *Monascus*-nata complex. *World Journal of Microbiology & Biotechnology*. 20: 875–879.

Pattanagul, P. 2007. Effects of *Monascus* strains and their nutrients on the production of adlay angkak. Doctor of philosophy's thesis, Chiang Mai university, Chiang Mai, Thailand.

Sabater-Vilar, M., Maas R.F.M., Fink-Gremmels, J. 1999. Mutagenicity of commercial Monascus fermentation products and the role of citrinin contamination. *Mutation Research–Genetic Toxicology and Environmental Mutagenesis*. 444:7–16.

Sayyad, S., Panda, B., Javed, S., and Ali, M. 2007. Optimization of nutrient

parameters for lovastatin production by Monascus purpureus MTCC 369 under submerged fermentation using response surface methodology. *Appl Microbiol Biotechnol.* 73:1054–1058.

Su, Y., Wang, J., Lin, T., and Pan, T. 2003. Production of the secondary metabolites γ-aminobutyric acid and monacolin K by *Monascus*. *Journal of Industrial Microbiology and Biotechnology.* 30: 41–46.

Teng, S.S. and Feldheim, W. 1998. Analysis of Anka Pigments by Liquid Chromatography with Diode Array Detection and Tandem Mass Spectrometry. Chromatographia. 47(9): 529-536.

Taira, J., Miyagi, C., and Aniya, Y. 2002. Dimerumic acid as and antioxidant from the mold, *Monascus anka*: the inhibition mechanisms against lipid peroxidation. *Biochemical Pharmacology.* 63: 1019-1026.

Wang, J., Lee, C., and Pan, T. 2003. Improvement of monacolin K, γ - aminobutyric acid and citrinin production ratio as a function of environmental conditions of *Monascus purpureus* NTU 601. *Journal of Industrial Microbiology Biotechnology.* 30: 669–676.

Wang, J., Lee, C., and Pan, T. 2004. Modified Mutation Method for Screening Low Citrinin-Producing Strains of *Monascus purpureus on* Rice Culture. J. *Agric. Food Chem.* 52: 6977-6982.

Wang, J., Lu, Z., Chi, J., Wang, W., Su, M., Kou, W., Yu, P., Chen, L., Zhu, J., and Chang, J. 1997. Multicenter clinical trial of the serum lipid-lowering effect of *Monascus purpureus* (red yeast) rice preparation from traditional chinese medicine. *Current therapeutic research.* 58(12): 964-978.

Wang, S., Yen, Y., Tsiao, W., Chang, W., and Wang, C. 2002. Production of

antimicrobial compounds by *Monascus purpureus* CCRC31499 using shrimp and crab shell powder as a carbon source. *Enzyme and Microbial Technology*. 31: 337–344.

Wang, Y., Ju, X.,and Zhou, Y. 2005. The variability of citrinin production in *Monascus* type cultures. *Food Microbiology*. 22: 145–148.

Well, B.G. 2006. **Pharmacotherapy Handbook**. 6th edition. McGraw-Hill, USA, p.93-95.

Xu, B., Jia, X., Gu, L., and Sung, C. 2006. Review on the qualitative and quantitative analysis of the mycotoxin citrinin. *Food Control*. 17: 271–285.

Yang, S., Zhang, H., Li, Y., Qian, J., and Wang, W. 2005. The ultasonic effect on biological characteristics of *Monascus* sp. *Enzyme and Microbial Technology*. 37: 139–144.

Appendices

Appendix A

Spectra and chromatograms

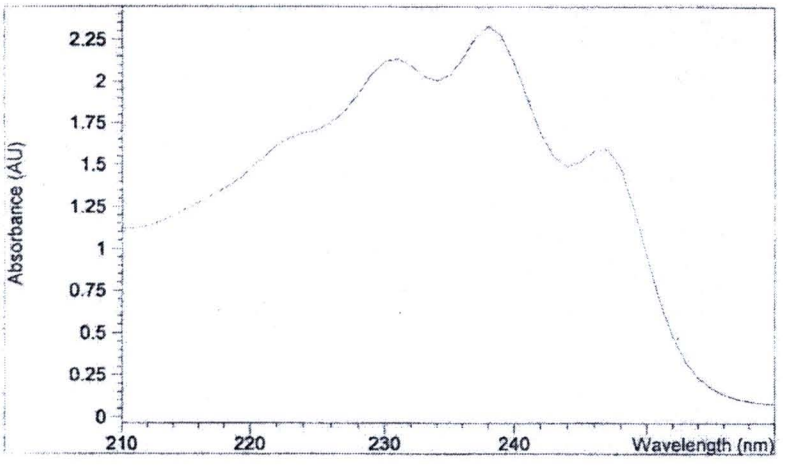

Fig A1 monacolin K UV spectrum

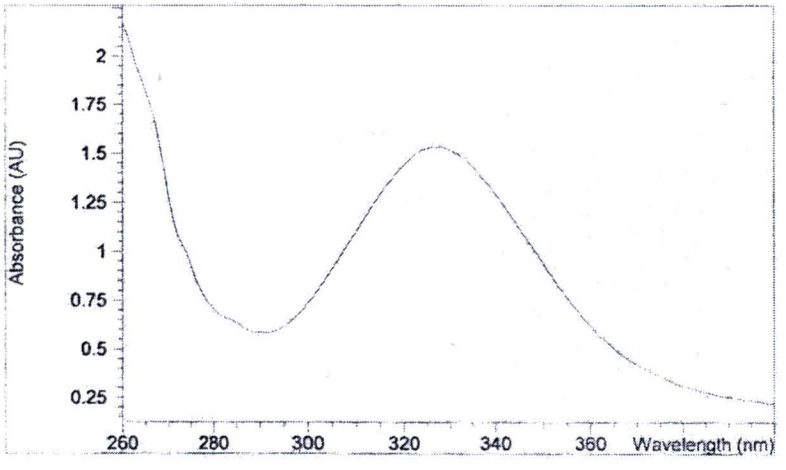

Fig A2 citrinin UV spectrum

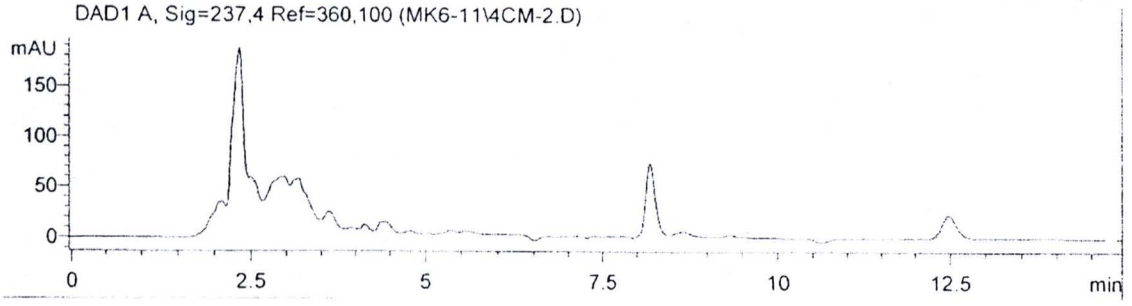

Fig A3 HPLC chromatogram of monacolin K in red fermented rice sample

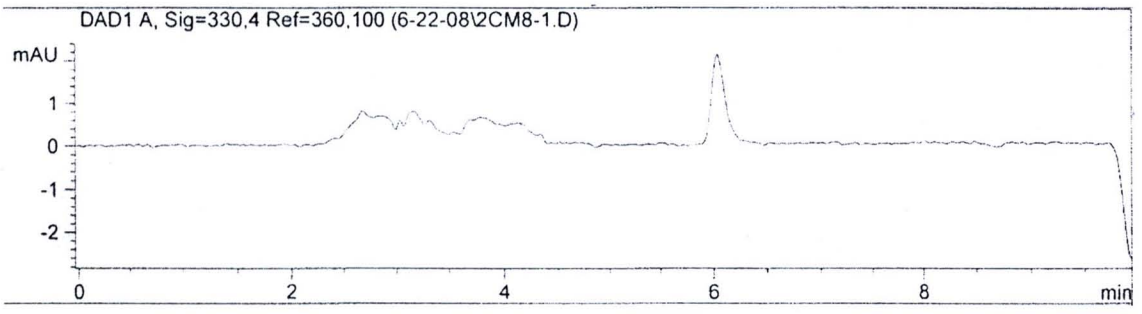

Fig A4 HPLC chromatogram of citrinin in red fermented rice sample

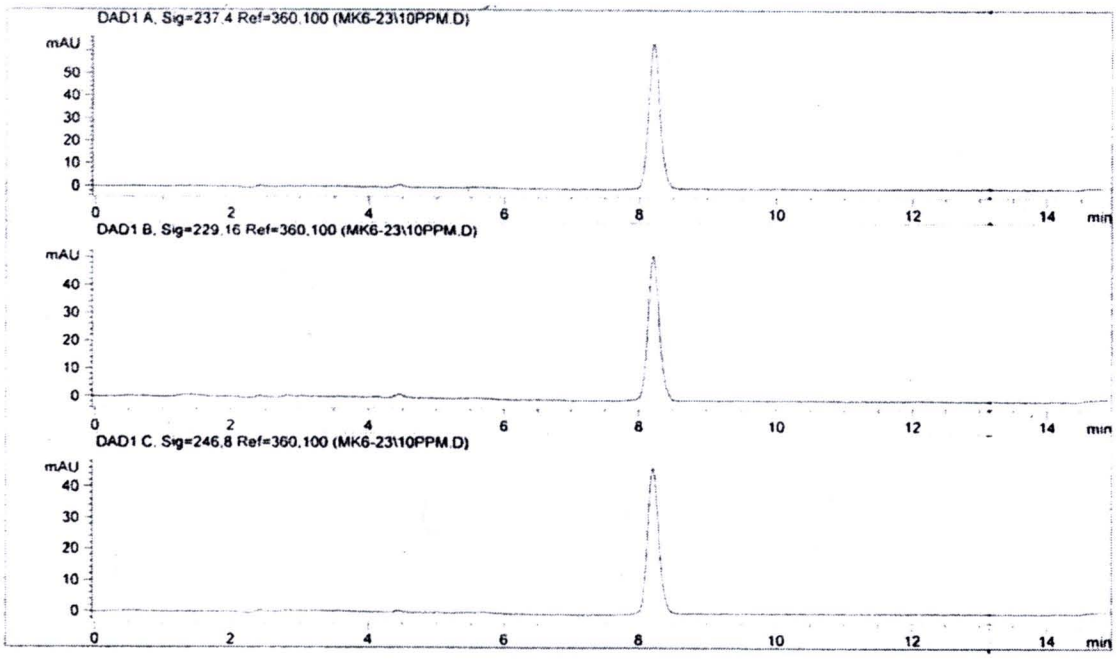

Fig 5A HPLC chromatogram of standard monacolin K

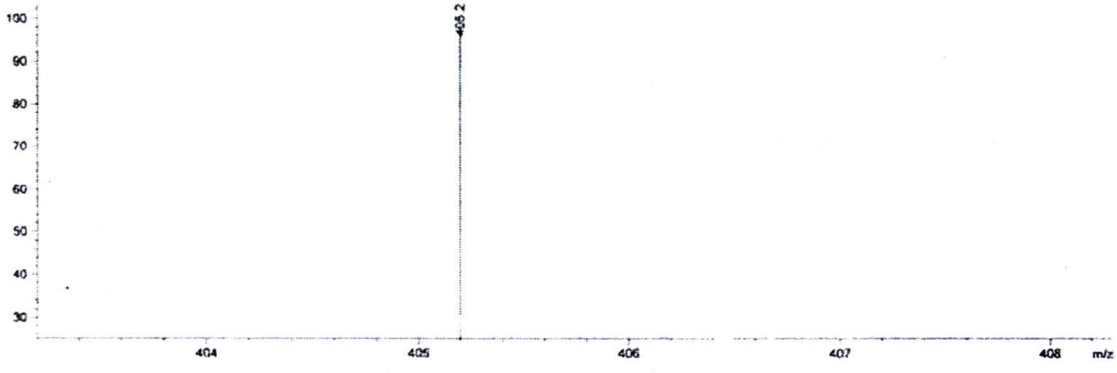

Fig A6 Mass spectrum of standard monacolin K

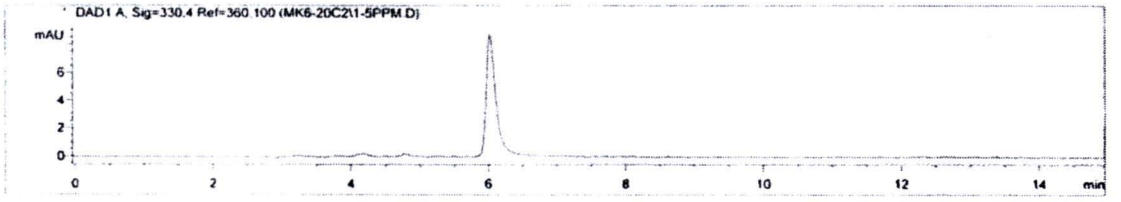

Fig A7 HPLC chromatogram of standard citrinin

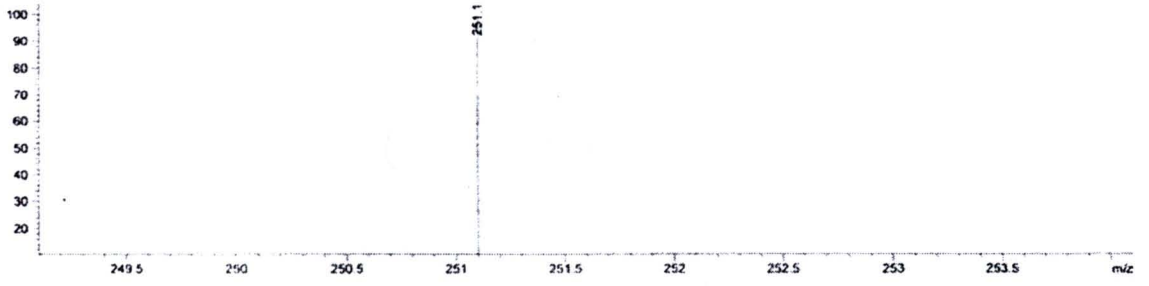

Fig A8 Mass spectrum of standard citrinin

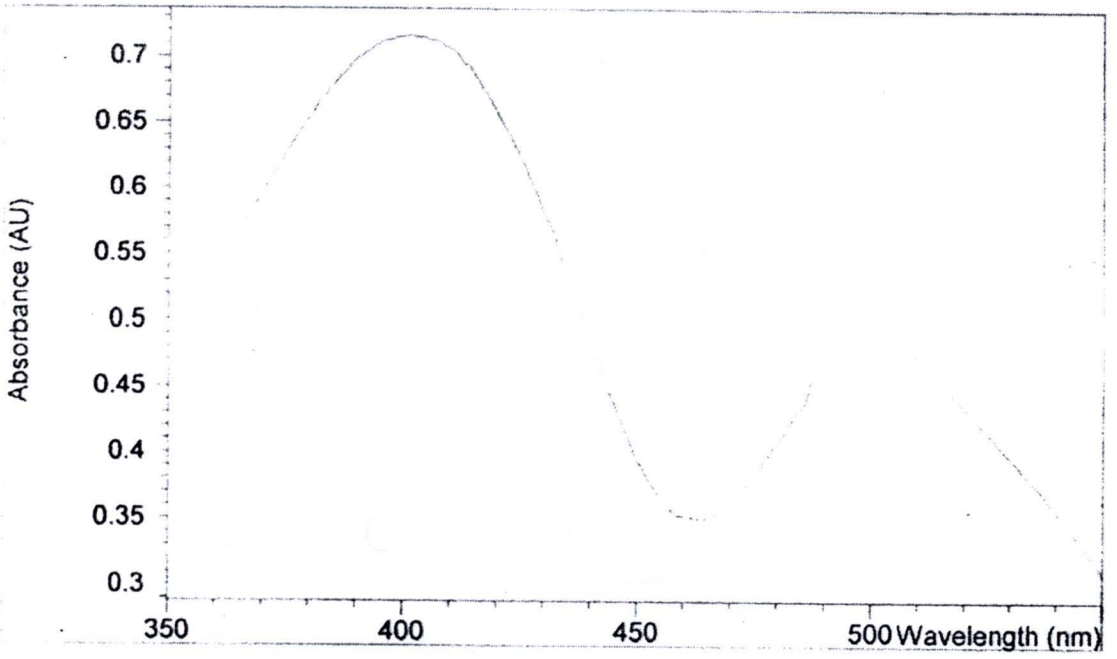

Fig A9 pigment visible spectrum

Appendix B

Monascus cultures

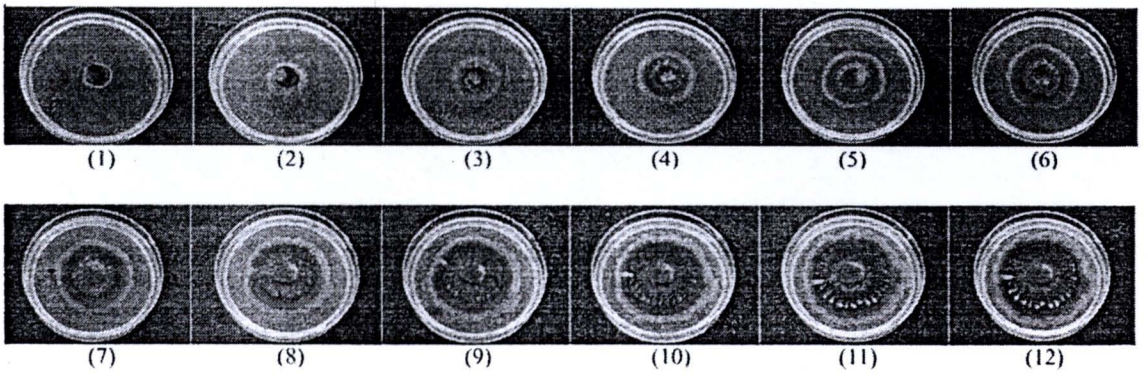

Fig B1 *Monascus purpureus* BCC 6131 culture on PDA from 1st to 12th day

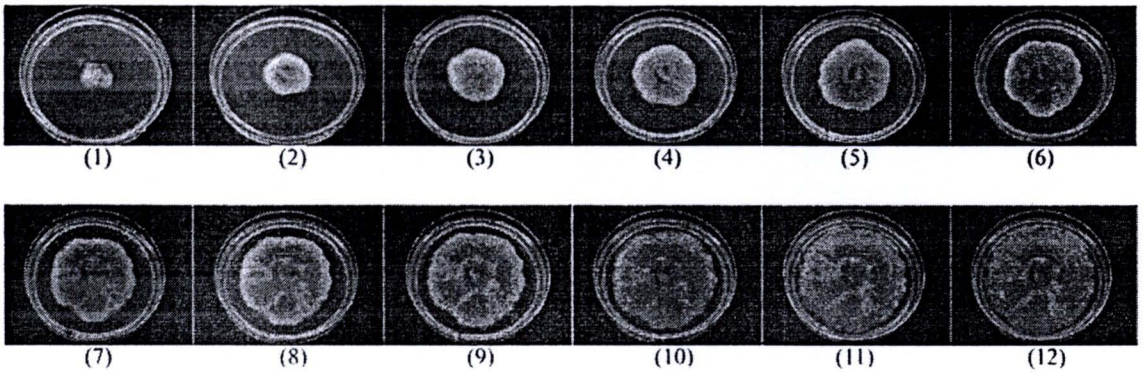

Fig B2 *Monascus. ruber* TISTR 3006 culture on PDA from 1st to 12th day

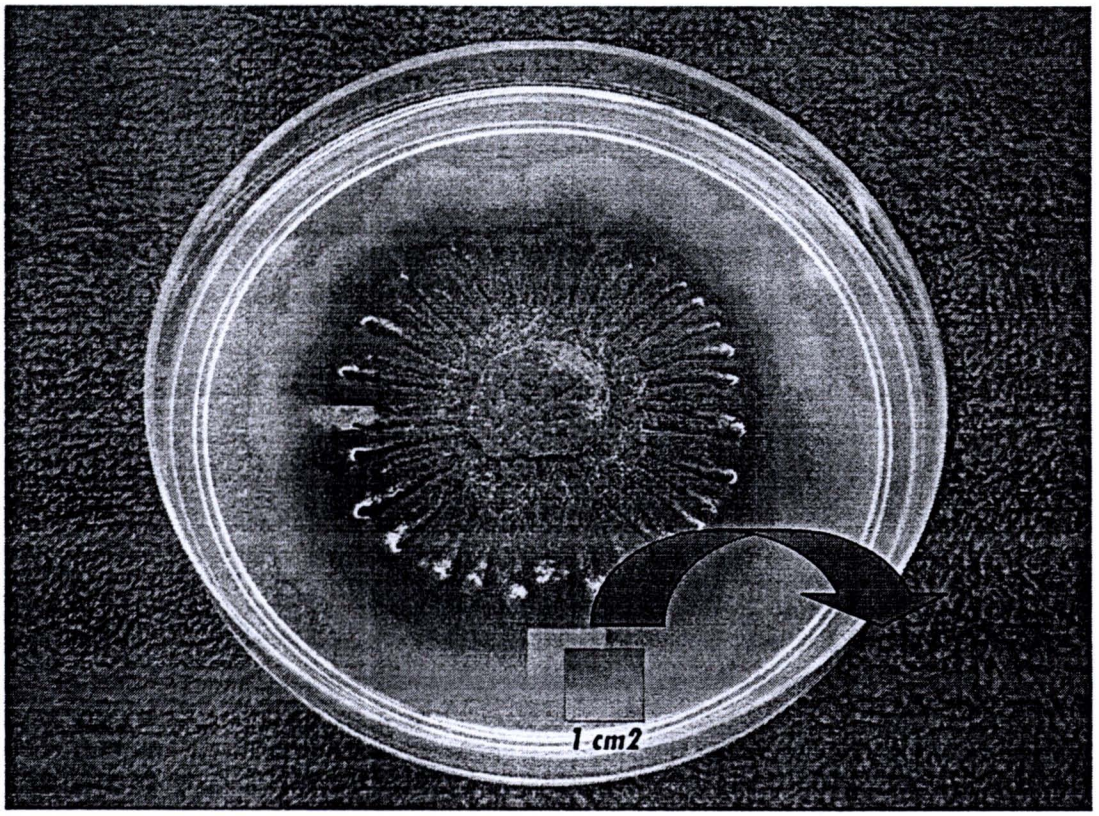

Fig B3 Cutting *Monascus* culture from PDA for inoculation

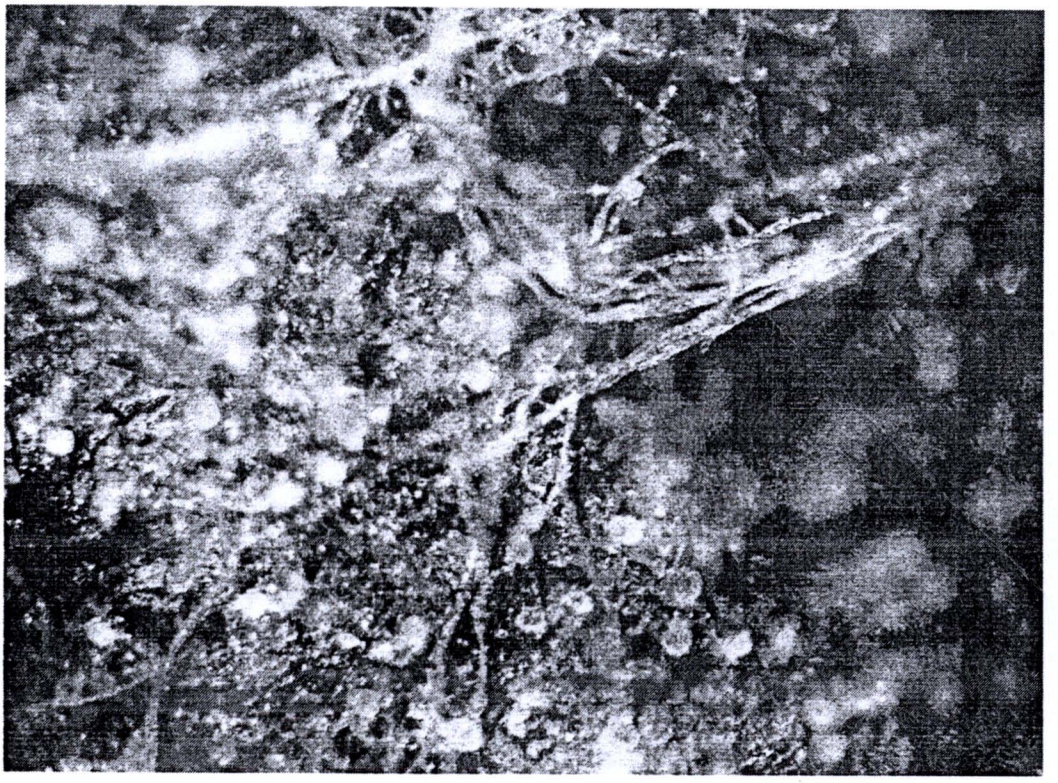

Fig B4 *Monascus* purpureus BCC 6131 fermented rice (x40)

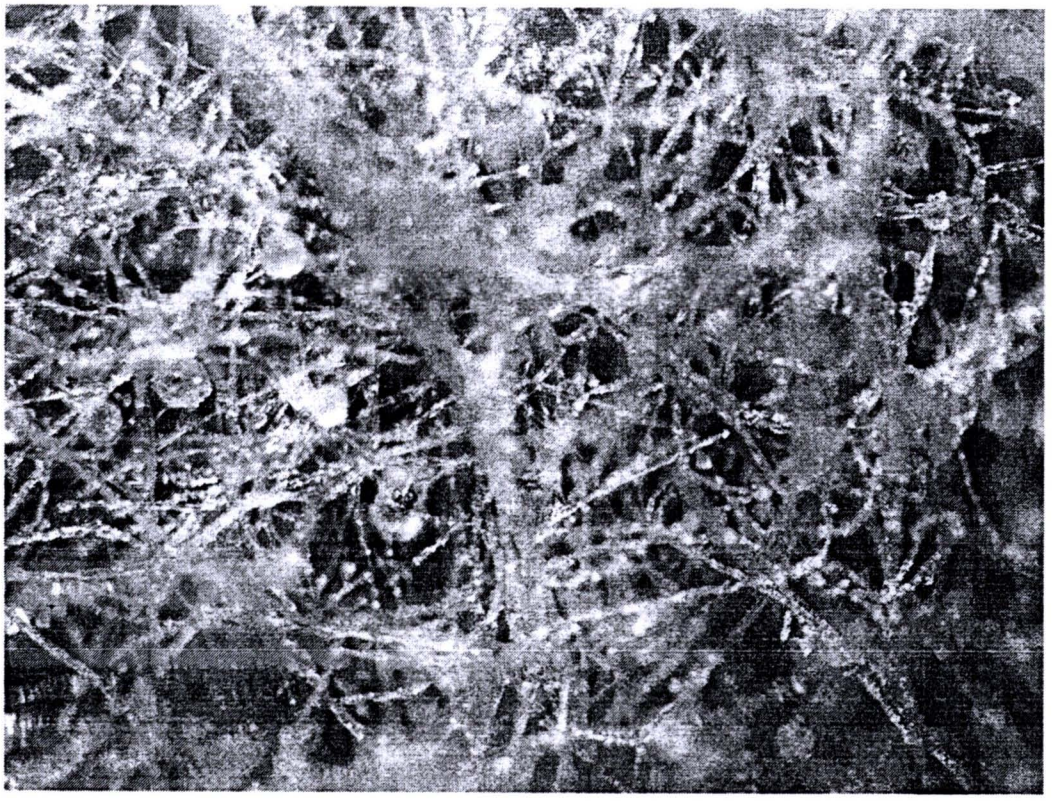

Fig B5 *Monascus. ruber* TISTR 3006 fermented rice (x40)

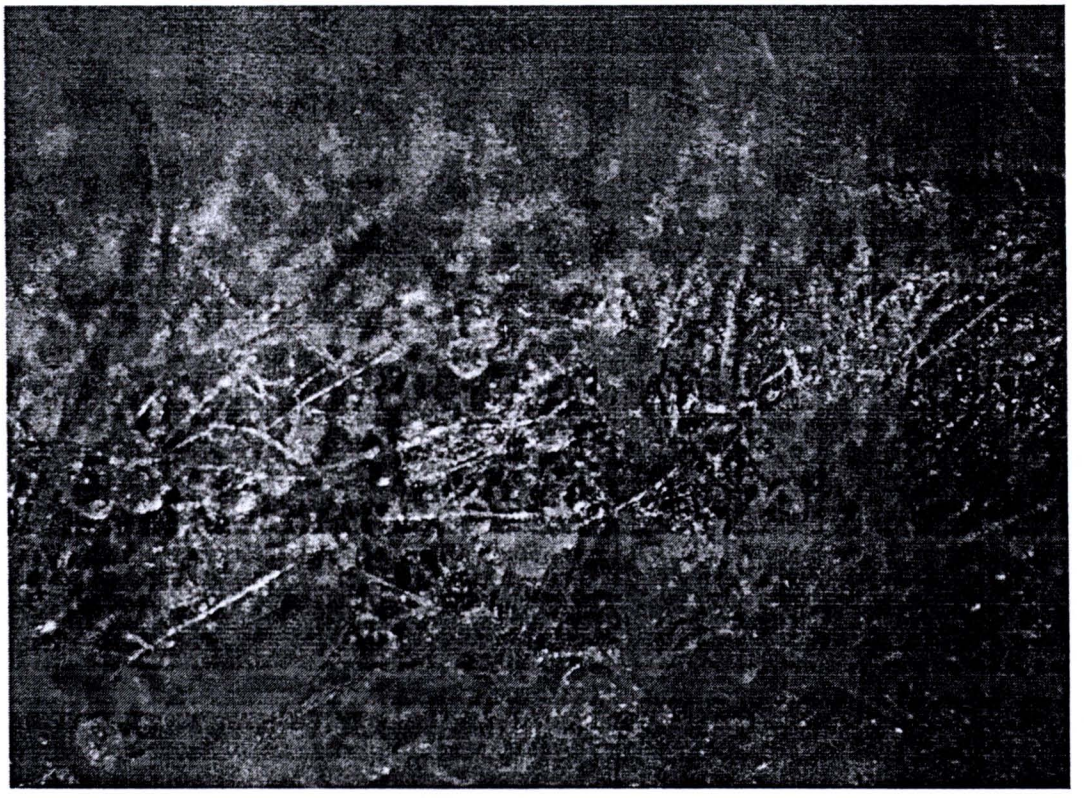

Fig B6 *Monascus* purpureus BCC 6131 on unpolished rice (x40)

Appendix C

Statistic analysis

Table C1 ANOVA table of monacolin K produced by *M. ruber* TISTR 3006 and *M. purpureus* BCC 6131 at 25°C or 30°C

Between-Subjects Factors

		N
days	.00	12
	3.00	12
	6.00	12
	9.00	12
	12.00	12
	15.00	12
	18.00	12
	21.00	12
	24.00	12
strains	purpureus 25 celsius	27
	purpureus 30 celsius	27
	ruber 25 celsius	27
	ruber 30 celsius	27

Levene's Test of Equality of Error Variances[a]

Dependent Variable: monacolinK

F	df1	df2	Sig.
2.358	35	72	.001

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+days+strains+days * strains

Tests of Between-Subjects Effects

Dependent Variable: monacolinK

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	88831.777[a]	35	2538.051	184.179	.000	.989
Intercept	67436.039	1	67436.039	4893.646	.000	.986
days	34356.879	8	4294.610	311.648	.000	.972
strains	29717.365	3	9905.788	718.836	.000	.968
days * strains	24757.534	24	1031.564	74.858	.000	.961
Error	992.183	72	13.780			
Total	157260.000	108				
Corrected Total	89823.960	107				

a. R Squared = .989 (Adjusted R Squared = .984)

monacolinK

	strains	N	Subset 1	Subset 2	Subset 3
Tukey HSD[a,b]	ruber 30 celsius	27	9.4273		
	ruber 25 celsius	27	9.5369		
	purpureus 25 celsius	27		32.1609	
	purpureus 30 celsius	27			48.8275
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 13.780.

a. Uses Harmonic Mean Sample Size = 27.000.

b. Alpha = .05.

Table C2 ANOVA table of monacolin K produced by *M. purpureus* BCC 6131 with different amount of water added

Between-Subjects Factors

		N
days	.00	12
	3.00	12
	6.00	12
	9.00	12
	12.00	12
	15.00	12
	18.00	12
	21.00	12
	24.00	12
moisture	15 ml water added	27
	20 ml water adeed	27
	25 ml water added	27
	30 ml water added	27

Levene's Test of Equality of Error Variances[a]

Dependent Variable: monacolinK

F	df1	df2	Sig.
1.976	35	72	.008

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+days+moisture+days * moisture

Tests of Between-Subjects Effects

Dependent Variable: monacolinK

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	633237.980[a]	35	18092.514	238.882	.000	.991
Intercept	688591.793	1	688591.793	9091.722	.000	.992
days	546000.425	8	68250.053	901.130	.000	.990
moisture	39983.424	3	13327.808	175.972	.000	.880
days * moisture	47254.131	24	1968.922	25.996	.000	.897
Error	5453.159	72	75.738			
Total	1327282.933	108				
Corrected Total	638691.140	107				

a. R Squared = .991 (Adjusted R Squared = .987)

monacolinK

	moisture	N	Subset 1	Subset 2	Subset 3
Tukey HSD[a,b]	30 ml water added	27	50.1726		
	15 ml water added	27		75.5947	
	25 ml water added	27			95.0196
	20 ml water adeed	27			98.6088
	Sig.		1.000	1.000	.434

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 75.738.

a. Uses Harmonic Mean Sample Size = 27.000.

b. Alpha = .05.

Table C3 ANOVA table of monacolin K produced by *M. purpureus* BCC 6131 with different rice substrates

Between-Subjects Factors

		N
days	.00	9
	3.00	9
	6.00	9
	9.00	9
	12.00	9
	15.00	9
	18.00	9
	21.00	9
	24.00	9
substrate	broken rice	27
	polished rice	27
	unoilished rice	27

Levene's Test of Equality of Error Variances[a]

Dependent Variable: monacolinK

F	df1	df2	Sig.
2.243	26	54	.006

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+days+substrate+days * substrate

Tests of Between-Subjects Effects

Dependent Variable: monacolinK

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	432917.025[a]	26	16650.655	256.657	.000	.992
Intercept	376295.952	1	376295.952	5800.315	.000	.991
days	337472.505	8	42184.063	650.235	.000	.990
substrate	51093.608	2	25546.804	393.784	.000	.936
days * substrate	44350.912	16	2771.932	42.727	.000	.927
Error	3503.255	54	64.875			
Total	812716.232	81				
Corrected Total	436420.280	80				

a. R Squared = .992 (Adjusted R Squared = .988)

monacolinK

	substrate	N	Subset 1	Subset 2	Subset 3
Tukey HSD[a,b]	unoilished rice	27	33.4308		
	broken rice	27		79.0692	
	polished rice	27			91.9766
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 64.875.

a. Uses Harmonic Mean Sample Size = 27.000.

b. Alpha = .05.

Table C4 ANOVA table of monacolin K produced by *M. purpureus* BCC 6131 with different inoculum sizes

Between-Subjects Factors

		N
days	.00	15
	3.00	15
	6.00	15
	9.00	15
	12.00	15
	15.00	15
	18.00	15
	21.00	15
	24.00	15
inoculum	1 sq.cm	27
	2 sq.cm.	27
	3 sq.cm.	27
	4 sq.cm.	27
	5 sq.cm.	27

Levene's Test of Equality of Error Variances[a]

Dependent Variable: monacolinK

F	df1	df2	Sig.
1.923	44	90	.005

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+days+inoculum+days * inoculum

Tests of Between-Subjects Effects

Dependent Variable: monacolinK

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1658942.312[a]	44	37703.234	270.247	.000	.992
Intercept	1852736.048	1	1852736.048	13279.909	.000	.993
days	1523628.716	8	190453.590	1365.120	.000	.992
inoculum	78647.081	4	19661.770	140.930	.000	.862
days * inoculum	56666.515	32	1770.829	12.693	.000	.819
Error	12556.279	90	139.514			
Total	3524234.639	135				
Corrected Total	1671498.591	134				

a. R Squared = .992 (Adjusted R Squared = .989)

monacolinK

	inoculum	N	Subset 1	Subset 2	Subset 3	Subset 4
Tukey HSD[a,b]	1 sq.cm	27	91.4519			
	2 sq.cm.	27	96.4844			
	3 sq.cm.	27		108.6319		
	5 sq.cm.	27			133.4759	
	4 sq.cm.	27				155.7026
	Sig.		.523	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 139.514.

a. Uses Harmonic Mean Sample Size = 27.000.

b. Alpha = .05.

Table C5 ANOVA table of citrinin produced by *M. ruber* TISTR 3006 and *M. purpureus* BCC 6131 at 25°C or 30°C

Between-Subjects Factors

		N
days	.00	12
	3.00	12
	6.00	12
	9.00	12
	12.00	12
	15.00	12
	18.00	12
	21.00	12
	24.00	12
strains	purpureus 25celsius	27
	purpureus 30celsius	27
	ruber 25celsius	27
	ruber 30celsius	27

Levene's Test of Equality of Error Variances[a]

Dependent Variable: citrinin

F	df1	df2	Sig.
2.606	35	72	.000

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+days+strains+days * strains

Tests of Between-Subjects Effects

Dependent Variable: citrinin

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	59.735[a]	35	1.707	323.352	.000	.994
Intercept	38.635	1	38.635	7319.717	.000	.990
days	24.531	8	3.066	580.962	.000	.985
strains	21.937	3	7.312	1385.395	.000	.983
days * strains	13.266	24	.553	104.726	.000	.972
Error	.380	72	.005			
Total	98.750	108				
Corrected Total	60.115	107				

a. R Squared = .994 (Adjusted R Squared = .991)

citrinin

	strains	N	Subset 1	Subset 2	Subset 3
Tukey HSD[a,b]	purpureus 25celsius	27	.1469		
	purpureus 30celsius	27	.1693		
	ruber 25celsius	27		.9007	
	ruber 30celsius	27			1.1756
	Sig.		.669	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = .005.

a. Uses Harmonic Mean Sample Size = 27.000.

b. Alpha = .05.

Table C6ANOVA table of citrinin produced by *M. purpureus* BCC 6131 with different amount of water added

Between-Subjects Factors

		N
days	.00	12
	3.00	12
	6.00	12
	9.00	12
	12.00	12
	15.00	12
	18.00	12
	21.00	12
	24.00	12
moisture	15 ml water added	27
	20 ml water added	27
	25 ml water added	27
	30 ml water added	27

Levene's Test of Equality of Error Variances[a]

Dependent Variable: citrinin

F	df1	df2	Sig.
2.442	35	72	.001

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+days+moisture+days * moisture

Tests of Between-Subjects Effects

Dependent Variable: citrinin

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2.304[a]	35	.066	327.307	.000	.994
Intercept	2.411	1	2.411	11985.635	.000	.994
days	2.162	8	.270	1343.710	.000	.993
moisture	.079	3	.026	131.457	.000	.846
days * moisture	.063	24	.003	12.986	.000	.812
Error	.014	72	.000			
Total	4.729	108				
Corrected Total	2.319	107				

a. R Squared = .994 (Adjusted R Squared = .991)

citrinin

	moisture	N	Subset 1	2	3	4
Tukey HSD[a,b]	15 ml water added	27	.1124			
	20 ml water added	27		.1371		
	25 ml water added	27			.1639	
	30 ml water added	27				.1842
	Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = .000.

a. Uses Harmonic Mean Sample Size = 27.000.

b. Alpha = .05.

Table C7 ANOVA table of citrinin produced by *M. purpureus* BCC 6131 with different rice substrates

Between-Subjects Factors

		N
days	.00	9
	3.00	9
	6.00	9
	9.00	9
	12.00	9
	15.00	9
	18.00	9
	21.00	9
	24.00	9
substrate	broken rice	27
	polished rice	27
	unpolished rice	27

Levene's Test of Equality of Error Variances[a]

Dependent Variable: citrinin

F	df1	df2	Sig.
2.291	26	54	.005

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+days+substrate+days * substrate

Tests of Between-Subjects Effects

Dependent Variable: citrinin

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1.427[a]	26	.055	314.897	.000	.993
Intercept	1.339	1	1.339	7680.961	.000	.993
days	1.336	8	.167	958.196	.000	.993
substrate	.047	2	.023	133.564	.000	.832
days * substrate	.044	16	.003	15.914	.000	.825
Error	.009	54	.000			
Total	2.776	81				
Corrected Total	1.437	80				

a. R Squared = .993 (Adjusted R Squared = .990)

citrinin

	substrate	N	Subset 1	Subset 2	Subset 3
Tukey HSD[a,b]	unpolished rice	27	.0952		
	broken rice	27		.1399	
	polished rice	27			.1506
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = .000.

a. Uses Harmonic Mean Sample Size = 27.000.

b. Alpha = .05.

Table C8 ANOVA table of citrinin produced by *M. purpureus* BCC 6131 with different inoculum sizes

Between-Subjects Factors

		N
days	.00	15
	3.00	15
	6.00	15
	9.00	15
	12.00	15
	15.00	15
	18.00	15
	21.00	15
	24.00	15
inoculum	1 sq.cm	27
	2 sq.cm.	27
	3 sq.cm.	27
	4 sq.cm.	27
	5 sq.cm.	27

Levene's Test of Equality of Error Variances[a]

Dependent Variable: citrinin

F	df1	df2	Sig.
1.871	44	90	.006

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+days+inoculum+days * inoculum

Tests of Between-Subjects Effects

Dependent Variable: citrinin

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3.266[a]	44	.074	280.682	.000	.993
Intercept	3.751	1	3.751	14185.386	.000	.994
days	3.161	8	.395	1494.154	.000	.993
inoculum	.048	4	.012	45.243	.000	.668
days * inoculum	.057	32	.002	6.744	.000	.706
Error	.024	90	.000			
Total	7.041	135				
Corrected Total	3.290	134				

a. R Squared = .993 (Adjusted R Squared = .989)

citrinin

	inoculum	N	Subset 1	Subset 2	Subset 3
Tukey HSD[a,b]	1 sq.cm	27	.1410		
	2 sq.cm.	27	.1503		
	3 sq.cm.	27		.1711	
	4 sq.cm.	27		.1778	
	5 sq.cm.	27			.1932
	Sig.		.229	.559	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = .000.

a. Uses Harmonic Mean Sample Size = 27.000.

b. Alpha = .05.

Table C9 ANOVA table of monacolin K produced by *M. ruber* TISTR 3006 and *M. purpureus* BCC 6131 at 25°C or 30°C on 18th day of cultivation

Between-Subjects Factors

		N
strains	purpureus 25 celsius	3
	purpureus 30 celsius	3
	ruber 25 celsius	3
	ruber 30 celsius	3

Levene's Test of Equality of Error Variances[a]

Dependent Variable: monacolinK

F	df1	df2	Sig.
1.956	3	8	.199

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+strains

Tests of Between-Subjects Effects

Dependent Variable: monacolinK

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	19831.908[a]	3	6610.636	313.438	.000	.992
Intercept	25085.787	1	25085.787	1189.423	.000	.993
strains	19831.908	3	6610.636	313.438	.000	.992
Error	168.726	8	21.091			
Total	45086.421	12				
Corrected Total	20000.634	11				

a. R Squared = .992 (Adjusted R Squared = .988)

monacolinK

	strains	N	Subset 1	Subset 2	Subset 3
Tukey HSD[a,b]	ruber 25 celsius	3	9.5824		
	ruber 30 celsius	3	11.7390		
	purpureus 25 celsius	3		51.7038	
	purpureus 30 celsius	3			109.8620
	Sig.		.937	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 21.091.

a. Uses Harmonic Mean Sample Size = 3.000.

b. Alpha = .05.

Table C10 ANOVA table of monacolin K produced by *M. purpureus* BCC 6131 on the

18^{th} day of cultivation with different amount of water added

Between-Subjects Factors

		N
moisture	15 ml water added	3
	20 ml water added	3
	25 ml water added	3
	30 ml water added	3

Levene's Test of Equality of Error Variances[a]

Dependent Variable: monacolinK

F	df1	df2	Sig.
.107	3	8	.954

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+moisture

Tests of Between-Subjects Effects

Dependent Variable: monacolinK

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	28913.587[a]	3	9637.862	55.976	.000	.955
Intercept	441986.079	1	441986.079	2567.041	.000	.997
moisture	28913.587	3	9637.862	55.976	.000	.955
Error	1377.418	8	172.177			
Total	472277.084	12				
Corrected Total	30291.005	11				

a. R Squared = .955 (Adjusted R Squared = .937)

monacolinK

	moisture	N	Subset 1	Subset 2	Subset 3	Subset 4
Tukey HSD[a,b]	30 ml water added	3	119.6570			
	15 ml water added	3		178.9380		
	25 ml water added	3			217.0007	
	20 ml water added	3				252.0727
	Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 172.177.

a. Uses Harmonic Mean Sample Size = 3.000.

b. Alpha = .05.

Table C11 ANOVA table of monacolin K produced by *M. purpureus* BCC 6131 on the 18th day of cultivation with different rice substrates

Between-Subjects Factors

		N
substrate	broken rice	3
	polished rice	3
	unpolished rice	3

Levene's Test of Equality of Error Variances[a]

Dependent Variable: monacolinK

F	df1	df2	Sig.
.487	2	6	.637

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+substrate

Tests of Between-Subjects Effects

Dependent Variable: monacolinK

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	37817.674[a]	2	18908.837	129.099	.000	.977
Intercept	248065.025	1	248065.025	1693.650	.000	.996
substrate	37817.674	2	18908.837	129.099	.000	.977
Error	878.806	6	146.468			
Total	286761.505	9				
Corrected Total	38696.480	8				

a. R Squared = .977 (Adjusted R Squared = .970)

monacolinK

	substrate	N	Subset 1	Subset 2
Tukey HSD[a,b]	unpolished rice	3	75.0050	
	broken rice	3		202.0368
	polished rice	3		221.0195
	Sig.		1.000	.213

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 146.468.

a. Uses Harmonic Mean Sample Size = 3.000.

b. Alpha = .05.

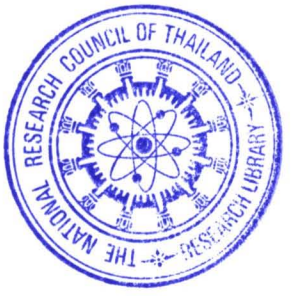

Table C12 ANOVA table of monacolin K produced by *M. purpureus* BCC 6131 on the 18th day of cultivation with different inoculum sizes

Between-Subjects Factors

		N
inoculum	1 sq.cm.	3
	2 sq.cm	3
	3 sq.cm	3
	4 sq.cm	3
	5 sq.cm	3

Levene's Test of Equality of Error Variances(a)

Dependent Variable: monacolinK

F	df1	df2	Sig.
.146	4	10	.961

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a Design: Intercept+inoculum

Tests of Between-Subjects Effects

Dependent Variable: monacolinK

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	28633.139[a]	4	7158.285	16.976	.000	.872
Intercept	1143120.423	1	1143120.423	2710.942	.000	.996
inoculum	28633.139	4	7158.285	16.976	.000	.872
Error	4216.691	10	421.669			
Total	1175970.252	15				
Corrected Total	32849.829	14				

a. R Squared = .872 (Adjusted R Squared = .820)

monacolinK

	inoculum	N	Subset 1	Subset 2
Tukey HSD[a,b]	1 sq.cm.	3	227.9875	
	2 sq.cm	3	238.5571	
	3 sq.cm	3	280.3747	
	5 sq.cm	3	281.2772	
	4 sq.cm	3		352.0936
	Sig.		.060	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 421.669.

a. Uses Harmonic Mean Sample Size = 3.000.

b. Alpha = .05.

Table C13 ANOVA table of citrinin produced by *M. ruber* TISTR 3006 and *M. purpureus* BCC 6131 at 25°C or 30°C on 18th day of cultivation

Between-Subjects Factors

		N
strains	purpureus at 25celsius	3
	purpureus at 30celsius	3
	ruber at 25celsius	3
	ruber at 30celsius	3

Levene's Test of Equality of Error Variances[a]

Dependent Variable: citrinin

F	df1	df2	Sig.
1.389	3	8	.315

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+strains

Tests of Between-Subjects Effects

Dependent Variable: citrinin

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7.554[a]	3	2.518	251.762	.000	.990
Intercept	15.134	1	15.134	1513.090	.000	.995
strains	7.554	3	2.518	251.762	.000	.990
Error	.080	8	.010			
Total	22.768	12				
Corrected Total	7.634	11				

a. R Squared = .990 (Adjusted R Squared = .986)

citrinin

	strains	N	Subset 1	Subset 2
Tukey HSD[a,b]	purpureus at 25celsius	3	.3064	
	purpureus at 30celsius	3	.3599	
	ruber at 25celsius	3		1.8100
	ruber at 30celsius	3		2.0157
	Sig.		.911	.131

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = .010.

a. Uses Harmonic Mean Sample Size = 3.000.

b. Alpha = .05.

Table C14 ANOVA table of citrinin produced by *M. purpureus* BCC 6131 on 18th day of cultivation with different amount of water added

Between-Subjects Factors

		N
moisture	15 ml water added	3
	20 ml water added	3
	25 ml water added	3
	30 ml water added	3

Levene's Test of Equality of Error Variances[a]

Dependent Variable: citrinin

F	df1	df2	Sig.
1.479	3	8	.292

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+moisture

Tests of Between-Subjects Effects

Dependent Variable: citrinin

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.013[a]	3	.004	8.608	.007	.763
Intercept	1.385	1	1.385	2729.114	.000	.997
moisture	.013	3	.004	8.608	.007	.763
Error	.004	8	.001			
Total	1.402	12				
Corrected Total	.017	11				

a. R Squared = .763 (Adjusted R Squared = .675)

citrinin

	moisture	N	Subset 1	Subset 2
Tukey HSD[a,b]	15 ml water added	3	.3000	
	20 ml water added	3	.3209	
	25 ml water added	3	.3500	.3500
	30 ml water added	3		.3880
	Sig.		.099	.242

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = .001.

a. Uses Harmonic Mean Sample Size = 3.000.

b. Alpha = .05.

Table C15 ANOVA table of citrinin produced by *M. purpureus* BCC 6131 on 18th day of cultivation with different rice substrates

Between-Subjects Factors

		N
substrate	broken rice	3
	polished rice	3
	unpolished rice	3

Levene's Test of Equality of Error Variances[a]

Dependent Variable: citrinin

F	df1	df2	Sig.
.178	2	6	.841

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+substrate

Tests of Between-Subjects Effects

Dependent Variable: citrinin

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.024[a]	2	.012	27.737	.001	.902
Intercept	.771	1	.771	1790.812	.000	.997
substrate	.024	2	.012	27.737	.001	.902
Error	.003	6	.000			
Total	.797	9				
Corrected Total	.026	8				

a. R Squared = .902 (Adjusted R Squared = .870)

citrinin

	substrate	N	Subset 1	Subset 2
Tukey HSD[a,b]	unpolished rice	3	.2200	
	broken rice	3		.3239
	polished rice	3		.3339
	Sig.		1.000	.830

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = .000.

a. Uses Harmonic Mean Sample Size = 3.000.

b. Alpha = .05.

Table C16 ANOVA table of citrinin produced by *M. purpureus* BCC 6131 on the 18th day of cultivation with different inoculum sizes

Between-Subjects Factors

		N
inoculum	1 sq.cm	3
	2 sq.cm	3
	3 sq.cm	3
	4 sq.cm	3
	5 sq.cm	3

Levene's Test of Equality of Error Variances[a]

Dependent Variable: citrinin

F	df1	df2	Sig.
.054	4	10	.994

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+inoculum

Tests of Between-Subjects Effects

Dependent Variable: citrinin

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.006[a]	4	.002	2.376	.122	.487
Intercept	1.829	1	1.829	2894.360	.000	.997
inoculum	.006	4	.002	2.376	.122	.487
Error	.006	10	.001			
Total	1.841	15				
Corrected Total	.012	14				

a. R Squared = .487 (Adjusted R Squared = .282)

citrinin

	inoculum	N	Subset 1
Tukey HSD[a,b]	1 sq.cm	3	.3239
	2 sq.cm	3	.3320
	3 sq.cm	3	.3500
	4 sq.cm	3	.3600
	5 sq.cm	3	.3800
	Sig.		.118

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = .001.

a. Uses Harmonic Mean Sample Size = 3.000.

b. Alpha = .05.

Table C17 ANOVA table of monacolin/citrinin ratio produced by *M. ruber* TISTR 3006 and *M. purpureus* BCC 6131 at 25°C or 30°C on 18th day of cultivation

Between-Subjects Factors

		N
strains	purpureus at 25 celsius	3
	purpureus at 30 celsius	3
	ruber at 25 celsius	3
	ruber at 30 celsius	3

Levene's Test of Equality of Error Variances[a]

Dependent Variable: ratio

F	df1	df2	Sig.
4.419	3	8	.041

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+strains

Tests of Between-Subjects Effects

Dependent Variable: ratio

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	190941.903[a]	3	63647.301	392.284	.000	.993
Intercept	177791.342	1	177791.342	1095.799	.000	.993
strains	190941.903	3	63647.301	392.284	.000	.993
Error	1297.985	8	162.248			
Total	370031.230	12				
Corrected Total	192239.888	11				

a. R Squared = .993 (Adjusted R Squared = .991)

ratio

	strains	N	Subset 1	Subset 2	Subset 3
Tukey HSD[a,b]	ruber at 25 celsius	3	5.2909		
	ruber at 30 celsius	3	5.8178		
	purpureus at 25 celsius	3		168.3578	
	purpureus at 30 celsius	3			307.4165
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 162.248.

a. Uses Harmonic Mean Sample Size = 3.000.

b. Alpha = .05.

Table C18 ANOVA table of monacolin/citrinin ratio produced by *M. purpureus* BCC 6131 on 18th day of cultivation with different amount of water added

Between-Subjects Factors

		N
moisture	15 ml water added	3
	20 ml water added	3
	25 ml water added	3
	30 ml water added	3

Levene's Test of Equality of Error Variances[a]

Dependent Variable: ratio

F	df1	df2	Sig.
3.143	3	8	.087

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+moisture

Tests of Between-Subjects Effects

Dependent Variable: ratio

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	354285.536[a]	3	118095.179	177.234	.000	.985
Intercept	4003891.311	1	4003891.311	6008.936	.000	.999
moisture	354285.536	3	118095.179	177.234	.000	.985
Error	5330.583	8	666.323			
Total	4363507.430	12				
Corrected Total	359616.119	11				

a. R Squared = .985 (Adjusted R Squared = .980)

ratio

	moisture	N	Subset 1	Subset 2	Subset 3
Tukey HSD[a,b]	30 ml water added	3	308.2069		
	15 ml water added	3		596.2910	
	25 ml water added	3		620.1991	
	20 ml water added	3			785.8271
	Sig.		1.000	.680	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 666.323.

a. Uses Harmonic Mean Sample Size = 3.000.

b. Alpha = .05.

Table C19 ANOVA table of monacolin/citrinin ratio produced by *M. purpureus* BCC 6131 on 18th day of cultivation with different rice substrates

Between-Subjects Factors

		N
substrate	broken rice	3
	polished rice	3
	unpolished rice	3

Levene's Test of Equality of Error Variances[a]

Dependent Variable: ratio

F	df1	df2	Sig.
2.378	2	6	.174

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+substrate

Tests of Between-Subjects Effects

Dependent Variable: ratio

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	184998.279[a]	2	92499.139	4115.698	.000	.999
Intercept	2645095.998	1	2645095.998	117692.1	.000	1.000
substrate	184998.279	2	92499.139	4115.698	.000	.999
Error	134.848	6	22.475			
Total	2830229.125	9				
Corrected Total	185133.127	8				

a. R Squared = .999 (Adjusted R Squared = .999)

ratio

	substrate	N	Subset 1	Subset 2	Subset 3
Tukey HSD[a,b]	unpolished rice	3	340.5893		
	broken rice	3		623.6427	
	polished rice	3			662.1431
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 22.475.

a. Uses Harmonic Mean Sample Size = 3.000.

b. Alpha = .05.

Table C20 ANOVA table of monacolin/citrinin ratio produced by *M. purpureus* BCC 6131 on the 18th day of cultivation with different inoculum sizes

Between-Subjects Factors

		N
inoculum	1 sq.cm	3
	2 sq.cm	3
	3 sq.cm	3
	4 sq.cm	3
	5 sq.cm	3

Levene's Test of Equality of Error Variances[a]

Dependent Variable: ratio

F	df1	df2	Sig.
3.538	4	10	.048

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+inoculum

Tests of Between-Subjects Effects

Dependent Variable: ratio

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	151225.347[a]	4	37806.337	604.901	.000	.996
Intercept	9320200.569	1	9320200.569	149123.1	.000	1.000
inoculum	151225.347	4	37806.337	604.901	.000	.996
Error	625.000	10	62.500			
Total	9472050.916	15				
Corrected Total	151850.347	14				

a. R Squared = .996 (Adjusted R Squared = .994)

ratio

	inoculum	N	Subset 1	Subset 2	Subset 3	Subset 4
Tukey HSD[a,b]	1 sq.cm	3	703.8757			
	2 sq.cm	3	718.8808			
	5 sq.cm	3		740.1639		
	3 sq.cm	3			800.3192	
	4 sq.cm	3				978.0378
	Sig.		.214	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 62.500.

a. Uses Harmonic Mean Sample Size = 3.000.

b. Alpha = .05.

Appendix D

Instrument

Fig D1 Analytical Balance (Mettler Toledo AX205, Switzerland)

Fig D2 Autoclave (ALP CL-40 LDP, Japan)

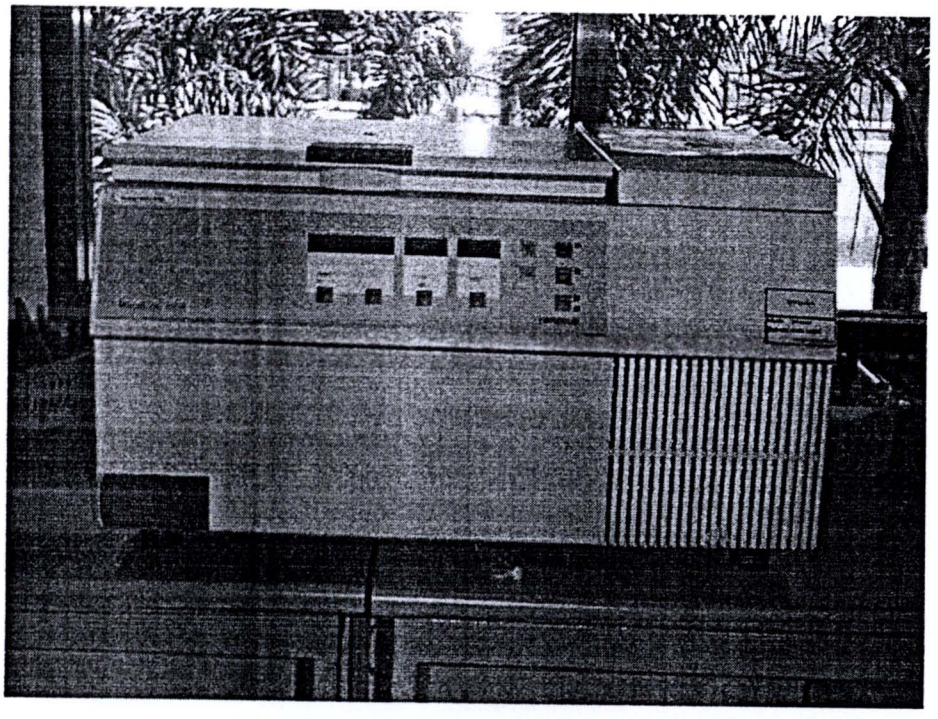

Fig D3 Centrifuge (Heraeus Megafuge 1.0R, Germany)

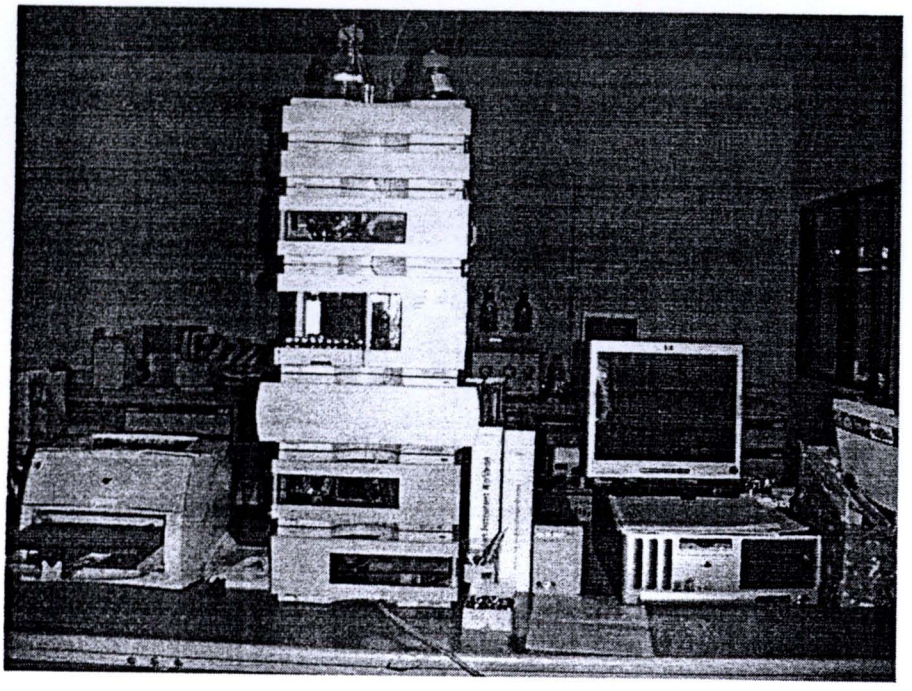

Fig D4 HPLC (Agilent 1100series, USA)

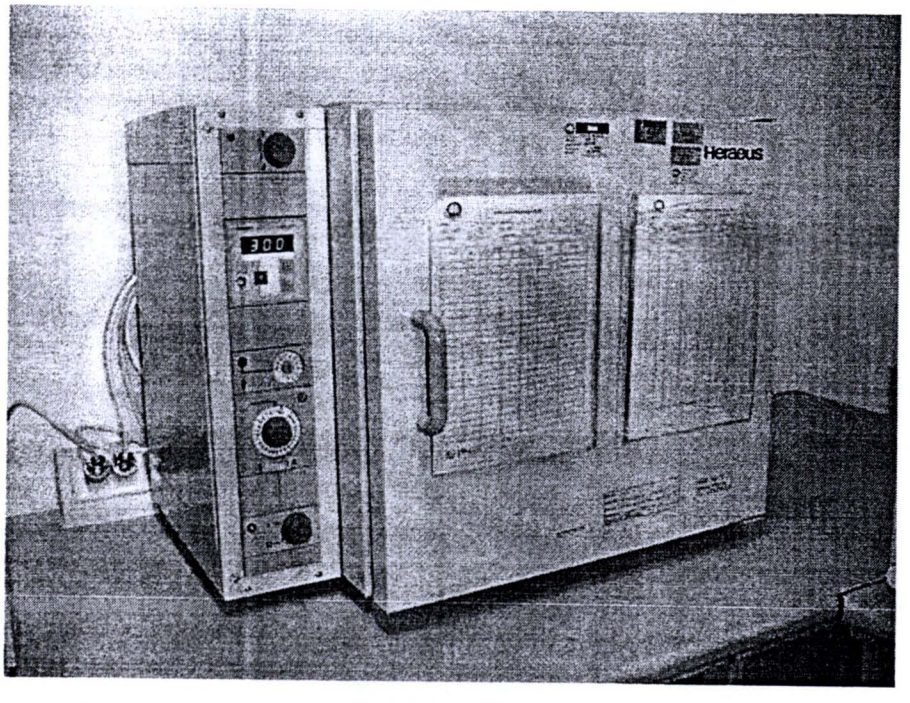

Fig D5 Incubator (Heraeus B6060, Germany)

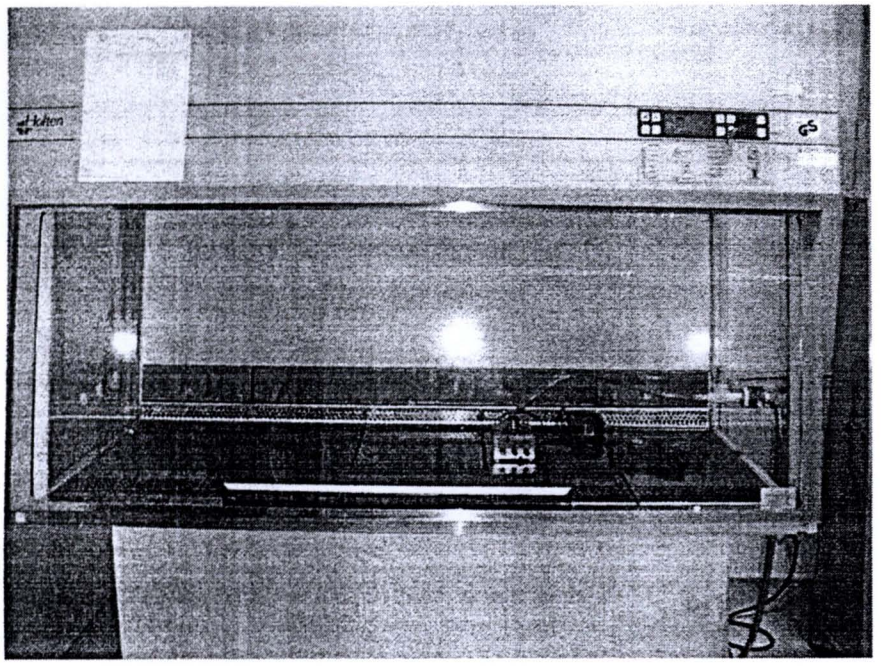

Fig D6 Laminar air flow (Holten model 1.5, Denmark)

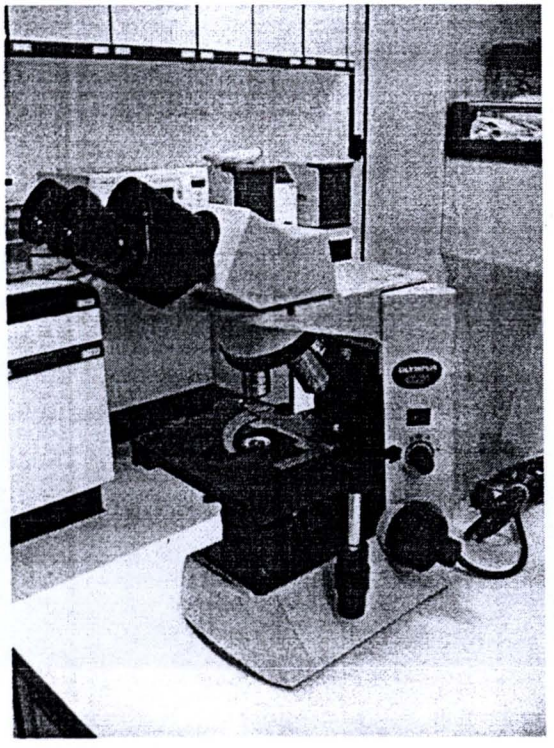

Fig D7 Microscope (olympus CX31RBSF Philippines)

Fig D8 pH meter (mettler teledo sever easy, Switzerland)

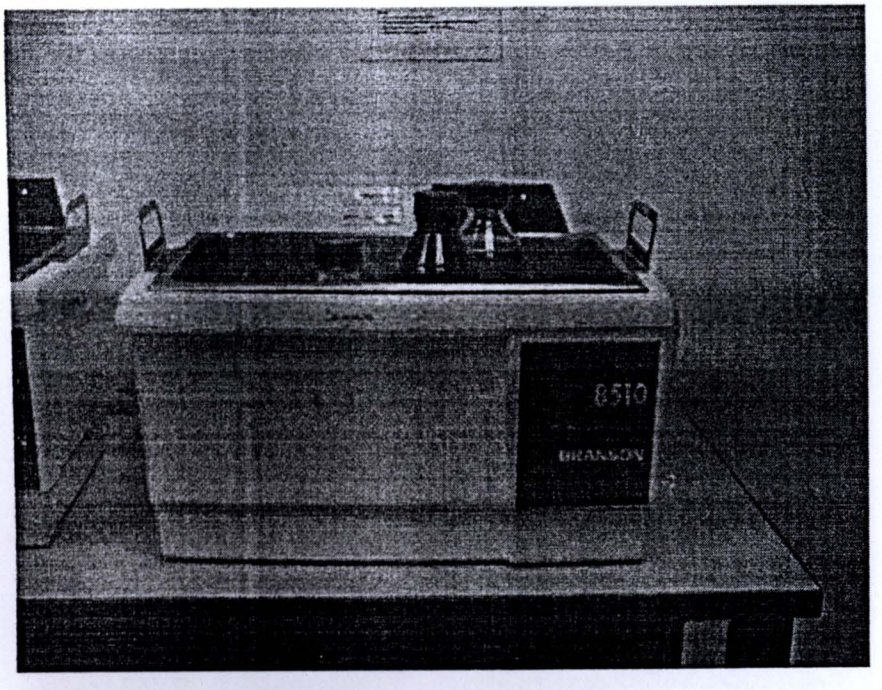

Fig D9 Ultrasonic bath (branson8510, USA)

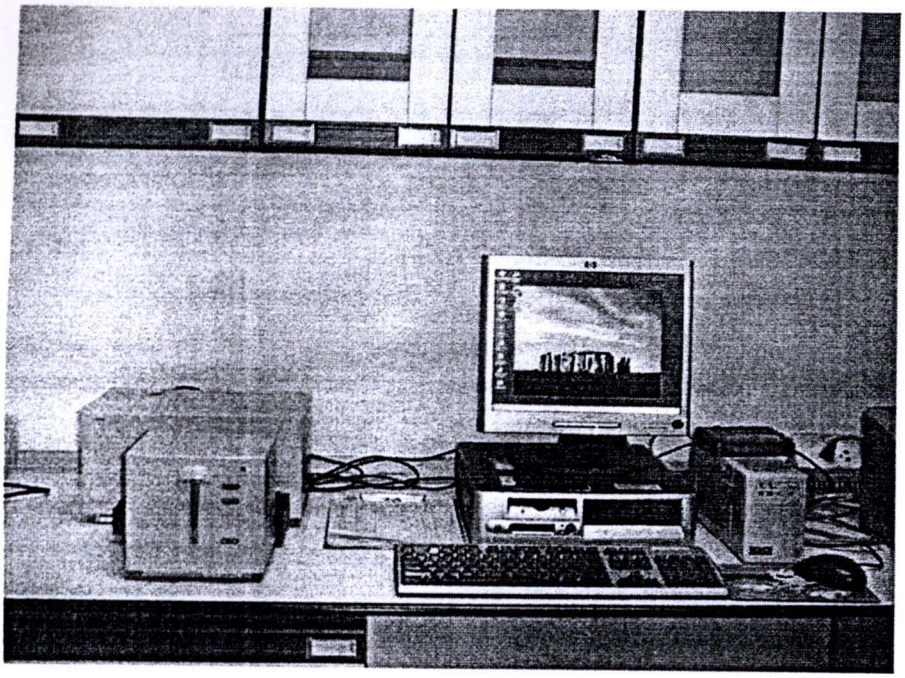

Fig D10 UV-Visible Spectrophotometer (Agilent 8453, USA)

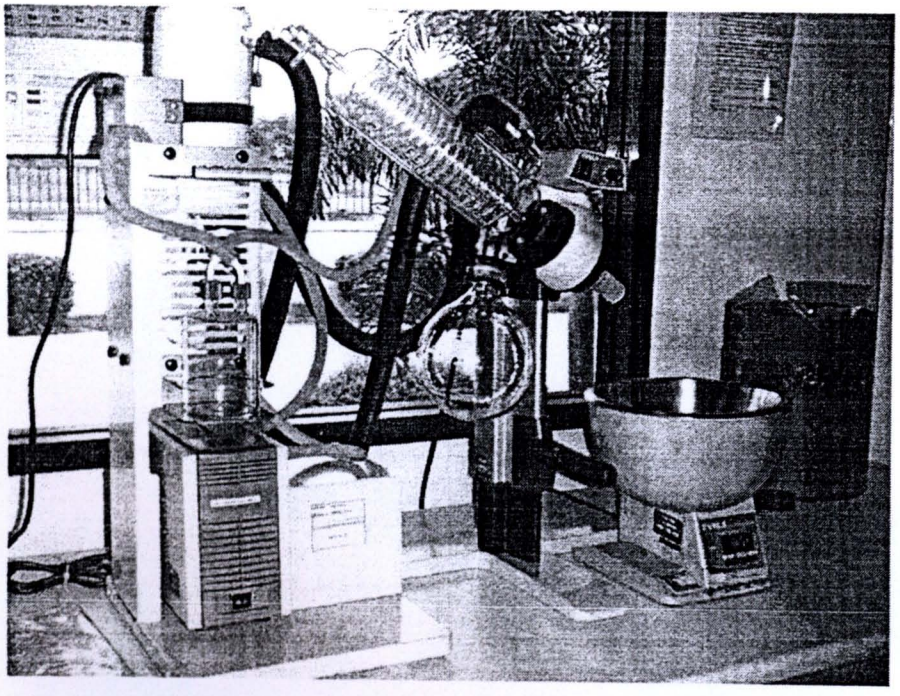

Fig D11 Rotary Evaporator (Eyela N-1000 sw, Japan)

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