BIOVANILLIN PRODUCTION FROM LEMONGRASS LEAVES HYDROLYSATES BY *Phanerochaete chrysosporium* ATCC 24725 IN BATCH CULTURE

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ABSTRACT

Biovanillin is one of fungi secondary metabolites, that is widely used as aromatic and flavour compound with high fiscal value. The use of vanillin as flavour for various products is its foremost application in food industries. The global market demand for natural vanillin as flavour stands for less than one percent (1%) of its market demand annually. However, most of the flavour compounds are normally obtained through the process of chemical synthesis, which could cause health problem and environmental hitches. Demand for natural and healthy products coupled with the fact that acid ferulic (FA) extracted from plant materials can be a precursor for biovanilin production makes it relatively inexpensive as a natural product. The research was aimed to extract FA from lemongrass leaves (LGL), which was used as precursor for one-step biovanillin production by *Phanerochaete chrysosporium* (ATCC 24725) in batch culture. Initially, optimization of the LGL pretreatment practices using liquid hot water with sodium bisulfite (0.5% w/v) towards the release of the FA was investigated with central composite design (CCD). The optimized results produced 0.750 g/L as the highest FA released from the lemongrass leaves hydrolysates (LLH). Considerable alterations of the major LGL contents were observed during the pretreatment process, which increased the cellulose content by 39%. The Fourier transform infrared (FTIR) and field emission scanning electron microscopic (FESEM) analyses confirmed that the lignin which serves as the shielding layer from the LGL components became fragmented, thus decreasing the lignin content by 46%. The total reducing sugar production with enzymatic saccharification using enzymes cocktail (celluclast and viscozyme, 1 % v/v each) improved by up to 8.4-folds as compared to the direct enzymatic saccharification without removing the LGL extracts. Screening of significant factors for biovanillin production using 2-level Factorial Design showed that the biovanillin production processes was affected by the interactive effects of initial FA concentration, incubation temperature, incubation time and initial pH. The highest biovanillin production (0.093 g/L with molar yield 23 %) in shake flasks using the CCD was determined with FA (0.5 g/L), temperature (35 °C), time (72 h), and initial pH (6.0). Application of both pH and dissolved oxygen control strategies in 2 litre stirred tank bioreactor had increased the biovanillin production by 1.41 and 1.53-folds as compared to the optimized experiment using the shake flasks. The evaluation of kinetics from the two-phase pH control strategy demonstrated the performance of *P. chrysosporium* with the highest specific growth rate (μ) of 0.056 h^{-1}, with an increase in the yield coefficient of biomass formation $Y_{x/s}$ (0.5191 g/g) and maximum cell concentration X_{max} (13.0 g/L) by 1.03 and 1.05-folds as compared to one-phase of pH control, respectively. Performance of the kinetics using two-phase dissolved oxygen (DO) control strategy has shown that 80 % saturations of DO during active growth phase with 40 % saturations during production phase were highly essential for enhancement of biovanillin production from LLH by *P. chrysosporium* using 2 litre stirred tank bioreactor. LGL residue which contained FA can be used as a precursor to produce biovanillin by natural means via one-step bioconversion process with *P. chrysosporium* in batch culture using 2 litre stirred tank bioreactors.

ABSTRAK

Biovanillin merupakan salah satu metabolit sekunder kulat, yang digunakan sebagai sebatian aromatik dan perasa dengan nilai fiskal yang tinggi. Penggunaan vanillin sebagai perasa untuk pelbagai produk adalah aplikasi terpenting dalam industri makanan. Permintaan pasaran global untuk vanillin semula jadi sebagai perasa adalah kurang dari satu peratus (1 %) dari permintaan pasarannya setiap tahun. Namun, sebilangan besar sebatian perasa biasanya diperoleh melalui proses sintesis kimia, yang boleh menyebabkan masalah kesihatan dan persekitaran. Permintaan untuk produk semulajadi yang sihat serta fakta bahawa asid ferulik (FA) yang diekstrak daripada bahan tumbuhan boleh menjadi bahan pendahulu bagi pengeluaran biovanilin menjadikannya secara relatif murah sebagai produk semulajadi. Penyelidikan ini bertujuan untuk mengekstrak FA dari daun serai (LGL), yang digunakan sebagai substrat untuk pengeluaran biovanillin satu langkah oleh *Phanerochaete chrysosporium* (ATCC 24725) dalam kultur kelompok. Pada peringkat awal, pengoptimuman prarawatan LGL menggunakan air panas dengan natrium bisulfit (0.5 % w/v) untuk meningkatkan pengeluaran FA dikaji dengan reka bentuk komposit pusat (CCD). Hasil FA yang optimum sebanyak 0.750 g/L merupakan FA tertinggi yang dikeluarkan dari proses hidrolisis daun serai (LLH). Perubahan besar kandungan LGL utama diperhatikan semasa proses prarawatan, dengan peningkatan kandungan selulosa sebanyak 39 %. Analisis Fourier transform infrared (FTIR) dan elektron mikroskopik pengimbasan emisi medan (FESEM) telah mengesahkan bahawa lignin yang berfungsi sebagai lapisan pelindung dari komponen LGL dipecahkan dan ini terbukti dengan penurunan kandungan lignin sebanyak 46 %. Peningkatan penghasilan gula secara keseluruhan semasa sakarifikasi enzimatik menggunakan enzim koktail (celluclast dan viscozyme, masing-masing 1 % v/v) adalah 8.4 kali ganda berbanding dengan sakarifikasi enzimatik secara langsung dengan tanpa mengeluarkan ekstrak LGL. Penyaringan faktor-faktor penting untuk pengeluaran biovanilin menggunakan Reka Bentuk Faktor 2 Peringkat menunjukkan bahawa penghasilan biovanilin dipengaruhi oleh kesan interaktif kepekatan FA awal, suhu pengeraman, jangkamasa pengeraman dan pH awal. Penghasilan biovanillin tertinggi sebanyak 0.093 g/L dengan hasil molar 23 % dalam kelalang penggoncang menggunakan CCD menunjukkan bahawa FA (0.5 g/L), suhu (35 °C), jangkamasa pengeraman (72 jam), dan pH awal (6.0). Aplikasi strategi pengawalan pH dan oksigen terlarut dalam bioreaktor tangki pengaduk 2 liter telah meningkatkan pengeluaran biovanillin sebanyak 1.41 dan 1.53 kali ganda berbanding eksperimen yang dioptimumkan kelalang penggoncang. Penilaian kinetik dari strategi kawalan pH secara dua fasa menunjukkan peningkatan prestasi *P. chrysosporium* bagi kadar pertumbuhan spesifik tertinggi (μ) 0.056 h^{-1}, hasil pembentukan biomassa $Y_{x/s}$ (0.5191 g/g) dan kepekatan sel maksimum X_{max} (13.0 g/L) sebanyak 1.03 dan 1.05 kali ganda berbanding kawalan pH satu fasa. Prestasi kinetik menggunakan strategi kawalan oksigen terlarut (DO) dua fasa telah menunjukkan bahawa 80 % oksigen terlarut tepu semasa fasa pertumbuhan aktif dengan 40 % oksigen terlarut tepu semasa fasa penghasilan sangat penting untuk peningkatan pengeluaran biovanilin dari LLH oleh *P. chrysosporium* menggunakan bioreaktor tangki pengaduk bersaiz 2 liter. Residu LGL yang mengandungi FA berpotensi untuk digunakan sebagai substrat untuk menghasilkan biovanillin dengan cara semula jadi melalui proses biopenukaran satu langkah oleh *P. chrysosporium* dalam kultur kelompok menggunakan bioreaktor tangki pengaduk 2 liter.

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LIST OF ABBREVIATIONS

ATCC	-	American Type Culture Collection
2-LFD	-	Two-Level Factorial Design
ANOVA	-	Analysis of Variance
CCD	-	Central Composite Design
DNS	-	Dinitrosalicyclic Acid
DOT	-	Dissolved Oxygen Tension
FA	-	Ferulic Acid
FESEM	-	Field Emission Scanning Electron Microscope
FS	-	Faculty of Science
FTIR	-	Fourier Transform Infrared Spectroscopy
g	-	Gram
G	-	Growth Phase
H_2SO_4	-	Sulphuric Acid
HCl	-	Hydrochloric Acid
HNO_3	-	Nitric Acid
HPLC	-	High Performance Liquid Chromatography
L	-	Litre
LLH	-	Lemongrass Leaves Hydrolysates
LGL	-	Lemongrass Leaves
mL	-	Millilitre
mm	-	Millimetre
MW	-	Molecular Weight
$NADPH_2$	-	Nicotinamide Adenine Dinucleotide Hydrogen Phosphate
NaOH	-	Sodium Hydroxide
PDA	-	Potato Dextrose Agar
P	-	Production Phase
RSM	-	Random Surface Methodology
v/v	-	Volume Per Volume

w/v	-	Weight per Volume
μL	-	Micro Litre
ºC	-	Degree Celsius
μ	-	Specific Growth rate
μ_{max}	-	Maximum Specific Growth rate
P_{max}	-	Maximum Product
X_{max}	-	Cell Biomass Concentration
t_d	-	Doubling Time
$Y_{x/s}$	-	Yield Coefficient of Biomass Formation Related to Substrate Utilization
$Y_{p/s}$	-	Yield Coefficient of Biovanillin Formation Related to Substrate Utilization
$Y_{p/x}$	-	Yield Coefficient of Biovanillin Formation Related to Cell Biomass Concentration

LIST OF SYMBOLS

±	-	Plus, or Minus
≤	-	Less than or Equal to
≥	-	Greater or Equal to
-	-	Minus
=	-	Equal to
%	-	Percent

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Biovanillin is a secondary metabolite, which is used as flavouring component present in natural vanilla (Gallage *et al.*, 2018; Pérez-Rodríguez *et al.*, 2016). The use of vanillin as flavour for production of various products was its foremost application in food industries, particularly beverages and dairy products (Chakraborty *et al.*, 2017a). However, researchers had discovered its potential applications in other industries like cosmetics, agriculture, drugs, and household (Galadima *et al.*, 2019a; Priefert *et al.*, 2001; Zamzuri and Abd-Aziz, 2013). The production of biovanillin through biotechnological processes was based on microbial conversions of natural precursors including ferulic acid, vanillic acid, phenolic stilbenes, eugenol, aromatic amino acids and isoeugenol (Chen *et al.*, 2016; Hua *et al.*, 2007a; Lesage-Meessen *et al.*, 1999; Ramachandra Rao and Ravishankar, 2000; Stentelaire *et al.*, 2000). These precursors could be obtained by pretreatment from agro-based residues like sugar beet pulp, maize stalk, wheat straw, rice bran, sugarcane bagasse, maize bran, oil palm empty fruit bunch (Galadima *et al.*, 2019b; Zheng *et al.*, 2015; Zheng *et al.*, 2007b; Zulkarnain *et al.*, 2018). Therefore, the bioconversions of the precursors to biovanillin could be performed through the biotechnological process by applying plant cells, fungi, bacteria, microalgae, genetically modified microorganisms or de novo biosynthesis (Gallage and Moller, 2015; Hua, *et al.*, 2007a; Overhage *et al.*, 2003; Priefert, *et al.*, 2001; Zheng, *et al.*, 2007b). Due to the lower yield of the biovanillin because of high toxic effects of the other precursors during fermentation process, as well as chemical similarity of ferulic acid (FA) to vanillin, the use of FA obtained from agricultural residues was established among the best routes for biovanillin production (Galadima, *et al.*, 2019a; Hua, *et al.*, 2007a; Patil and Yadav, 2018; Tilay *et al.*, 2010; Zheng, *et al.*, 2007b).

Ferulic acid (FA) is among the readily available hydroxycinnamates that exist in the cell wall of various plants (Hua, *et al.*, 2007a; Ishii, 1997; Yan *et al.*, 2016; Zheng, *et al.*, 2007b). It was discovered to be existed freely in plants, and linked covalently between arabinoxylans and lignin fragments by ester and ether linkages, which require application of certain pretreatment techniques to cleave the linkages before it could be released and used for the biotransformation processes (Hua, *et al.*, 2007a; Johnson *et al.*, 1996; Saulnier *et al.*, 2001; Saulnier and Thibault, 1999; Zheng, *et al.*, 2007b). There are many reports on the application of various pretreatment techniques to facilitate the release of the FA from different plant residues (Galadima, *et al.*, 2019a; Mirghani *et al.*, 2012; Zulkarnain, *et al.*, 2018). However, very limited literature is available on the utilization of statistical software to optimize the release of the FA from lemongrass leaves. Therefore, among the objectives of this research is to explore the application of central composite design to optimize the release of the FA from lemongrass leaves.

Majority of the available literature on the application of different microorganisms for the transformation of ferulic acid to biovanillin have confined on using two-step bioconversion processes with certain plant residues as FA sources (Galadima, *et al.*, 2019a; Motedayen *et al.*, 2013; Nazila *et al.*, 2013; Zulkarnain, *et al.*, 2018). The two-step bioconversion process was discovered to have some hitches like time mismanagement, formation of side-products, vulnerable to contaminations and labour intensive (Galadima, *et al.*, 2019b; Hua, *et al.*, 2007a; Hussin *et al.*, 2015). However, one-step bioconversion process is rather time efficient, lesser labour intensive, lower level of side-products formation with minimal risk of contamination (Galadima, *et al.*, 2019a; Hua, *et al.*, 2007a; Hussin, *et al.*, 2015). But there are very limited reports on application of the one-step bioconversion process for biovanillin production using lemongrass leaves. Also, there are no literatures on the application of pH and dissolved oxygen control strategies toward biovanillin production by *Phanerochaete chrysosporium* ATCC 24725 using 2 litre stirred tank bioreactor. The *P. chrysosporium* ATCC 24725 was reported with capability of liberating enzymes like laccases, lignin peroxidase and manganese peroxidase with high affinity to degrade lignin (which serves as a barrier) from the biomass, utilizing nitrogen and carbon that were used as substrates for growth and metabolism (Ürek and Pazarlioğlu, 2005). Despite having high affinity to attack lignin by fungi, they also have higher tolerance to the toxic effect of the ferulic acid when compared to the other microorganisms like bacteria.

Therefore, this research has been tailored to explore the application of one-step bioconversion process towards biovanillin production using lemongrass leaves. The research further employed the application of pH and dissolved oxygen control strategies toward biovanillin production by *P. chrysosporium* ATCC 24725 using the 2-litre stirred tank bioreactor. Various problems that have instigated the purposes of this research were described below.

1.2 Statement of Problems

In Malaysia, there are more than 250 acres of farmlands for lemongrass production, which are responsible for producing over 12, 000 tonnes of dry lemongrass leaves annually (Hussin, *et al.*, 2015). From the total dry leaves of the lemongrass generated, only about 300 tonnes could be transformed into value-added products. More than 8, 000 tonnes are being disposed on farmlands (Hussin, *et al.*, 2015). These disposed wastes of the lemongrass leaves could only be left on the farmlands to deteriorate naturally, because they could not be used as feedstuffs to feed animals due to the attribute of their aroma (Hussin, *et al.*, 2015; Kaur and Dutt, 2013). Alternatively, they could be destroyed by burning using conventional technique, however this would pose some challenges pertinent to environmental pollution (Hussin, *et al.*, 2015; Norli *et al.*, 2017). Research have discovered that various agro-based residues including lemongrass leaves consisted of ferulic acid, but the major challenge is with the best method of pretreatment to be adopted for its normal release.

The global market demand for fragrances and flavours is incessantly escalating (Batista, 2014; Dal Bello, 2013; Gallage and Moller, 2015). Majority of flavouring composites are normally obtained through the process of chemical synthesis with a minute involvement of natural means (Bomgardner, 2016; Gallage and Moller, 2015; Krings *et al.*, 1993). The foremost downside of chemical synthesis is that the method is not welcomed environmentally as well as the needed compounds often emerged as adverse mixtures that could affect fermentation processes (Krings, *et al.*, 1993). The chemical means of flavour production suffers quite a lot of weaknesses including increasing effects on environment (Dal Bello, 2013). Furthermore, the compounds produced chemically are tagged “artificial products” or “nature identical”, which lessened their economic significance (Bomgardner, 2016; Dal Bello, 2013). Also, the natural vanillin extracted out of vanilla stands for less than one percent (1 %) of the market demand annually, and the demand for natural and healthy products is incessantly escalating.

However, in order to overcome these challenges and make the bioconversion routes viable economically, it became highly essential to get a precursor which is relatively near to vanillin and at the same time cost-efficient and easily accessible. Flavours obtained via biological means are termed “bioflavours” which are relatively abundant, cost-efficient and readily available (Dal Bello, 2013; Gallage, *et al.*, 2018). The application of biotechnology as imminent basis of biovanillin production was established promising using fungi via biotransformation of FA utilizing agricultural residues including lemon grass leaves (Galadima, *et al.*, 2019b; Hussin, *et al.*, 2015), and the process is universally accepted as natural (Bomgardner, 2016; Dal Bello, 2013) Interestingly, various plant materials has been discovered to consist ferulic acid, which has been extracted and utilized in many different fields (Batista, 2014; Kumar and Pruthi, 2014; Pérez-Rodríguez, *et al.,* 2016). Although, there are various literatures that have reported the bioconversion of FA obtained from different plant residues into biovanillin (Converti *et al.*, 2010; Karode *et al.*, 2013; Makela *et al.*, 2015; Motedayen, *et al.*, 2013; Pérez-Rodríguez, *et al.*, 2016; Thibault *et al.*, 1998; Zulkarnain, *et al.*, 2018), very limited literature is available on the utilization of lemongrass leaves as main source of FA for biovanillin production. Hence, this research has been focused on optimization of the release of FA from lemongrass leave hydrolysates, which was ultimately used for biovanillin production by *P. chrysosporium* ATCC 24725 using 2-

litre stirred tank bioreactor. Detail description of the objectives of this research is highlighted below.

1.3 Research Objectives

The research gave more concern towards production of biovanillin from lemon grass leave hydrolysates by *P. chrysosporium* ATCC 24725 in 2 litre stirred tank bioreactor with the aim to improve the production. Therefore, the main objectives of this research include.

(a) To analyse the products from physico-chemical pretreatment and enzymatic saccharification of lemongrass leaves

(b) To optimize ferulic acid (FA) release via physico-chemical pretreatment technique using Central Composite Design (CCD).

(c) To screen and optimize the biovanillin production in shake flasks using 2 level factorial design (2-LFD) and central composite design (CCD) respectively.

(d) To evaluate pH and Dissolved Oxygen control strategy for One-step biovanillin production from lemongrass leaves hydrolysates in batch culture using 2 litre stirred tank bioreactor.

(e) To compare the biovanillin production by *Phanerochaete chrysosporium* ATCC 24725 in shake flasks and 2 litre stirred tank bioreactor.

1.4 Research Scope

The research gave more priority on the production of biovanillin with lemongrass by *P. chrysosporium* ATCC 24725 using fermentation processes in batch culture. The whole research was broadly segmented into different parts. Initially, this research was confined on the optimization of the FA release by physico-chemical pretreatment technique using Central Composite Design (CCD). The optimized FA released from the lemon grass hydrolysates was used in designing the subsequent experiments. The potentials of the lemongrass leaves were explored by determining the contents of cellulose, hemicellulose and lignin. The glucose contents from lemongrass leaves were equally assessed through enzymatic saccharification. The efficiency of the pretreatment technique was evaluated with Fourier-Transform Infrared Spectroscopy (FTIR) and field emission scanning electron microscope (FESEM). The parameters that were found to influence the biovanillin production were screened using 2-level factorial design to get the significant few ones, which were subsequently used to optimize the biovanillin production using CCD.

The research further employed the use of various pH control strategies toward biovanillin production in batch culture using 2 litre stirred tank bioreactor. pH of the culture medium was controlled by single-phase at 6.5, 6, 5.5, 5.0, 4.5, 4.0, 3.5 and without any pH control (initial pH of 6.0). The two-phase control of the culture pH towards biovanillin production in 2 litre stirred tank bioreactor with *P. chrysosporium* ATCC 24725 was also performed by strategic monitoring of the pH at both growth and production phases. Furthermore, the influence of dissolved oxygen on biovanillin production with *P. chrysosporium* ATCC 24725 in 2 litre stirred tank bioreactor by monitoring the dissolved oxygen during the fermentation processes was equally conducted. The fermentation kinetics of the biovanillin production from both shake flasks and the 2 litre stirred tank bioreactor were ultimately evaluated.

REFERENCES

Abdel-Fattah, Y. R. and Olama, Z. A. (2002). L-asparaginase production by *Pseudomonas aeruginosa* in solid-state culture: evaluation and optimization of culture conditions using factorial designs. *Process Biochemistry*. 38(1), 115-122.

Abdul, P. M., Jahim, J. M., Harun, S., Markom, M., Lutpi, N. A., Hassan, O., Balan, V., Dale, B. E. and Nor, M. T. M. (2016). Effects of changes in chemical and structural characteristic of ammonia fibre expansion (AFEX) pretreated oil palm empty fruit bunch fibre on enzymatic saccharification and fermentability for biohydrogen. *Bioresource technology*. 211, 200-208.

Aditiya, H., Sing, K., Hanif, M. and Mahlia, T. (2015). Effect of acid pretreatment on enzymatic hydrolysis in bioethanol production from rice straw. *International Journal of Technol*ogy 6, 3-10.

Agamuthu, P., Milow, P., Nurul, A., Nurhawa, A. and Fauziah, S. (2015). Impact of flood on waste generation and composition in Kelantan. *Malaysian journal of Science*. 34(2), 130-140.

Agbor, V. B., Cicek, N., Sparling, R., Berlin, A. and Levin, D. B. (2011). Biomass pretreatment: fundamentals toward application. *Biotechnology advances*. 29(6), 675-685.

Ahdno, H. and Jafarizadeh-Malmiri, H. (2017). Development of a sequenced enzymatically pre-treatment and filter pre-coating process to clarify date syrup. *Food and bioproducts processing*. 101, 193-204.

Akhtar, N., Gupta, K., Goyal, D. and Goyal, A. (2016). Recent advances in pretreatment technologies for efficient hydrolysis of lignocellulosic biomass. *Environmental Progress & Sustainable Energy*. 35(2), 489-511.

Akin, D., Rigsby, L., Sethuraman, A., Morrison, W., Gamble, G. and Eriksson, K. (1995). Alterations in structure, chemistry, and biodegradability of grass lignocellulose treated with the white rot fungi *Ceriporiopsis subvermispora* and *Cyathus stercoreus*. *Applied and environmental microbiology*. 61(4), 1591-1598.

Alara, O. R., Abdurahman, N. H. and Olalere, O. A. (2018). Optimization of microwave-assisted extraction of flavonoids and antioxidants from *Vernonia amygdalina* leaf using response surface methodology. *Food and Bioproducts Processing*. 107, 36-48.

Alvira, P., Tomás-Pejó, E., Ballesteros, M. and Negro, M. (2010). Pretreatment technologies for an efficient bioethanol production process based on enzymatic hydrolysis: a review. *Bioresource technology*. 101(13), 4851-4861.

Amarasekara, A. S., Wiredu, B. and Razzaq, A. (2012). Vanillin based polymers: I. An electrochemical route to polyvanillin. *Green Chemistry*. 14(9), 2395-2397.

Amin, F. R., Khalid, H., Zhang, H., u Rahman, S., Zhang, R., Liu, G. and Chen, C. (2017). Pretreatment methods of lignocellulosic biomass for anaerobic digestion. *Applied Microbiology Express*. 7(1), 72.

Anderson, M. and Whitcomb, P. (2005). Response surface methods simplified. *New York: Productivity Google Scholar*.

Anderson, M. J. and Whitcomb, P. J. (2007). Response surface methods (RSM) for peak process performance at the most robust operating conditions. *Proceedings of the 2007 Proceeding from International SEMATECH Manufacturing Initiative (ISMI) Symposium on Manufacturing Effectiveness*.

Anderson, M. J. and Whitcomb, P. J. (2016). *RSM simplified: optimizing processes using response surface methods for design of experiments*. Productivity press.

Anderson, V. L. and McLean, R. A. (2018). *Design of experiments: a realistic approach*. Routledge.

Ang, S., Yahya, A., Abd Aziz, S. and Md Salleh, M. (2015). Isolation, screening, and identification of potential cellulolytic and xylanolytic producers for biodegradation of untreated oil palm trunk and its application in saccharification of lemongrass leaves. *Preparative Biochemistry and Biotechnology*. 45(3), 279-305.

Ang, S. K. (2015). *Cellulases and Xylanase Production by Aspergillus fumigatus SK1 Through Solid State Fermentation for Ethanol Fermentation*, Universiti Teknologi Malaysia.

Ang, S. K., Eva, M. S., Yahaya, A., Abdu-Aziz, S. and Madihah, S. M. (2013). Production of cellulases and xylanase by *Aspergillus fumigatus* SK1 using untreated oil palm trunk through solid state fermentation. *Process Biochemistry*. 48(9), 1293-1302.

Antony, J., Chou, T.-Y. and Ghosh, S. (2003). Training for design of experiments. *Work study*. 52(7), 341-346.

Anwar, Z., Gulfraz, M. and Irshad, M. (2014). Agro-industrial lignocellulosic biomass a key to unlock the future bio-energy: a brief review. *Journal of radiation research and applied sciences*. 7(2), 163-173.

Apiwatanapiwat, W., Vaithanomsat, P., Somkliang, P. and Malapant, T. (2009). Optimization of protein hydrolysate production process from *Jatropha curcas* cake. *World Academy of Science, Engineering and Technology*. 53, 109-112.

Apiwatanapiwat, W., Vaithanomsat, P., Ushiwaka, S., Morimitsu, K., Machida, M., Thanapase, W., Murata, Y. and Kosugi, A. (2016). A new pretreatment using ammonia gas absorption fiber expansion for saccharification of cassava pulp. *Biomass Conversion and Biorefinery*. 6(2), 181-188.

Arevalo-Gallegos, A., Ahmad, Z., Asgher, M., Parra-Saldivar, R. and Iqbal, H. M. (2017). Lignocellulose: A sustainable material to produce value-added products with a zero waste approach—A review. *International journal of biological macromolecules*. 99, 308-318.

Ariff, A., Salleh, M., Ghani, B., Hassan, M., Rusul, G. and Karim, M. (1996). Aeration and yeast extract requirements for kojic acid production by *Aspergillus flavus* link. *Enzyme and microbial technology*. 19(7), 545-550.

Aripin, N. M., Mohd, A. F. and Salleh, M. M. (2012). *Screening of Factors Influencing Biobutanol Production from Pineapple Waste Using 2-level Factorial Design*.

Asfaram, A., Ghaedi, M., Azqhandi, M. A., Goudarzi, A. and Dastkhoon, M. (2016). Statistical experimental design, least squares-support vector machine (LS-SVM) and artificial neural network (ANN) methods for modeling the facilitated adsorption of methylene blue dye. *Advances*. 6(46), 40502-40516.

Ashengroph, M., Nahvi, I. and Amini, J. (2013). Application of Taguchi design and Response surface methodology for improving conversion of isoeugenol into vanillin by resting cells of *Psychrobacter sp.* CSW4. *Iranian journal of pharmaceutical research* 12(3), 411.

Ashengroph, M., Nahvi, I., Zarkesh-Esfahani, H. and Momenbeik, F. (2010). Optimization of media composition for improving conversion of isoeugenol into vanillin with *Pseudomonas sp*. strain KOB10 using the Taguchi method. *Biocatalysis and Biotransformation*. 28(5-6), 339-347.

Ashengroph, M., Nahvi, I., Zarkesh-Esfahani, H. and Momenbeik, F. (2012). Conversion of isoeugenol to vanillin by Psychrobacter sp. strain CSW4. *Applied biochemistry and biotechnology*. 166(1), 1-12.

Asuncion, M. and Mario, H. (2009). A text book of molecular biotechnology. *I. K. International Pvt Ltd.* Chapter 30, 690-704.

Auxenfans, T., Cronier, D., Chabbert, B. and Paes, G. (2017). Understanding the structural and chemical changes of plant biomass following steam explosion pretreatment. *Biotechnoly and Biofuels*. 10, 36.

Azad, F. N., Ghaedi, M., Asfaram, A., Jamshidi, A., Hassani, G., Goudarzi, A., Azqhandi, M. H. A. and Ghaedi, A. (2016). Optimization of the process parameters for the adsorption of ternary dyes by Ni doped FeO (OH)-NWs–AC using response surface methodology and an artificial neural network. *Advances*. 6(24), 19768-19779.

Azhar, S. H. M., Abdulla, R., Jambo, S. A., Marbawi, H., Gansau, J. A., Faik, A. A. M. and Rodrigues, K. F. (2017). Yeasts in sustainable bioethanol production: A review. *Biochemistry and Biophysics Reports*. 10, 52-61.

Baadhe, R. R., Potumarthi, R. and Mekala, N. K. (2014). Influence of dilute acid and alkali pretreatment on reducing sugar production from corncobs by crude enzymatic method: a comparative study. *Bioresource technology*. 162, 213-217.

Bajpai, P. (2016). Structure of Lignocellulosic Biomass *Pretreatment of Lignocellulosic Biomass for Biofuel Production* (10.1007/978-981-10-0687-6_2pp. 7-12).

Bak, J. S., Ko, J. K., Han, Y. H., Lee, B. C., Choi, I.-G. and Kim, K. H. (2009). Improved enzymatic hydrolysis yield of rice straw using electron beam irradiation pretreatment. *Bioresource Technology*. 100(3), 1285-1290.

Balasubashini, M. S., Rukkumani, R. and Menon, V. (2003). Protective effects of ferulic acid on hyperlipidemic diabetic rats. *Acta Diabetologica*. 40(3), 118-122.

Bali, G., Meng, X., Deneff, J. I., Sun, Q. and Ragauskas, A. J. (2015). The effect of alkaline pretreatment methods on cellulose structure and accessibility. *ChemSusChem*. 8(2), 275-279.

Ballesteros, I., Negro, M. J., Oliva, J. M., Cabañas, A., Manzanares, P. and Ballesteros, M. (2006). Ethanol production from steam-explosion pretreated wheat straw. *Proceedings of the 2006 Twenty-Seventh Symposium on Biotechnology for Fuels and Chemicals*: Springer, 496-508.

Bandyopadhyay, B., Humphrey, A. and Taguchi, H. (1967). Dynamic measurement of the volumetric oxygen transfer coefficient in fermentation systems. *Biotechnology and bioengineering*. 9(4), 533-544.

Barghini, P., Di Gioia, D., Fava, F. and Ruzzi, M. (2007). Vanillin production using metabolically engineered *Escherichia coli* under non-growing conditions. *Microbial cell factories*. 6(1), 1.

Barkalow, D. G. and Whistler, R. L. (2012). Cellulose. *AccessScience, McGraw-Hill, doi*. 10, 1097-8542.118200.

Batista, R. (2014). Uses and potential applications of ferulic acid. *Ferulic acid: antioxidant properties, uses and potential health benefits. 1st ed. New York, NY.: Nova Science Publishers, Inc. p*. 39-70.

Béguin, P. and Aubert, J.-P. (1994). The biological degradation of cellulose. *Federation of European Microbiological Societies microbiology reviews*. 13(1), 25-58.

Bekele, L. D., Zhang, W., Liu, Y., Duns, G. J., Yu, C., Jin, L., Li, X., Jia, Q. and Chen, J. (2017). Preparation and characterization of lemongrass fiber (*Cymbopogon species*) for reinforcing application in thermoplastic composites. *Biotechnoly Resources*. 12(3), 5664-5681.

Belanger, F. C. and Havkin-Frenkel, D. (2011). Molecular analysis of a Vanilla hybrid cultivated in Costa Rica. *Handbook of Vanilla Science and technology*. 256-263.

Belmessikh, A., Boukhalfa, H., Mechakra-Maza, A., Gheribi-Aoulmi, Z. and Amrane, A. (2013). Statistical optimization of culture medium for neutral protease production by *Aspergillus oryzae*. Comparative study between solid and submerged fermentations on tomato pomace. *Journal of the Taiwan Institute of Chemical Engineers*. 44(3), 377-385.

Bennett, J. P., Bertin, L., Moulton, B., Fairlamb, I. J., Brzozowski, A. M., Walton, N. J. and Grogan, G. (2008). A ternary complex of hydroxycinnamoyl-CoA hydratase–lyase (HCHL) with acetyl-CoA and vanillin gives insights into substrate specificity and mechanism. *Biochemical Journal*. 414(2), 281-289.

Berlowska, J., Cieciura, W., Borowski, S., Dudkiewicz, M., Binczarski, M., Witonska, I., Otlewska, A. and Kregiel, D. (2016). Simultaneous saccharification and fermentation of sugar beet pulp with mixed bacterial cultures for lactic acid and propylene glycol production. *Molecules*. 21(10), 1380.

Bhutto, A. W., Qureshi, K., Harijan, K., Abro, R., Abbas, T., Bazmi, A. A., Karim, S. and Yu, G. (2017). Insight into progress in pre-treatment of lignocellulosic biomass. *Energy*. 122, 724-745.

Bilal, M., Asgher, M., Iqbal, H. M., Hu, H. and Zhang, X. (2017). Biotransformation of lignocellulosic materials into value-added products—A review. *International journal of biological macromolecules*. 98, 447-458.

Bomgardner, M. (2016). The problem with vanilla–After vowing to go natural, food brands face a shortage of the favored flavor. *Chemical Engineers News*. 94.

Boominathan, K. and Reddy, C. A. (1992). cAMP-mediated differential regulation of lignin peroxidase and manganese-dependent peroxidase production in the white-rot basidiomycete *Phanerochaete chrysosporium*. *Proceedings of the National Academy of Sciences*. 89(12), 5586-5590.

Boukhatem, M. N., Ferhat, M. A., Kameli, A., Saidi, F. and Kebir, H. T. (2014). Lemon grass (*Cymbopogon citratus*) essential oil as a potent anti-inflammatory and antifungal drugs. *Libyan Journal of Medicine*. 9(1), 25431.

Brandon, S. K., Eiteman, M. A., Patel, K., Richbourg, M. M., Miller, D. J., Anderson, W. F. and Doran Peterson, J. (2008). Hydrolysis of Tifton 85 bermudagrass in a pressurized batch hot water reactor. *Journal of chemical technology and biotechnology*. 83(4), 505-512.

Buranov, A. U. and Mazza, G. (2008). Lignin in straw of herbaceous crops. *Industrial crops and products*. 28(3), 237-259.

Burri, J., Graf, M., Lambelet, P. and Löliger, J. (1989). Vanillin: more than a flavouring agent—a potent antioxidant. *Journal of the Science of Food and Agriculture*. 48(1), 49-56.

Cao, Y., Meng, D.-j., Lu, J. and Long, J. (2008). Statistical optimization of xylanase production by Aspergillus niger AN-13 under submerged fermentation using response surface methodology. *African Journal of Biotechnology*. 7(5).

Cara, C., Ruiz, E., Oliva, J. M., Sáez, F. and Castro, E. (2008). Conversion of olive tree biomass into fermentable sugars by dilute acid pretreatment and enzymatic saccharification. *Bioresource Technology*. 99(6), 1869-1876.

Carden, A. A. (1987). Skin tanning composition. Google Patents.

Carvalheiro, F., Duarte, L. C. and Gírio, F. M. (2008). Hemicellulose biorefineries: a review on biomass pretreatments. *Journal of Scientific & Industrial Research*. 849-864.

Cazetta, M., Celligoi, M., Buzato, J. and Scarmino, I. (2007). Fermentation of molasses by *Zymomonas mobilis*: Effects of temperature and sugar concentration on ethanol production. *Bioresource technology*. 98(15), 2824-2828.

Cerrutti, P., Alzamora, S. M. and Vidales, S. L. (1997). Vanillin as an antimicrobial for producing shelf-stable strawberry puree. *Journal of Food Science*. 62(3), 608-610.

Chakraborty, D., Gupta, G. and Kaur, B. (2016). Metabolic engineering of *E. coli* top 10 for production of vanillin through FA catabolic pathway and bioprocess optimization using RSM. *Protein expression and purification*. 128, 123-133.

Chakraborty, D., Kaur, B., Obulisamy, K., Selvam, A. and Wong, J. W. (2017a). Agrowaste to vanillin conversion by a natural *Pediococcus acidilactici* strain BD16. *Environmental technology*. 38(13-14), 1823-1834.

Chakraborty, D., Selvam, A., Kaur, B., Wong, J. W. C. and Karthikeyan, O. P. (2017b). Application of recombinant *Pediococcus acidilactici* BD16 (fcs+/ech+) for bioconversion of agrowaste to vanillin. *Applied microbiology and biotechnology*. 101(14), 5615-5626.

Chandra, R. P., Bura, R., Mabee, W., Berlin, d. A., Pan, X. and Saddler, J. (2007). Substrate pretreatment: The key to effective enzymatic hydrolysis of lignocellulosics? *Biofuels* (pp. 67-93)Springer.

Cheison, S. C., Leeb, E., Toro-Sierra, J. and Kulozik, U. (2011). Influence of hydrolysis temperature and pH on the selective hydrolysis of whey proteins by trypsin and potential recovery of native alpha-lactalbumin. *International Dairy Journal*. 21(3), 166-171.

Chen, H., Zhou, X. and Zhang, J. (2014). Optimization of enzyme assisted extraction of polysaccharides from *Astragalus membranaceus*. *Carbohydrate polymers*. 111, 567-575.

Chen, H. Z. and Liu, Z. H. (2015). Steam explosion and its combinatorial pretreatment refining technology of plant biomass to bio-based products. *Biotechnology journal*. 10(6), 866-885.

Chen, J., Zhang, L.-C., Xing, Y.-M., Wang, Y.-Q., Xing, X.-K., Zhang, D.-W., Liang, H.-Q. and Guo, S.-X. (2013). Diversity and taxonomy of *endophytic xylariaceous* fungi from medicinal plants of Dendrobium (Orchidaceae). *Public Library of Science* 8(3), e58268.

Chen, P., Yan, L., Wu, Z., Li, S., Bai, Z., Yan, X., Wang, N., Liang, N. and Li, H. (2016). A microbial transformation using *Bacillus subtilis* B7-S to produce natural vanillin from ferulic acid. *Science Rep*orts 6, 20400.

Choi, G.-G., Oh, S.-J., Lee, S.-J. and Kim, J.-S. (2015). Production of bio-based phenolic resin and activated carbon from bio-oil and biochar derived from fast pyrolysis of palm kernel shells. *Bioresource technology*. 178, 99-107.

Chundawat, S. P., Venkatesh, B. and Dale, B. E. (2007b). Effect of particle size based separation of milled corn stover on AFEX pretreatment and enzymatic digestibility. *Biotechnology and bioengineering*. 96(2), 219-231.

Converti, A., Aliakbarian, B., Domínguez, J., Vázquez, G. B. and Perego, P. (2010). Microbial production of biovanillin. *Brazilian Journal of Microbiology*. 41(3), 519-530.

Converti, A., Faveri, D. d., Perego, P., Barghini, P., Ruzzi, M. and Sene, L. (2003). Vanillin production by recombinant strains of *Escherichia coli*. *Brazilian Journal of Microbiology*. 34, 108-110.

Costa, C. C., Vaz, M. R. F., Da Costa, J. G., Santos, E. S. and Macedo, G. R. (2011). Selection, Isolation and Growth Kinetic Study of a Bacterial Consortium Obtained from the Potengi Mangrove in the Presence of Crude Oil. *Brazilian Journal of Petroleum and Gas*. 5(4), 217-225.

Croteau, R., Kutchan, T. M. and Lewis, N. G. (2000). Natural products (secondary metabolites). *Biochemistry and molecular biology of plants*. 24, 1250-1319.

Czitrom, V. (1999). One-factor-at-a-time versus designed experiments. *The American Statistician*. 53(2), 126-131.

Dal Bello, E. (2013). Vanillin production from ferulic acid with *Pseudomonas fluorescens* BF13-1p4. Doctoral dissertation, alma

Damato, G. (2012). Biotechnological valorisation of agro-industrial wastes for the production of cellulases.

Davidson, P. and Naidu, A. (2000). Natural food antimicrobial systems *Phytophenols* (pp. 265-293) CRC Press.

Daw, Z., ElBaroty, G. and Ebtesam, A. (1994). Inhibition of *Aspergillus parasiticus* growth and aflatoxin production by some essential oils. *Chemie, Mikrobiologie, Technologie der Lebensmittel (Germany)*.

Dawes, I. W., Sutherland, I. W., Dawes, I. W. and Sutherland, I. W. (1976). *Microbial physiology*. Blackwell Scientific.

de Andrade, H. H. R., Santos, J. H., Gimmler-Luz, M. C., Correa, M. J. F., Lehmann, M. and Reguly, M. L. (1992). Suppressing effect of vanillin on chromosome aberrations that occur spontaneously or are induced by mitomycin C in the germ cell line of *Drosophila melanogaster*. *Mutation Research/Genetic Toxicology*. 279(4), 281-287.

de Carvalho Oliveira, F., Srinivas, K., Helms, G. L., Isern, N. G., Cort, J. R., Gonçalves, A. R. and Ahring, B. K. (2018). Characterization of coffee (Coffea arabica) husk lignin and degradation products obtained after oxygen and alkali addition. *Bioresource technology*. 257, 172-180.

De Faveri, D., Torre, P., Aliakbarian, B., Domínguez, J. M., Perego, P. and Converti, A. (2007). Response surface modeling of vanillin production by *Escherichia coli* JM109pBB1. *Biochemical Engineering Journal*. 36(3), 268-275.

Deba, A. A. (2013). *Production of Biodiesel from Waste cooking oil by Immobilized lipase in pva-alginate-sulfate beads*, Universiti Teknologi Malaysia.

Deshpande, R. (2015). *The initial phase of the sodium bisulfite pulping of softwood dissolving pulp*, Karlstads universitet.

Di Gioia, D., Luziatelli, F., Negroni, A., Ficca, A. G., Fava, F. and Ruzzi, M. (2011). Metabolic engineering of *Pseudomonas fluorescens* for the production of vanillin from ferulic acid. *Journal of biotechnology*. 156(4), 309-316.

Di Gioia, D., Sciubba, L., Ruzzi, M., Setti, L. and Fava, F. (2009). Production of vanillin from wheat bran hydrolyzates via microbial bioconversion. *Journal of chemical technology and biotechnology*. 84(10), 1441-1448.

Dignum, M. J., Kerler, J. and Verpoorte, R. (2001). Vanilla production: technological, chemical, and biosynthetic aspects. *Food Reviews International*. 17(2), 119-120.

dos Santos Barbosa, E., Perrone, D., do Amaral Vendramini, A. L. and Leite, S. G. F. (2008). Vanillin production by *Phanerochaete chrysosporium* grown on green coconut agro-industrial husk in solid state fermentation. *Biotechnology Resources*. 3(4), 1042-1050.

Duff, S. J. and Murray, W. D. (1996). Bioconversion of forest products industry waste cellulosics to fuel ethanol: a review. *Bioresource technology*. 55(1), 1-33.

Duke, S. O. (2010). Herbicide and pharmaceutical relationships. *Weed science*. 58(3), 334-339.

Durant, S. and Karran, P. (2003). Vanillins—a novel family of DNA-PK inhibitors. *Nucleic acids research*. 31(19), 5501-5512.

Egli, T. and Quayle, J. (1986). Influence of the carbon: nitrogen ratio of the growth medium on the cellular composition and the ability of the methylotrophic yeast *Hansenula polymorpha* to utilize mixed carbon sources. *Microbiology*. 132(7), 1779-1788.

El-Etre, A. (2001). Inhibition of acid corrosion of aluminum using vanillin. *Corrosion Science*. 43(6), 1031-1039.

Ezeji, T., Qureshi, N. and Blaschek, H. P. (2007). Butanol production from agricultural residues: Impact of degradation products on *Clostridium beijerinckii* growth and butanol fermentation. *Biotechnoly and Bioeng*ineering 97(6), 1460-1469.

Fache, M., Boutevin, B. and Caillol, S. (2015). Vanillin, a key-intermediate of biobased polymers. *European polymer journal*. 68, 488-502.

Falconnier, B., Lapierre, C., Lesage-Meessen, L., Yonnet, G., Brunerie, P., Colonna-Ceccaldi, B., Corrieu, G. and Asther, M. (1994). Vanillin as a product of ferulic acid biotransformation by the white-rot fungus *Pycnoporus cinnabarinus* I-937: identification of metabolic pathways. *Journal of Biotechnology*. 37(2), 123-132.

Faulds, C. B. and Williamson, G. (1994). Purification and characterization of a ferulic acid esterase (FAE-III) from *Aspergillus niger*: specificity for the phenolic moiety and binding to microcrystalline cellulose. *Microbiology*. 140(4), 779-787.

Fleige, C., Hansen, G., Kroll, J. and Steinbüchel, A. (2013). Investigation of the *Amycolatopsis sp.* strain ATCC 39116 vanillin dehydrogenase and its impact on the biotechnical production of vanillin. *Applied Environmental Microbiology* 79(1), 81-90.

Galaction, A.-I., Cascaval, D., Oniscu, C. and Turnea, M. (2004). Enhancement of oxygen mass transfer in stirred bioreactors using oxygen-vectors. 1. Simulated fermentation broths. *Bioprocess and biosystems engineering*. 26(4), 231-238.

Galadima, A. I., Salleh, M. M., Hussin, H., Chong, C. S., Yahya, A., Mohamad, S. E., Abd-Aziz, S., Yusof, N. N. M., Naser, M. A. and Al-Junid, A. F. M. (2019a). Biovanillin: production concepts and prevention of side product formation. *Biomass Conversion and Biorefinery*. 1-21.

Galadima, A. I., Salleh, M. M., Hussin, H., Safri, N. M., Noor, R. M., Chong, C. S., Yahya, A., Mohamad, S. E., Abd-Aziz, S. and Yusof, N. N. M. (2019b). One-Step Conversion of Lemongrass Leaves Hydrolysate to Biovanillin by *Phanerochaete chrysosporium* ATCC 24725 in Batch Culture. *Waste and Biomass Valorization*. 1-14.

Galbe, M. and Zacchi, G. (2007). Pretreatment of lignocellulosic materials for efficient bioethanol production *Biofuels* (pp. 41-65) Springer.

Gallage, N. J., Hansen, E. H., Kannangara, R., Olsen, C. E., Motawia, M. S., Jorgensen, K., Holme, I., Hebelstrup, K., Grisoni, M. and Moller, B. L. (2014). Vanillin formation from ferulic acid in *Vanilla planifolia* is catalysed by a single enzyme. *Natute Commun*ication 5, 4037.

Gallage, N. J., Jorgensen, K., Janfelt, C., Nielsen, A. J. Z., Naake, T., Dunski, E., Dalsten, L., Grisoni, M. and Moller, B. L. (2018). The Intracellular Localization of the Vanillin Biosynthetic Machinery in Pods of *Vanilla planifolia*. *Plant Cell Physiol*ogy 59(2), 304-318.

Gallage, N. J. and Møller, B. L. (2015). Vanillin–bioconversion and bioengineering of the most popular plant flavor and its de novo biosynthesis in the vanilla orchid. *Molecular plant*. 8(1), 40-57.

Garai, D. and Kumar, V. (2013). A Box–Behnken design approach for the production of xylanase by Aspergillus candidus under solid state fermentation and its application in saccharification of agro residues and *Parthenium hysterophorus* L. *Industrial Crops and Products*. 44, 352-363.

Garcia-Cubero, M. A., Gonzalez-Benito, G., Indacoechea, I., Coca, M. and Bolado, S. (2009). Effect of ozonolysis pretreatment on enzymatic digestibility of wheat and rye straw. *Bioresource Technol*ogy 100(4), 1608-1613.

Garcia-Ochoa, F. and Gomez, E. (2009). Bioreactor scale-up and oxygen transfer rate in microbial processes: an overview. *Biotechnology advances*. 27(2), 153-176.

Garcia-Peña, E. I., Parameswaran, P., Kang, D., Canul-Chan, M. and Krajmalnik-Brown, R. (2011). Anaerobic digestion and co-digestion processes of vegetable and fruit residues: process and microbial ecology. *Bioresource Technology*. 102(20), 9447-9455.

Gasson, M. J., Kitamura, Y., McLauchlan, W. R., Narbad, A., Parr, A. J., Parsons, E. L. H., Payne, J., Rhodes, M. J. and Walton, N. J. (1998). Metabolism of Ferulic Acid to Vanillin A bacterial gene of the enoyl-SCoA *hydratase/isomerase* superfamily encodes an enzyme for the hydration and cleavage of a hydroxycinnamic acid SCoA thioester. *Journal of Biological Chemistry*. 273(7), 4163-4170.

Gauthier, L., Thibault, J. and LeDuy, A. (1991). Measuring kLa with randomly pulsed dynamic method. *Biotechnology and bioengineering*. 37(9), 889-893.

Gawande, P. and Kamat, M. (1999). Production of *Aspergillus xylanase* by lignocellulosic waste fermentation and its application. *Journal of Applied Microbiology*. 87(4), 511-519.

Genova, G., Iacopini, P., Baldi, M., Ranieri, A., Storchi, P. and Sebastiani, L. (2012). Temperature and storage effects on antioxidant activity of juice from red and white grapes. *International journal of food science & technology*. 47(1), 13-23.

Gershenzon, J. (1984). Changes in the levels of plant secondary metabolites under water and nutrient stress *Phytochemical adaptations to stress* (pp. 273-320) Springer.

Ghosh, S., Sachan, A. and Mitra, A. (2005). Degradation of ferulic acid by a white rot fungus *Schizophyllum commune*. *World Journal of Microbiology and Biotechnology*. 21(3), 385-388.

Goëau, H., Bonnet, P. and Joly, A. (2016). Plant identification in an open-world (lifeclef 2016). *Proceedings of the 2016 CLEF 2016-Conference and Labs of the Evaluation forum*, 428-439.

Goff, H. D. and Hartel, R. W. (2013). Flavoring and Coloring Materials *Ice Cream* (pp. 89-119) Springer.

Gottipati, R. and Mishra, S. (2010). Process optimization of adsorption of Cr (VI) on activated carbons prepared from plant precursors by a two-level full factorial design. *Chemical Engineering Journal*. 160(1), 99-107.

Grabber, J. H. (2005). How do lignin composition, structure, and cross-linking affect degradability? A review of cell wall model studies. *Crop Science*. 45(3), 820-831.

Graf, E. (1992). Antioxidant potential of ferulic acid. *Free radical biology and medicine*. 13(4), 435-448.

Gugsa, T. and Yaya, E. E. (2018). Chemical constituents of the traditional skin care and fragrance nut, *Cyperus esculentus* (Tigernut). *American Journal of Essential Oils and Natural Products*. 6(4), 04-12.

Gupta, A. and Verma, J. P. (2015). Sustainable bio-ethanol production from agro-residues: a review. *Renewable and sustainable energy reviews*. 41, 550-567.

Hallac, B. B., Sannigrahi, P., Pu, Y., Ray, M., Murphy, R. J. and Ragauskas, A. J. (2010). Effect of ethanol organosolv pretreatment on enzymatic hydrolysis of *Buddleja davidii* stem biomass. *Industrial & Engineering Chemistry Research*. 49(4), 1467-1472.

Hanaa, A. M., Sallam, Y., El-Leithy, A. and Aly, S. E. (2012). Lemongrass (*Cymbopogon citratus)* essential oil as affected by drying methods. *Annals of Agricultural Sciences*. 57(2), 113-116.

Hassan, E. (2016). Comparative study on the biosorption of Pb (II), Cd (II) and Zn (II) using Lemon grass (*Cymbopogon citratus*): kinetics, isotherms and thermodynamics. *Chemistry International*. 2(2), 89-102.

Hassan, V., Saleem, M., Shaffi, N., Din, K. and Qasuer, M. (2007). Lemongrass: Botany, ethnobotany and chemistry. *Pakistan Journal of Weed Science Research*. 13(1-2), 129-134.

Hendriks, A. and Zeeman, G. (2009a). Pretreatments to enhance the digestibility of lignocellulosic biomass. *Bioresource technology*. 100(1), 10-18.

Herring, C. D., Kenealy, W. R., Shaw, A. J., Covalla, S. F., Olson, D. G., Zhang, J., Sillers, W. R., Tsakraklides, V., Bardsley, J. S. and Rogers, S. R. (2016). Strain and bioprocess improvement of a thermophilic anaerobe for the production of ethanol from wood. *Biotechnology for biofuels*. 9(1), 125.

Hoffmann, R. (1997). Fraudulent molecules. *American Scientist*. 85(4), 314.

Hou, F., Mu, T., Ma, M. and Blecker, C. (2018). Optimization of processing technology using response surface methodology and physicochemical properties of roasted sweet potato. *Food Chemistry*.

Hsu, T.-A. (2018). Pretreatment of biomass *Handbook on bioethanol* (pp. 179-212) Routledge.

Hua, D., Ma, C., Song, L., Lin, S., Zhang, Z., Deng, Z. and Xu, P. (2007). Enhanced vanillin production from ferulic acid using adsorbent resin. *Applied Microbiology and Biotechnol*ogy 74(4), 783-790.

Huang, C., Jeuck, B. and Yong, Q. (2017). Using Pretreatment and Enzymatic Saccharification Technologies to Produce Fermentable Sugars from Agricultural Wastes *Waste Biomass Management–A Holistic Approach* (pp. 15-38) Springer.

Huang, H.-J., Ramaswamy, S., Tschirner, U. W. and Ramarao, B. V. (2008). A review of separation technologies in current and future biorefineries. *Separation and Purification Technology*. 62(1), 1-21.

Huang, Y., Wei, X., Zhou, S., Liu, M., Tu, Y., Li, A., Chen, P., Wang, Y., Zhang, X. and Tai, H. (2015). Steam explosion distinctively enhances biomass enzymatic saccharification of cotton stalks by largely reducing cellulose polymerization degree in *Gossypium barbadense* and *Gossypium hirsutum. Bioresource technology*. 181, 224-230.

Huang, Z., Dostal, L. and Rosazza, J. (1994). Purification and characterization of a ferulic acid decarboxylase from *Pseudomonas fluorescens*. *Journal of bacteriology*. 176(19), 5912-5918.

Hussin, A. M., Collins, S., Merali, Z., Parker, M., Elliston, A., Wellner, N. and Waldron, K. (2013). Characterisation of lignocellulosic sugars from municipal solid waste residue. *Biomass and bioenergy*. 51, 17-25.

Hussin, H., Salleh, M. M., Siong, C. C., Naser, M. A., Abd-Aziz, S. and Al-Junid, A. F. M. (2015). Optimization of Biovanillin Production of Lemongrass Leaves Hydrolysates Through *Phanerochaete Chrysosporium*. *Jurnal Teknologi*. 77(31).

Idrees, M., Adnan, A. and Qureshi, F. A. (2013). Optimization of sulfide/sulfite pretreatment of lignocellulosic biomass for lactic acid production. *Biomedical Research International*. 2013, 934171.

Iekhsan, O., Jaya, V., Mustaffa, M. and Rais, M. (1998). Antitoxin compounds from the plant extracts of Ipomea pes-caprae (L.) R. Br. *Proceedings of the 1998 8th FAOBMB Congress. Kuala Lumpur*, 20.

Ishii, T. (1997). Structure and functions of feruloylated polysaccharides. *Plant Science*. 127(2), 111-127.

Jiang, K., Li, L., Long, L. and Ding, S. (2018). Comprehensive evaluation of combining hydrothermal pretreatment (autohydrolysis) with enzymatic hydrolysis for efficient release of monosaccharides and ferulic acid from corn bran. *Industrial Crops and Prod*ucts 113, 348-357.

Johnson, T. S., Ravishankar, G. and Venkataraman, L. (1996). Biotransformation of ferulic acid and vanillylamine to *capsaicin* and vanillin in immobilized cell cultures of *Capsicum frutescens*. *Plant cell, tissue and organ culture*. 44(2), 117-121.

Jönsson, L. J. and Martín, C. (2016). Pretreatment of lignocellulose: formation of inhibitory by-products and strategies for minimizing their effects. *Bioresource technology*. 199, 103-112.

Jørgensen, H., Kristensen, J. B. and Felby, C. (2007). Enzymatic conversion of lignocellulose into fermentable sugars: challenges and opportunities. *Biofuels, Bioproducts and Biorefining*. 1(2), 119-134.

Jurková, M. and Wurst, M. (1993). Biodegradation of aromatic carboxylic acids by *Pseudomonas mira*. *Federation of European microbiological Society* 111(2-3), 245-250.

Kamberović, Ž., Korać, M., Ivšić, D., Nikolić, V. and Ranitović, M. (2018). Hydrometallurgical process for extraction of metals from electronic waste-part I: Material characterization and process option selection. *Metallurgical and Materials Engineering*.

Kamsani, N., Salleh, M. M., Yahya, A. and Chong, C. S. (2016). Production of lignocellulolytic enzymes by microorganisms isolated from *Bulbitermes sp*. termite gut in solid-state fermentation. *Waste and biomass valorization*. 7(2), 357-371.

Kang, H.-S., Kim, M.-H., Aramanadka, S. B., Kang, H.-Y. and Lee, K.-Q. (2017). Suppression of tension variations in hydro-pneumatic riser tensioner by using force compensation control. *Ocean Systems Engineering*. 7(3), 225-246.

Karode, B., Patil, U. and Jobanputra, A. (2013). Biotransformation of low cost lignocellulosic substrates into vanillin by white rot fungus, *Phanerochaete chrysosporium* NCIM 1197.

Kaur, B. and Chakraborty, D. (2013). Biotechnological and molecular approaches for vanillin production: a review. *Applied biochemistry and biotechnology*. 169(4), 1353-1372.

Kaur, B., Chakraborty, D. and Kumar, B. (2014). Metabolic engineering of *Pediococcus acidilactici* BD16 for production of vanillin through ferulic acid catabolic pathway and process optimization using response surface methodology. *Applied microbiology and biotechnology*. 98(20), 8539-8551.

Kaur, H. and Dutt, D. (2013). Anatomical, morphological and chemical characterization of lignocellulose by-products of lemon and sofia grasses obtained after recuperation of essential oils by steam distillation. *Cellulose Chemistry and Technology*. 47(1-2), 83-94.

Keshava, C., Keshava, N., Whong, W. Z., Nath, J. and Ong, T. m. (1997). Inhibition of methotrexate-induced chromosomal damage by vanillin and chlorophyllin in V79 cells. *Teratogenesis, carcinogenesis, and mutagenesis*. 17(6), 313-326.

Kim, D., Schwalbe, W., Unger, H., Hohmann, H. and Schins, H. (1984). Two-phase description of hydrodynamic fragmentation processes within thermal detonation waves. *Journal of heat transfer*. 106(4), 728-734.

Kim, J. S., Lee, Y. and Kim, T. H. (2016). A review on alkaline pretreatment technology for bioconversion of lignocellulosic biomass. *Bioresource Technology*. 199, 42-48.

Kim, S. and Holtzapple, M. T. (2006). Effect of structural features on enzyme digestibility of corn stover. *Bioresource Technology*. 97(4), 583-591.

Kirk, T. K. (2018). *Lignin Biodegradation: Microbiology, Chemistry, and Potential Applications: Volume I*. CRC press.

Klemm, D., Heublein, B., Fink, H. P. and Bohn, A. (2005). Cellulose: fascinating biopolymer and sustainable raw material. *Angewandte Chemie International Edition*. 44(22), 3358-3393.

Kohlmann, K., Sarikaya, A., Westgate, P., Weil, J., Velayudhan, A., Hendrickson, R. and Ladisch, M. (1995). Enhanced enzyme activities on hydrated lignocellulosic substrates. *Enzymatic degradation of insoluble carbohydrates*. 618, 237-255.

Kometani, T., Tanimoto, H., Nishimura, T. and Okada, S. (1993). Glucosylation of vanillin by cultured plant cells. *Bioscience, biotechnology, and biochemistry*. 57(8), 1290-1293.

Korpi, A., Pasanen, A.-L., Pasanen, P. and Kalliokoski, P. (1997). Microbial growth and metabolism in house dust. *International Biodeterioration & Biodegradation*. 40(1), 19-27.

Kostka, G. and Kaczkowski, J. (1989). Oxygen requirements of *Aspergillus awamori* fungi in the process of glucoamylase biosynthesis. *Acta biotechnologica*. 9(3), 227-232.

Krings, U., Kelch, M. and Berger, R. G. (1993). Adsorbents for the recovery of aroma compounds in fermentation processes. *Journal of Chemical Technology & Biotechnology*. 58(3), 293-299.

Kulkarni, S. J., Shinde, N. L. and Goswami, A. K. (2015). A review on ethanol production from agricultural waste raw material. *International Journal of Scientific Research in Science, Engineering and Technology* 1, 231-233.

Kumar, A. K. and Sharma, S. (2017). Recent updates on different methods of pretreatment of lignocellulosic feedstocks: a review. *Bioresources and Bioprocessing*. 4(1), 7.

Kumar, N. and Pruthi, V. (2014). Potential applications of ferulic acid from natural sources. *Biotechnology Reports*. 4, 86-93.

Kumar, P., Barrett, D. M., Delwiche, M. J. and Stroeve, P. (2009). Methods for pretreatment of lignocellulosic biomass for efficient hydrolysis and biofuel production. *Industrial & engineering chemistry research*. 48(8), 3713-3729.

Kundu, A. (2017). Vanillin biosynthetic pathways in plants. *Planta*. 245(6), 1069-1078.

Laser, M., Schulman, D., Allen, S. G., Lichwa, J., Antal, M. J. and Lynd, L. R. (2002). A comparison of liquid hot water and steam pretreatments of sugar cane bagasse for bioconversion to ethanol. *Bioresource technology*. 81(1), 33-44.

Lee, H., Hamid, S. B. A. and Zain, S. (2014). Conversion of lignocellulosic biomass to nanocellulose: structure and chemical process. *The Scientific World Journal*. 2014, 631013

Lee, K.-Y., Lee, J.-H., Yang, H.-J. and Song, K. B. (2016a). Characterization of a starfish gelatin film containing vanillin and its application in the packaging of crab stick. *Food science and biotechnology*. 25(4), 1023-1028.

Lee, S. H., Chan, C. S., Wilkin, P. and Remagnino, P. (2015). Deep-plant: Plant identification with convolutional neural networks. *Proceedings of the 2015 Image Processing (ICIP), 2015 IEEE International Conference on*: IEEE, 452-456.

Lee, S. H., Chang, Y. L., Chan, C. S. and Remagnino, P. (2016b). Plant Identification System based on a Convolutional Neural Network for the LifeClef 2016 Plant Classification Task. *Proceedings of the 2016b CLEF (Working Notes)*, 502-510.

Lesage-Meessen, L., Delattre, M., Haon, M., Thibault, J.-F., Ceccaldi, B. C., Brunerie, P. and Asther, M. (1996a). A two-step bioconversion process for vanillin production from ferulic acid combining *Aspergillus niger* and *Pycnoporus cinnabarinus*. *Journal of biotechnology*. 50(2-3), 107-113.

Lesage-Meessen, L., Haon, M., Delattre, M., Thibault, J.-F., Ceccaldi, B. C. and Asther, M. (1997). An attempt to channel the transformation of vanillic acid into vanillin by controlling methoxyhydroquinone formation in *Pycnoporus cinnabarinus* with cellobiose. *Applied microbiology and biotechnology*. 47(4), 393-397.

Lesage-Meessen, L., Lomascolo, A., Bonnin, E., Thibault, J.-F., Buleon, A., Roller, M., Asther, M., Record, E., Ceccaldi, B. C. and Asther, M. (2002). A biotechnological process involving filamentous fungi to produce natural crystalline vanillin from maize bran. *Applied biochemistry and biotechnology*. 102(1-6), 141-153.

Lesage-Meessen, L., Stentelaire, C., Lomascolo, A., Couteau, D., Asther, M., Moukha, S., Record, E., Sigoillot, J. C. and Asther, M. (1999). Fungal transformation of ferulic acid from sugar beet pulp to natural vanillin. *Journal of the Science of Food and Agriculture*. 79(3), 487-490.

Li, X., Yang, J., Li, X., Gu, W., Huang, J. and Zhang, K.-Q. (2008). The metabolism of ferulic acid via 4-vinylguaiacol to vanillin by *Enterobacter sp*. Px6-4 isolated from Vanilla root. *Process Biochemistry*. 43(10), 1132-1137.

Li, Y., Cui, F., Liu, Z., Xu, Y. and Zhao, H. (2007). Improvement of xylanase production by *Penicillium oxalicum* ZH-30 using response surface methodology. *Enzyme and Microbial Technology*. 40(5), 1381-1388.

Lima, L. N., Oliveira, G. C., Rojas, M. J., Castro, H. F., Da Rós, P. C., Mendes, A. A., Giordano, R. L. and Tardioli, P. W. (2015). Immobilization of *Pseudomonas fluorescens* lipase on hydrophobic supports and application in biodiesel synthesis by transesterification of vegetable oils in solvent-free systems. *Journal of industrial microbiology & biotechnology*. 42(4), 523-535.

Lin, C. B. (2011). Vanillin polymers for use in darkening the skin. Google Patents.

Lin, J.-Y. and Lin, K.-Y. A. (2019). Catalytic conversion of a lignin model compound to value-added products using Cu/TEMPO-catalyzed aerobic oxidation. *Biomass Conversion and Biorefinery*. 1-7.

Lin, L., Yan, R., Liu, Y. and Jiang, W. (2010). In-depth investigation of enzymatic hydrolysis of biomass wastes based on three major components: cellulose, hemicellulose and lignin. *Bioresource Technology*. 101(21), 8217-8223.

Lingier, S., Spiesschaert, Y., Dhanis, B., De Wildeman, S. and Du Prez, F. E. (2017). Rigid polyurethanes, polyesters, and polycarbonates from renewable ketal monomers. *Macromolecules*. 50(14), 5346-5352.

Lirdprapamongkol, K., Sakurai, H., Kawasaki, N., Choo, M.-K., Saitoh, Y., Aozuka, Y., Singhirunnusorn, P., Ruchirawat, S., Svasti, J. and Saiki, I. (2005). Vanillin suppresses in vitro invasion and in vivo metastasis of mouse breast cancer cells. *European journal of pharmaceutical sciences*. 25(1), 57-65.

Liu, Y. A. (2018). *Physical Cleaning of Coal: Present Developing Methods*. CRC Press.

Llevot, A., Dannecker, P. K., von Czapiewski, M., Over, L. C., Soeyler, Z. and Meier, M. A. (2016). Renewability is not Enough: Recent Advances in the Sustainable Synthesis of Biomass-Derived Monomers and Polymers. *Chemistry–A European Journal*. 22(33), 11510-11521.

Lopez-Malo, A., Alzamora, S. and Argaiz, A. (1997). Effect of vanillin concentration, pH and incubation temperature onAspergillus flavus, *Aspergillus niger*, *Aspergillus ochraceus* and *Aspergillus parasiticus growth*. *Food Microbiology*. 14(2), 117-124.

López-Malo, A., Alzamora, S. and Argaiz, A. (1998). Vanillin and pH synergistic effects on mold growth. *Journal of Food Science*. 63(1), 143-146.

Lun, O. K., Wai, T. B. and Ling, L. S. (2014). Pineapple cannery waste as a potential substrate for microbial biotranformation to produce vanillic acid and vanillin. *International Food Research Journal*. 21(3), 953.

Ma, H., Liu, W.-W., Chen, X., Wu, Y.-J. and Yu, Z.-L. (2009). Enhanced enzymatic saccharification of rice straw by microwave pretreatment. *Bioresource Technology*. 100(3), 1279-1284.

Ma, X. k. and Daugulis, A. J. (2014). Transformation of ferulic acid to vanillin using a fed-batch solid–liquid two-phase partitioning bioreactor. *Biotechnology progress*. 30(1), 207-214.

Madihah, M., Ariff, A., Sahaid, K., Suraini, A. and Karim, M. (2001). Direct fermentation of gelatinized sago starch to acetone–butanol–ethanol by *Clostridium acetobutylicum*. *World Journal of Microbiology and Biotechnology*. 17(6), 567-576.

Madihah, M. and Suraini, A.-A. (2017). Application of pH Control Strategies for Biobutanol Production by *Clostridium beijerinckii* SR1 using hydrolysate of pretreated lemongrass leaves. 41.

Magnusson, L., Islam, R., Sparling, R., Levin, D. and Cicek, N. (2008). Direct hydrogen production from cellulosic waste materials with a single-step dark fermentation process. *International Journal of Hydrogen Energy*. 33(20), 5398-5403.

Makela, M. R., Marinovic, M., Nousiainen, P., Liwanag, A. J., Benoit, I., Sipila, J., Hatakka, A., de Vries, R. P. and Hilden, K. S. (2015). Aromatic metabolism of filamentous fungi in relation to the presence of aromatic compounds in plant biomass. *Advance and Applied Microbiol*ogy 91, 63-137.

Manabe, Y., Verhertbruggen, Y., Gille, S., Harholt, J., Chong, S.-L., Pawar, P. M.-A., Mellerowicz, E. J., Tenkanen, M., Cheng, K. and Pauly, M. (2013). Reduced wall acetylation proteins play vital and distinct roles in cell wall O-acetylation in *Arabidopsis*. *Plant physiology*. 163(3), 1107-1117.

Masamba, W., Kamanula, J., Henry, E. and Nyirenda, G. (2003). Extraction and analysis of lemongrass (*Cymbopogon citratus*) oil: an essential oil with potential to control the larger grain borer (*Prostephanus truncatus*) in stored roducts in Malawi. *Malawi Journal of Agricultural Sciences*. 2(1), 56-64.

Matasyoh, J. C., Wagara, I. N. and Nakavuma, J. L. (2011). Chemical composition of *Cymbopogon citratus* essential oil and its effect on mycotoxigenic *Aspergillus species*. *African Journal of Food Science*. 5(3), 138-142.

Mathew, S. and Abraham, T. E. (2004). Ferulic acid: an antioxidant found naturally in plant cell walls and feruloyl esterases involved in its release and their applications. *Critical reviews in biotechnology*. 24(2-3), 59-83.

Mathews, S. L., Pawlak, J. and Grunden, A. M. (2015). Bacterial biodegradation and bioconversion of industrial lignocellulosic streams. *Applied microbiology and biotechnology*. 99(7), 2939-2954.

Maurya, D. P., Singla, A. and Negi, S. (2015). An overview of key pretreatment processes for biological conversion of lignocellulosic biomass to bioethanol. *3 Biotech*. 5(5), 597-609.

McIntosh, S. and Vancov, T. (2010). Enhanced enzyme saccharification of Sorghum bicolor straw using dilute alkali pretreatment. *Bioresource technology*. 101(17), 6718-6727.

McIntosh, S., Vancov, T., Palmer, J. and Spain, M. (2012). Ethanol production from *Eucalyptus* plantation thinnings. *Bioresource Technol*ogy 110, 264-272.

McMillan, J. D. (1994). Pretreatment of lignocellulosic biomass. *Proceedings of the 1994 American Chemical Society symposium series (USA)*,

Meilgaard, M. C. (2017). Beer Flavor Terminology—A Case History *Applied Sensory Analysis of Foods* (pp. 73-87) Routledge.

Meiying, Z., Guocheng, D. and Jian, C. (2002). pH control strategy of batch microbial transglutaminase production with *Streptoverticillium mobaraense*. *Enzyme and Microbial Technology*. 31(4), 477-481.

Menon, V. and Rao, M. (2012). Trends in bioconversion of lignocellulose: biofuels, platform chemicals & biorefinery concept. *Progress in energy and combustion science*. 38(4), 522-550.

Miller, G. (1959). Use of DNS reagent for the measurement of reducing sugar. *Anals of Chem*istry 31(1), 426-428.

Mirghani, M. E. S., Liyana, Y. and Parveen, J. (2012). Bioactivity analysis of lemongrass (*Cymbopogan citratus*) essential oil.

Mishra, S., Singh, P. K., Dash, S. and Pattnaik, R. (2018). Microbial pretreatment of lignocellulosic biomass for enhanced biomethanation and waste management. *3 Biotech*. 8(11), 458.

Mohamed, M. S., Mohamad, R., Manan, M. A. and Ariff, A. B. (2012). Enhancement of red pigment production by *Monascus purpureus* FTC 5391 through retrofitting of helical ribbon impeller in stirred-tank fermenter. *Food and bioprocess technology*. 5(1), 80-91.

Mohd Sharif, N. S. A., Thor, E. S., Zainol, N. and Jamaluddin, M. F. (2017). Optimization of ferulic acid production from banana stem waste using central composite design. *Environmental Progress & Sustainable Energy*. 36(4), 1217-1223.

Monlau, F., Barakat, A., Trably, E., Dumas, C., Steyer, J.-P. and Carrère, H. (2013). Lignocellulosic materials into biohydrogen and biomethane: impact of structural features and pretreatment. *Critical reviews in environmental science and technology*. 43(3), 260-322.

Montes, A., Merino, R., De los Santos, D., Pereyra, C. and De La Ossa, E. M. (2017). Micronization of vanillin by rapid expansion of supercritical solutions process. *Journal of CO2 Utilization*. 21, 169-176.

Montgomery, D. C. (2017). *Design and analysis of experiments*. John wiley & sons.

Morjanoff, P. and Gray, P. (1987). Optimization of steam explosion as a method for increasing susceptibility of sugarcane bagasse to enzymatic saccharification. *Biotechnology and Bioengineering*. 29(6), 733-741.

Mosier, N., Hendrickson, R., Ho, N., Sedlak, M. and Ladisch, M. R. (2005a). Optimization of pH controlled liquid hot water pretreatment of corn stover. *Bioresource technology*. 96(18), 1986-1993.

Mosier, N., Wyman, C., Dale, B., Elander, R., Lee, Y., Holtzapple, M. and Ladisch, M. (2005b). Features of promising technologies for pretreatment of lignocellulosic biomass. *Bioresource technology*. 96(6), 673-686.

Motedayen, N., Ismail, M. B. and Nazarpour, F. (2013). Bioconversion of ferulic acid to vanillin by combined action of *Aspergillus niger* K8 and *Phanerochaete crysosporium* ATCC 24725. *African Journal of Biotechnology*. 12(47), 6618-6624.

Muheim, A. and Lerch, K. (1999). Towards a high-yield bioconversion of ferulic acid to vanillin. *Applied microbiology and biotechnology*. 51(4), 456-461.

Murthy, H. N., Lee, E.-J. and Paek, K.-Y. (2014). Production of secondary metabolites from cell and organ cultures: strategies and approaches for biomass improvement and metabolite accumulation. *Plant Cell, Tissue and Organ Culture (PCTOC)*. 118(1), 1-16.

Musaalbakri, A., Ariff, A., Rosfarizan, M. and Ismail, A. (2006). Aeration and agitation strategies for the improvement of red pigment production by *Monascus purpureus* FTC 5391. *Journal of Tropical Agriculture and Food Science*. 34(1), 89.

Myers, R. H., Montgomery, D. C., Vining, G. G., Borror, C. M. and Kowalski, S. M. (2004). Response surface methodology: a retrospective and literature survey. *Journal of quality technology*. 36(1), 53-77.

Nadja, G. and Altenbuchner, J. (2016). Genetic engineering of *pseudomonas putida* kt2440 for rapid and high yield production of vanillin from ferulic acid. Google Patents.

Narbad, A. and Gasson, M. J. (1998). Metabolism of ferulic acid via vanillin using a novel CoA-dependent pathway in a newly-isolated strain of *Pseudomonas fluorescens*. *Microbiology*. 144(5), 1397-1405.

Nazareth, S. and Mavinkurve, S. (1986). Degradation of ferulic acid via 4-vinylguaiacol by *Fusarium solani* (Mart.) Sacc. *Canadian Journal of Microbiology*. 32(6), 494-497.

Nazila, M., Maznah, B. T. I. and Forough, N. (2013). Bioconversion of ferulic acid to vanillin by combined action of *Aspergillus niger* K8 and *Phanerochaete crysosporium* ATCC 24725. *African Journal of Biotechnology*. 12(47), 6618-6624.

Negrelle, R. and Gomes, E. (2007). Cymbopogon citratus (DC.) Stapf: chemical composition and biological activities. *Brazilian Journal of Medicinal Plants*. 9(1), 80-92.

Negro, M. J., Manzanares, P., Ballesteros, I., Oliva, J. M., Cabañas, A. and Ballesteros, M. (2003). Hydrothermal pretreatment conditions to enhance ethanol production from poplar biomass *Biotechnology for Fuels and Chemicals* (pp. 87-100) Springer.

Nickell, L. G. (1976). Vanillin as ripener for sugarcane. Google Patents.

Nitayavardhana, S., Rakshit, S. K., Grewell, D., van Leeuwen, J. H. and Khanal, S. K. (2008). Ultrasound pretreatment of cassava chip slurry to enhance sugar release for subsequent ethanol production. *Biotechnology and bioengineering*. 101(3), 487-496.

Niu, F., Li, M., Huang, Q., Zhang, X., Pan, W., Yang, J. and Li, J. (2017). The characteristic and dispersion stability of nanocellulose produced by mixed acid hydrolysis and ultrasonic assistance. *Carbohydrate polymers*. 165, 197-204.

Norli, I., Fazilah, A. and Pazli, I. M. (2017). Agricultural Biomass Utilisation as a Key Driver for Malaysian Bioeconomy *Knowledge-Driven Developments in the Bioeconomy* (pp. 141-159) Springer.

Ntaikou, I., Antonopoulou, G. and Lyberatos, G. (2010). Biohydrogen production from biomass and wastes via dark fermentation: a review. *Waste and Biomass Valorization*. 1(1), 21-39.

Oberoi, H. S., Rawat, R. and Chadha, B. S. (2014). Response surface optimization for enhanced production of cellulases with improved functional characteristics by newly isolated *Aspergillus niger* HN-2. *Antonie van Leeuwenhoek*. 105(1), 119-134.

Oddou, J., Stentelaire, C., Lesage-Meessen, L., Asther, M. and Ceccaldi, B. C. (1999). Improvement of ferulic acid bioconversion into vanillin by use of high-density cultures of *Pycnoporus cinnabarinus*. *Applied microbiology and biotechnology*. 53(1), 1-6.

Ou, S. and Kwok, K. C. (2004). Ferulic acid: pharmaceutical functions, preparation and applications in foods. *Journal of the Science of Food and Agriculture*. 84(11), 1261-1269.

Ou, S., Luo, Y., Xue, F., Huang, C., Zhang, N. and Liu, Z. (2007). Seperation and purification of ferulic acid in alkaline-hydrolysate from sugarcane bagasse by activated charcoal adsorption/anion macroporous resin exchange chromatography. *Journal of Food Engineering*. 78(4), 1298-1304.

Overhage, J., Priefert, H., Rabenhorst, J. and Steinbüchel, A. (1999). Biotransformation of eugenol to vanillin by a mutant of *Pseudomonas sp*. strain HR199 constructed by disruption of the vanillin dehydrogenase (*vdh*) gene. *Applied microbiology and biotechnology*. 52(6), 820-828.

Overhage, J., Steinbüchel, A. and Priefert, H. (2003). Highly efficient biotransformation of eugenol to ferulic acid and further conversion to vanillin in recombinant strains of *Escherichia coli*. *Applied and environmental microbiology*. 69(11), 6569-6576.

Özgen, S. and Yildiz, A. (2010). Application of Box—Behnken Design to Modeling the Effect of Smectite Content on Swelling to Hydrocyclone Processing of Bentonites with Various Geologic Properties. *Clays and Clay Minerals*. 58(3), 431-448.

Pandey, A. (2003). Solid-state fermentation. *Biochemical Engineering Journal*. 13(2-3), 81-84.

Park, S. H., Ong, R. G. and Sticklen, M. (2016). Strategies for the production of cell wall-deconstructing enzymes in lignocellulosic biomass and their utilization for biofuel production. *Plant biotechnology journal*. 14(6), 1329-1344.

Patil, P. D. and Yadav, G. D. (2018). Comparative Studies of White-Rot Fungal Strains (*Trametes hirsuta* MTCC-1171 and *Phanerochaete chrysosporium* NCIM-1106) for Effective Degradation and Bioconversion of Ferulic Acid. *American Chemical Society Omega*. 3(11), 14858-14868.

Peleteiro, S., Santos, V., Garrote, G. and Parajó, J. C. (2016). Furfural production from *eucalyptus* wood using an acidic ionic liquid. *Carbohydrate polymers*. 146, 20-25.

Pérez-Bibbins, B., Torrado-Agrasar, A., Salgado, J. M., Mussatto, S. I. and Domínguez, J. M. (2016). Xylitol production in immobilized cultures: a recent review. *Critical reviews in biotechnology*. 36(4), 691-704.

Pérez-Rodríguez, N., de Souza Oliveira, R. P., Agrasar, A. M. T. and Domínguez, J. M. (2016). Ferulic acid transformation into the main vanilla aroma compounds by *Amycolatopsis* sp. ATCC 39116. *Applied microbiology and biotechnology*. 100(4), 1677-1689.

Pérez, J., Ballesteros, I., Ballesteros, M., Sáez, F., Negro, M. and Manzanares, P. (2008). Optimizing liquid hot water pretreatment conditions to enhance sugar recovery from wheat straw for fuel-ethanol production. *Fuel*. 87(17-18), 3640-3647.

Pessôa, M. G., Paulino, B. N., Mano, M. C. R., Neri-Numa, I. A., Molina, G. and Pastore, G. M. (2017). Fusarium species—a promising tool box for industrial biotechnology. *Applied microbiology and biotechnology*. 101(9), 3493-3511.

Plaggenborg, R., Overhage, J., Loos, A., Archer, J. A., Lessard, P., Sinskey, A. J., Steinbüchel, A. and Priefert, H. (2006). Potential of *Rhodococcus* strains for biotechnological vanillin production from ferulic acid and eugenol. *Applied microbiology and biotechnology*. 72(4), 745.

Plaggenborg, R., Overhage, J., Steinbüchel, A. and Priefert, H. (2003). Functional analyses of genes involved in the metabolism of ferulic acid in *Pseudomonas putida* KT2440. *Applied microbiology and biotechnology*. 61(5-6), 528-535.

Potters, L., Kavanagh, B., Galvin, J. M., Hevezi, J. M., Janjan, N. A., Larson, D. A., Mehta, M. P., Ryu, S., Steinberg, M. and Timmerman, R. (2010). American Society for Therapeutic Radiology and Oncology (ASTRO) and American College of Radiology (ACR) practice guideline for the performance of stereotactic body radiation therapy. *International Journal of Radiation Oncology, Biology and Physics*. 76(2), 326-332.

Priefert, H., Rabenhorst, J. and Steinbüchel, A. (2001). Biotechnological production of vanillin. *Applied Microbiology and Biotechnology*. 56(3-4), 296-314.

Puligundla, P., Oh, S.-E. and Mok, C. (2016). Microwave-assisted pretreatment technologies for the conversion of lignocellulosic biomass to sugars and ethanol: a review. *Carbon Letters*. 17(1), 1-10.

Qiu, Z., Han, T., Lam, J. W. and Tang, B. Z. (2017). Recent new methodologies for acetylenic polymers with advanced functionalities *Polymer Synthesis Based on Triple-bond Building Blocks* (pp. 33-71) Springer.

Quesada-Medina, J., López-Cremades, F. J. and Olivares-Carrillo, P. (2010). Organosolv extraction of lignin from hydrolyzed almond shells and application of the δ-value theory. *Bioresource technology*. 101(21), 8252-8260.

Rabenhorst, J. (1996). Production of methoxyphenol-type natural aroma chemicals by biotransformation of eugenol with a new *Pseudomonas sp*. *Applied Microbiology and Biotechnology*. 46(5-6), 470-474.

Rabenhorst, J. and Hopp, R. (2000). Process for the preparation of vanillin and microorganisms suitable therefor. Google Patents.

Ramachandra Rao, S. and Ravishankar, G. A. (2000). Vanilla flavour: production by conventional and biotechnological routes. *Journal of the Science of Food and Agriculture*. 80(3), 289-304.

Rao, S. R. and Ravishankar, G. A. (2000). Biotransformation of protocatechuic aldehyde and caffeic acid to vanillin and *capsaicin* in freely suspended and immobilized cell cultures of *Capsicum frutescens*. *Journal of biotechnology*. 76(2), 137-146.

Ravindran, R. and Jaiswal, A. K. (2016). A comprehensive review on pre-treatment strategy for lignocellulosic food industry waste: challenges and opportunities. *Bioresource technology*. 199, 92-102.

Reddy, K. O., Maheswari, C. U., Shukla, M. and Rajulu, A. V. (2012). Chemical composition and structural characterization of *Napier* grass fibers. *Materials letters*. 67(1), 35-38.

Reiser, J., Muheim, A., Hardegger, M., Frank, G. and Fiechter, A. (1994). Aryl-alcohol dehydrogenase from the white-rot fungus *Phanerochaete chrysosporium*. Gene cloning, sequence analysis, expression, and purification of the recombinant enzyme. *Journal of Biological Chemistry*. 269(45), 28152-28159.

Rencoret, J., Prinsen, P., Gutiérrez, A., Martínez, A. n. T. and del Río, J. C. (2015). Isolation and structural characterization of the milled wood lignin, dioxane lignin, and cellulolytic lignin preparations from brewer's spent grain. *Journal of agricultural and food chemistry*. 63(2), 603-613.

Retnakaran, A. (1984). Repellent for black fly. Google Patents.

Rivers, D. B. and Emert, G. H. (1987). Lignocellulose pretreatment: a comparison of wet and dry ball attrition. *Biotechnology Letters*. 9(5), 365-368.

Rocha-Valadez, J., Albiter, V., Caro, M., Serrano-Carreón, L. and Galindo, E. (2007). A fermentation system designed to independently evaluate mixing and/or oxygen tension effects in microbial processes: development, application and performance. *Bioprocess and biosystems engineering*. 30(2), 115-122.

Rocha, M. V. P., Rodrigues, T. H. S., Melo, V. M., Gonçalves, L. R. and de Macedo, G. R. (2011). Cashew apple bagasse as a source of sugars for ethanol production by *Kluyveromyces marxianus* CE025. *Journal of industrial microbiology & biotechnology*. 38(8), 1099-1107.

Rodriguez, C., Alaswad, A., Benyounis, K. and Olabi, A. (2017). Pretreatment techniques used in biogas production from grass. *Renewable and sustainable energy reviews*. 68, 1193-1204.

Rols, J. and Goma, G. (1991). Enhanced oxygen transfer rates in fermentation using soybean oil-in-water dispersions. *Biotechnology letters*. 13(1), 7-12.

Rosfarizan, M., Arbakariya, A., Hassan, M. A., Karim, M. I. A., Hiroshi, S. and Suteaki, S. (2002). Importance of carbon source feeding and pH control strategies for maximum kojic acid production from sago starch by *Aspergillus flavus*. *Journal of bioscience and bioengineering*. 94(2), 99-105.

Rosfarizan, M. and Ariff, A. (2006). Kinetics of kojic acid fermentation by *Aspergillus flavus* link S44-1 using sucrose as a carbon source under different pH conditions. *Biotechnology and Bioprocess Engineering*. 11(1), 72-79.

Rosfarizan, M., Ariff, A. B., Hassan, M. A. and Karim, M. I. A. (2000). Influence of pH on Kojic Acid Fermentation by *Aspergillus flavus*. *Pakistan Journal of Biological Sciences*. 3(6), 977-982.

Roukas, T. (2016). The role of oxidative stress on carotene production by *Blakeslea trispora* in submerged fermentation. *Critical reviews in biotechnology*. 36(3), 424-433.

Ryu, D. D., Lee, S. B., Tassinari, T. and Macy, C. (1982). Effect of compression milling on cellulose structure and on enzymatic hydrolysis kinetics. *Biotechnology and Bioengineering*. 24(5), 1047-1067.

Saha, B. C., Iten, L. B., Cotta, M. A. and Wu, Y. V. (2005). Dilute acid pretreatment, enzymatic saccharification and fermentation of wheat straw to ethanol. *Process Biochemistry*. 40(12), 3693-3700.

Saha, R., Saha, N., Donofrio, R. S. and Bestervelt, L. L. (2013). Microbial siderophores: a mini review. *Journal of basic microbiology*. 53(4), 303-317.

Salleh, M. M., Tsuey, L. S. and Ariff, A. B. (2008). The profile of enzymes relevant to solvent production during direct fermentation of sago starch by *Clostridium saccharobutylicum* P262 utilizing different pH control strategies. *Biotechnology and Bioprocess Engineering*. 13(1), 33-39.

Salleh, N. H. M., Daud, M. Z. M., Arbain, D., Ahmad, M. S. and Ismail, K. S. K. (2011). Optimization of alkaline hydrolysis of paddy straw for ferulic acid extraction. *Industrial Crops and Products*. 34(3), 1635-1640.

Samah, R. A., Zainol, N., Yee, P. L., Pawing, C. M. and Abd-Aziz, S. (2013). Adsorption of vanillin using macroporous resin H103. *Adsorption Science & Technology*. 31(7), 599-610.

Santin, M. R., dos Santos, A. O., Nakamura, C. V., Dias Filho, B. P., Ferreira, I. C. P. and Ueda-Nakamura, T. (2009). In vitro activity of the essential oil of *Cymbopogon citratus* and its major component on *Leishmania amazonensis*. *Parasitology research*. 105(6), 1489-1496.

Sarangi, P. K. and Sahoo, H. P. (2010). Ferulic acid production from wheat bran using *Staphylococcus aureus*. *NewYork Science Journal* 3(4), 79-81.

Sasmitaloka, K. S., Suryani, A. and Mangunwidjaja, D. (2016). Microbial delignification of corn stover by *Phanerochaete chrysosporium* in solid state fermentation. *International Organization of Scientific Research Journal of Pharmacy*. 6, 12-19.

Sathitsuksanoh, N., Zhu, Z. and Zhang, Y.-H. P. (2012). Cellulose solvent-based pretreatment for corn stover and avicel: concentrated phosphoric acid versus ionic liquid. *Cellulose*. 19(4), 1161-1172.

Saulnier, L., Marot, C., Elgorriaga, M., Bonnin, E. and Thibault, J.-F. (2001). Thermal and enzymatic treatments for the release of free ferulic acid from maize bran. *Carbohydrate Polymers*. 45(3), 269-275.

Saulnier, L. and Thibault, J. F. (1999). Ferulic acid and diferulic acids as components of sugar-beet pectins and maize bran heteroxylans. *Journal of the Science of Food and Agriculture*. 79(3), 396-402.

Seigler, D. S. (2012). *Plant secondary metabolism*. Springer Science & Business Media.

Sert, M., Arslanoğlu, A. and Ballice, L. (2018). Conversion of sunflower stalk based cellulose to the valuable products using choline chloride based deep eutectic solvents. *Renewable Energy*. 118, 993-1000.

Shahidi, F. and Chandrasekara, A. (2010). Hydroxycinnamates and their in vitro and in vivo antioxidant activities. *Phytochemistry Reviews*. 9(1), 147-170.

Sills, D. L. and Gossett, J. M. (2011). Assessment of commercial hemicellulases for saccharification of alkaline pretreated perennial biomass. *Bioresource Technology*. 102(2), 1389-1398.

Sindhu, R., Binod, P. and Pandey, A. (2016). Biological pretreatment of lignocellulosic biomass–An overview. *Bioresource technology*. 199, 76-82.

Sindhu, R., Kuttiraja, M., Binod, P., Sukumaran, R. K. and Pandey, A. (2014). Physicochemical characterization of alkali pretreated sugarcane tops and optimization of enzymatic saccharification using response surface methodology. *Renewable Energy*. 62, 362-368.

Singh, A., Yadav, A. and Bishnoi, N. R. (2013). Statistical screening and optimization of process variables for xylanase production utilizing alkali-pretreated rice husk. *Annals of microbiology*. 63(1), 353-361.

Singh, J., Suhag, M. and Dhaka, A. (2015). Augmented digestion of lignocellulose by steam explosion, acid and alkaline pretreatment methods: a review. *Carbohydrate polymers*. 117, 624-631.

Singh, R., Krishna, B. B., Kumar, J. and Bhaskar, T. (2016). Opportunities for utilization of non-conventional energy sources for biomass pretreatment. *Bioresource technology*. 199, 398-407.

Skaria, B. P. (2007). *Aromatic plants*. (Vol. 1) New India Publishing.

Smith, M. M. and Hartley, R. D. (1983). Occurrence and nature of ferulic acid substitution of cell-wall polysaccharides in *graminaceous* plants. *Carbohydrate Research*. 118, 65-80.

Soleimaninanadegani, M., Madihah, M. and Ang, S. (2014). Factors affecting cellulase production by *Aspergillus fumigatus* SK1 from solid state fermentation of oil palm empty fruit bunches using application of 2-level factorial design. *Bulletin of Environmental and Scientific Research*. 3(2-3), 16-24.

Son, H. N. and Seo, Y. B. (2015). Physical and bio-composite properties of nanocrystalline cellulose from wood, cotton linters, cattail, and red algae. *Cellulose*. 22(3), 1789-1798.

Song, P., Chen, C., Tian, Q., Lin, M., Huang, H. and Li, S. (2013). Two-stage oxygen supply strategy for enhanced lipase production by *Bacillus subtilis* based on metabolic flux analysis. *Biochemical engineering journal*. 71, 1-10.

Song, Z., Liu, X., Yan, Z., Yuan, Y. and Liao, Y. (2014). Comparison of seven chemical pretreatments of corn straw for improving methane yield by anaerobic digestion. *Public Library of Science one*. 9(4), e93801.

Srinivasan, M., Sudheer, A. R. and Menon, V. P. (2007). Ferulic acid: therapeutic potential through its antioxidant property. *Journal of clinical biochemistry and nutrition*. 40(2), 92-100.

Srivastava, S., Luqman, S., Khan, F., Chanotiya, C. S. and Darokar, M. P. (2010). Metabolic pathway reconstruction of eugenol to vanillin bioconversion in *Aspergillus niger*. *Bioinformation*. 4(7), 320.

Stanbury, P. F., Whitaker, A. and Hall, S. J. (2013). *Principles of fermentation technology*. Elsevier.

Stentelaire, C., Lesage-Meessen, L., Delattre, M., Haon, M., Sigoillot, J., Ceccaldi, B. C. and Asther, M. (1997). By-passing of unwanted vanillyl alcohol formation using selective adsorbents to improve vanillin production with *Phanerochaete chrysosporium*. *World Journal of Microbiology and Biotechnology*. 14(2), 285-287.

Stentelaire, C., Lesage-Meessen, L., Oddou, J., Bernard, O., Bastin, G., Ceccaldi, B. C. and Asther, M. (2000). Design of a fungal bioprocess for vanillin production from vanillic acid at scalable level by *Pycnoporus cinnabarinus*. *Journal of bioscience and bioengineering*. 89(3), 223-230.

Sticklen, M. B. (2008). Plant genetic engineering for biofuel production: towards affordable cellulosic ethanol. *Nature Reviews Genetics*. 9(6), 433-443.

Streffer, F. (2014). Lignocellulose to Biogas and other Products. *Biotechnology & Biomedical Engineering*. 2, 1023.

Su, Y., Zhang, X., Hou, Z., Zhu, X., Guo, X. and Ling, P. (2011). Improvement of xylanase production by thermophilic fungus *Thermomyces lanuginosus* SDYKY-1 using response surface methodology. *New biotechnology*. 28(1), 40-46.

Sun, R., Lawther, J. and Banks, W. (1997). A tentative chemical structure of wheat straw lignin. *Industrial Crops and Products*. 6(1), 1-8.

Sun, S., Sun, S., Cao, X. and Sun, R. (2016). The role of pretreatment in improving the enzymatic hydrolysis of lignocellulosic materials. *Bioresource technology*. 199, 49-58.

Sun, Y. and Cheng, J. (2002). Hydrolysis of lignocellulosic materials for ethanol production: a review. *Bioresource technology*. 83(1), 1-11.

Suresh, S., Srivastava, V. C. and Mishra, I. (2009). Techniques for oxygen transfer measurement in bioreactors: a review. *Journal of Chemical Technology & Biotechnology: International Research in Process, Environmental & Clean Technology*. 84(8), 1091-1103.

Sutherland, J. B., Crawford, D. L. and Pometto III, A. L. (1983). Metabolism of cinnamic, p-coumaric, and ferulic acids by *Streptomyces setonii*. *Canadian journal of microbiology*. 29(10), 1253-1257.

Szwajgier, D. and Jakubczyk, A. (2010). Biotransformation of Ferulic acid by *Lactobacillus Acidophilus* K1 and Selected *Bifidobacterium* Strains. *Acta Scientiarum Polonorum. Technologia Alimentaria*. 9(1).

Taherzadeh, M. J. and Karimi, K. (2008). Pretreatment of lignocellulosic wastes to improve ethanol and biogas production: a review. *International journal of molecular sciences*. 9(9), 1621-1651.

Tajidin, N., Ahmad, S., Rosenani, A., Azimah, H. and Munirah, M. (2012). Chemical composition and citral content in lemongrass (*Cymbopogon citratus*) essential oil at three maturity stages. *African Journal of Biotechnology*. 11(11), 2685.

Tan, M., Liew, S., Maskat, M. Y., Aida, W. W. and Osman, H. (2015). Optimization of vanillin production using isoeugenol as substrate by *Aspergillus niger* I-1472. *International Food Research Journal*. 22(4), 1651.

Tang, P.-L., Hassan, O., Md-Jahim, J., Mustapha, W. A. W. and Maskat, M. Y. (2014). Fibrous agricultural biomass as a potential source for bioconversion to vanillic acid. *International Journal of Polymer Science*. 2014.

Tang, Y.-J. and Zhong, J.-J. (2003). Role of oxygen supply in submerged fermentation of *Ganoderma lucidum* for production of *Ganoderma* polysaccharide and *ganoderic* acid. *Enzyme and Microbial technology*. 32(3-4), 478-484.

Tang, Y. J., Zhang, W. and Zhong, J. J. (2009). Performance analyses of a pH-shift and DOT-shift integrated fed-batch fermentation process for the production of *ganoderic* acid and *Ganoderma* polysaccharides by medicinal mushroom Ganoderma lucidum. *Bioresource Technol*ogy 100(5), 1852-1859.

Tekere, M., Zvauya, R. and Read, J. S. (2001). Ligninolytic enzyme production in selected sub-tropical white rot fungi under different culture conditions. *Journal of basic microbiology*. 41(2), 115-129.

Tengborg, C., Stenberg, K., Galbe, M., Zacchi, G., Larsson, S., Palmqvist, E. and Hahn-Hägerdal, B. (1998). Comparison of SO_2 and H_2SO_4 impregnation of softwood prior to steam pretreatment on ethanol production *Biotechnology for Fuels and Chemicals* (pp. 3-15) Springer.

Thibault, J., Micard, V., Renard, C., Asther, M., Delattre, M., Lesage-Meessen, L., Faulds, C., Kroon, P., Williamson, G. and Duarte, J. (1998). Fungal bioconversion of agricultural by-products to vanillin. *Food Science and Technology*. 31(6), 530-536.

Tilay, A., Bule, M. and Annapure, U. (2010). Production of biovanillin by one-step biotransformation using fungus *Pycnoporous cinnabarinus*. *Journal of agricultural and food chemistry*. 58(7), 4401-4405.

Timilsena, Y. P. (2012). *Effect of different pretreatment methods in combination with the organosolv delignification process and enzymatic hydrolysability of three feedstocks in correlation with lignin structure*, Asian Institute of Technology.

Todaro, C. M. and Vogel, H. C. (2014). *Fermentation and biochemical engineering handbook*. William Andrew.

Torre, P., Aliakbarian, B., Rivas, B., Domínguez, J. M. and Converti, A. (2008). Release of ferulic acid from corn cobs by alkaline hydrolysis. *Biochemical Engineering Journal*. 40(3), 500-506.

Torre, P., De Faveri, D., Perego, P., Converti, A., Barghini, P., Ruzzi, M. and Faria, F. P. (2004). Selection of co-substrate and aeration conditions for vanillin production by *Escherichia coli* JM109/pBB1. *Food Technology and Biotechnology*. 42(3), 193-196.

Torre, P., Guarino, C., Converti, A., Barghini, P., Ruzzi, M. and Sato, S. (2003). Effects of temperature and starting substrate concentration on ferulate-to-vanillin bioconversion by *Escherichia coli* JM109 (pBB1). *Farmácia & Química*. 36(3), 39-42.

Torres, B. R., Aliakbarian, B., Torre, P., Perego, P., Domínguez, J. M., Zilli, M. and Converti, A. (2009). Vanillin bioproduction from alkaline hydrolyzate of corn cob by *Escherichia coli* JM109/pBB1. *Enzyme and Microbial Technology*. 44(3), 154-158.

Trache, D., Hussin, M. H., Haafiz, M. M. and Thakur, V. K. (2017). Recent progress in cellulose nanocrystals: sources and production. *Nanoscale*. 9(5), 1763-1786.

Triantafyllidis, K., Lappas, A. and Stöcker, M. (2013). *The Role of Catalysis for the Sustainable Production of Bio-fuels and Bio-chemicals*. Newnes.

Trick, J. K., Stuart, M. and Reeder, S. (2008). Contaminated groundwater sampling and quality control of water analyses *Environmental Geochemistry* (pp. 29-57) Elsevier.

Tripathi, P. and Dubey, N. (2004). Exploitation of natural products as an alternative strategy to control postharvest fungal rotting of fruit and vegetables. *Postharvest biology and Technology*. 32(3), 235-245.

Tumuluru, J. S., Lim, C. J., Bi, X. T., Kuang, X., Melin, S., Yazdanpanah, F. and Sokhansanj, S. (2015). Analysis on storage off-gas emissions from woody, herbaceous, and torrefied biomass. *Energies*. 8(3), 1745-1759.

Ummartyotin, S. and Manuspiya, H. (2015). A critical review on cellulose: from fundamental to an approach on sensor technology. *Renewable and Sustainable Energy Reviews*. 41, 402-412.

Urbaniec, K. and Bakker, R. R. (2015). Biomass residues as raw material for dark hydrogen fermentation–a review. *International Journal of Hydrogen Energy*. 40(9), 3648-3658.

Ürek, R. Ö. and Pazarlioğlu, N. K. (2005). Production and stimulation of manganese peroxidase by immobilized *Phanerochaete chrysosporium*. *Process Biochemistry*. 40(1), 83-87.

Vaithanomsat, P. and Apiwatanapiwat, W. (2009). Feasibility study on vanillin production from Jatropha curcas stem using steam explosion as a pretreatment. *International Journal of Chemical and Biological Engineering.* 2(4), 211-214.

Vaithanomsat, P., Chuichulcherm, S. and Apiwatanapiwat, W. (2009). Bioethanol production from enzymatically saccharified sunflower stalks using steam explosion as pretreatment. *Proceedings of the 2009 Proceedings of World Academy of Science, Engineering and Technology*, 140-143.

Van Dyk, J. and Pletschke, B. (2012). A review of lignocellulose bioconversion using enzymatic hydrolysis and synergistic cooperation between enzymes‒factors affecting enzymes, conversion and synergy. *Biotechnology advances*. 30(6), 1458-1480.

van Straalen, N. M. (1985). Production and biomass turnover in stationary stage-structured populations. *Journal of theoretical biology*. 113(2), 331-352.

Vandamme, E. J. (2003). Bioflavours and fragrances via fungi and their enzymes. *Fungal Diversity*. 13, 153-166.

Vandamme, E. J. and Soetaert, W. (2002). Bioflavours and fragrances via fermentation and biocatalysis. *Journal of Chemical Technology & Biotechnology: International Research in Process, Environmental & Clean Technology*. 77(12), 1323-1332.

Varman, A. M., He, L., Follenfant, R., Wu, W., Wemmer, S., Wrobel, S. A., Tang, Y. J. and Singh, S. (2016). Decoding how a soil bacterium extracts building blocks and metabolic energy from ligninolysis provides road map for lignin valorization. *Proceedings of the National Academy of Sciences U S A*. 113(40), E5802-E5811.

Vendruscolo, F., Tosin, I., Giachini, A. J., Schmidell, W. and Ninow, J. L. (2014). Antimicrobial Activity of *Monascus* Pigments Produced in Submerged Fermentation. *Journal of food processing and preservation*. 38(4), 1860-1865.

Villares, A., Moreau, C., Bennati-Granier, C., Garajova, S., Foucat, L., Falourd, X., Saake, B., Berrin, J.-G. and Cathala, B. (2017). Lytic polysaccharide monooxygenases disrupt the cellulose fibers structure. *Scientific reports*. 7, 40262.

Vyrides, I., Agathangelou, M., Dimitriou, R., Souroullas, K., Salamex, A., Ioannou, A. and Koutinas, M. (2015). Novel Halomonas sp. B15 isolated from Larnaca Salt Lake in Cyprus that generates vanillin and vanillic acid from ferulic acid. *World journal of microbiology and biotechnology*. 31(8), 1291-1296.

Wahid, Z. and Nadir, N. (2013). Improvement of one factor at a time through design of experiments. *World Applied Science J*ournal 21, 56-61.

Walton, N. J., Mayer, M. J. and Narbad, A. (2003). Vanillin. *Phytochemistry*. 63(5), 505-515.

Wang, G., Pan, X., Zhu, J., Gleisner, R. and Rockwood, D. (2009). Sulfite pretreatment to overcome recalcitrance of lignocellulose (SPORL) for robust enzymatic saccharification of hardwoods. *Biotechnology Progress*. 25(4), 1086-1093.

Wang, H., Zhang, C., He, H. and Wang, L. (2012). Glucose production from hydrolysis of cellulose over a novel silica catalyst under hydrothermal conditions. *Journal of Environmental Sciences*. 24(3), 473-478.

Wang, S., Dai, G., Yang, H. and Luo, Z. (2017a). Lignocellulosic biomass pyrolysis mechanism: a state-of-the-art review. *Progress in Energy and Combustion Science*. 62, 33-86.

Wang, W., Zhang, C., Sun, X., Su, S., Li, Q. and Linhardt, R. J. (2017b). Efficient, environmentally-friendly and specific valorization of lignin: promising role of non-radical lignolytic enzymes. *World Journal of Microbiology and Biotechnology*. 33(6), 125.

Wang, X., Yang, G., Li, F., Feng, Y., Ren, G. and Han, X. (2013). Evaluation of two statistical methods for optimizing the feeding composition in anaerobic co-digestion: mixture design and central composite design. *Bioresource Technol*ogy 131, 172-178.

Wanitwattanarumlug, B., Luengnaruemitchai, A. and Wongkasemjit, S. (2012). Characterization of corn cobs from microwave and potassium hydroxide pretreatment. *World Academy Science and Engineering Technol*ogy 64, 592-596.

Wasli, A. S., Salleh, M. M., Abd-Aziz, S., Hassan, O. and Mahadi, N. M. (2010). Medium optimization for chitinase production from *Trichoderma* virens using central composite design. *Biotechnology and Bioprocess Engineering*. 14(6), 781-787.

Widowati, W., Fauziah, N., Herdiman, H., Afni, M., Afifah, E., Kusuma, H. S. W., Nufus, H., Arumwardana, S. and Rihibiha, D. D. (2016). Antioxidant and anti aging assays of *Oryza sativa* extracts, vanillin and coumaric acid. *Journal of Natural Remedies*. 16(3), 88-99.

Williamson, G., Kroon, P. A. and Faulds, C. B. (1998). Hairy plant polysaccharides: a close shave with microbial esterases. *Microbiology*. 144(8), 2011-2023.

Worthington, C. C. (1988). *Worthington enzyme manual: enzymes and related biochemicals*. Worthington Biochemical Corporation.

Wyman, C. E. (2018). Ethanol production from lignocellulosic biomass: overview *Handbook on Bioethanol* (pp. 1-18) Routledge.

Wyman, C. E., Dale, B. E., Elander, R. T., Holtzapple, M., Ladisch, M. R., Lee, Y., Mitchinson, C. and Saddler, J. N. (2009). Comparative sugar recovery and fermentation data following pretreatment of poplar wood by leading technologies. *Biotechnology Progress*. 25(2), 333-339.

Xiao, Y., Zhang, X., Zhu, M. and Tan, W. (2013). Effect of the culture media optimization, pH and temperature on the biohydrogen production and the hydrogenase activities by *Klebsiella pneumoniae* ECU-15. *Bioresource Technol*ogy 137, 9-17.

Yadav, J. (1988). SSF of wheat straw with *alcaliphilic Coprinus*. *Biotechnology and bioengineering*. 31(5), 414-417.

Yamada, M., Okada, Y., Yoshida, T. and Nagasawa, T. (2008). Vanillin production using *Escherichia coli* cells over-expressing isoeugenol monooxygenase of *Pseudomonas putida*. *Biotechnology letters*. 30(4), 665-670.

Yan, L., Chen, P., Zhang, S., Li, S., Yan, X., Wang, N., Liang, N. and Li, H. (2016). Biotransformation of ferulic acid to vanillin in the packed bed-stirred fermentors. *Science Rep*orts 6, 34644.

Yang, B. and Wyman, C. E. (2004). Effect of xylan and lignin removal by batch and flowthrough pretreatment on the enzymatic digestibility of corn stover cellulose. *Biotechnology and bioengineering*. 86(1), 88-98.

Yang, C., Shen, Z., Yu, G. and Wang, J. (2008). Effect and after effect of γ radiation pretreatment on enzymatic hydrolysis of wheat straw. *Bioresource Technology*. 99(14), 6240-6245.

Yao, S., Nie, S., Zhu, H., Wang, S., Song, X. and Qin, C. (2017). Extraction of hemicellulose by hot water to reduce adsorbable organic halogen formation in chlorine dioxide bleaching of bagasse pulp. *Industrial crops and products*. 96, 178-185.

Yegneswaran, P., Gray, M. and Thompson, B. (1991). Effect of dissolved oxygen control on growth and antibiotic production in *Streptomyces clavuligerus* fermentations. *Biotechnology Progress*. 7(3), 246-250.

Yin, X., You, Q. and Jiang, Z. (2011). Optimization of enzyme assisted extraction of polysaccharides from Tricholoma matsutake by response surface methodology. *Carbohydrate Polymers*. 86(3), 1358-1364.

Yu, Q., Liang, Y., Cheng, J., Chen, S., Zhang, A., Miao, M. and Zhang, D. (2017). Synthesis of a degradable high-performance epoxy-ended hyperbranched polyester. *American Chemical Society, Omega*. 2(4), 1350-1359.

Zamzuri, N. A. and Abd-Aziz, S. (2013). Biovanillin from agro wastes as an alternative food flavour. *Journal of the Science of Food and Agriculture*. 93(3), 429-438.

Zhang, C., Madbouly, S. A. and Kessler, M. R. (2015). Renewable polymers prepared from vanillin and its derivatives. *Macromolecular Chemistry and Physics*. 216(17), 1816-1822.

Zhang, T., Kumar, R. and Wyman, C. E. (2013). Sugar yields from dilute oxalic acid pretreatment of maple wood compared to those with other dilute acids and hot water. *Carbohydrate Polym*er 92(1), 334-344.

Zhang, W., Liang, M. and Lu, C. (2007). Morphological and structural development of hardwood cellulose during mechanochemical pretreatment in solid state through pan-milling. *Cellulose*. 14(5), 447-456.

Zhang, X., Bao, T., Rao, Z., Yang, T., Xu, Z., Yang, S. and Li, H. (2014a). Two-stage pH control strategy based on the pH preference of *acetoin reductase* regulates acetoin and 2,3-butanediol distribution in *Bacillus subtilis*. *Public Library of Science One*. 9(3), e91187.

Zhang, Y.-H. P., Cui, J., Lynd, L. R. and Kuang, L. R. (2006a). A transition from cellulose swelling to cellulose dissolution by o-phosphoric acid: evidence from enzymatic hydrolysis and supramolecular structure. *Biomacromolecules*. 7(2), 644-648.

Zhang, Y., Xu, P., Han, S., Yan, H. and Ma, C. (2006b). Metabolism of isoeugenol via isoeugenol-diol by a newly isolated strain of *Bacillus subtilis* HS8. *Applied microbiology and biotechnology*. 73(4), 771-779.

Zhang, Z., Smith, C. and Li, W. (2014b). Extraction and modification technology of arabinoxylans from cereal by-products: a critical review. *Food research international*. 65, 423-436.

Zhao, M., Jing, J., Zhu, Y., Yang, X., Wang, X. and Wang, Z. (2016). Preparation and performance of lignin–phenol–formaldehyde adhesives. *International Journal of Adhesion and Adhesives*. 64, 163-167.

Zhao, X., Cheng, K. and Liu, D. (2009). Organosolv pretreatment of lignocellulosic biomass for enzymatic hydrolysis. *Applied Microbiology and Biotechnol*ogy 82(5), 815-827.

Zhao, X., Zhang, L. and Liu, D. (2012). Biomass recalcitrance. Part II: Fundamentals of different pre-treatments to increase the enzymatic digestibility of lignocellulose. *Biofuels, Bioproducts and Biorefining*. 6(5), 561-579.

Zhao, Z. and Moghadasian, M. H. (2008). Chemistry, natural sources, dietary intake and pharmacokinetic properties of ferulic acid: A review. *Food Chemistry*. 109(4), 691-702.

Zheng, A., Jiang, L., Zhao, Z., Huang, Z., Zhao, K., Wei, G., Wang, X., He, F. and Li, H. (2015). Impact of torrefaction on the chemical structure and catalytic fast pyrolysis behavior of hemicellulose, lignin, and cellulose. *Energy & Fuels*. 29(12), 8027-8034.

Zheng, L., Zheng, P., Sun, Z., Bai, Y., Wang, J. and Guo, X. (2007a). Production of vanillin from waste residue of rice bran oil by *Aspergillus niger* and *Pycnoporus cinnabarinus*. *Bioresource Technology*. 98(5), 1115-1119.

Zheng, Y. and Delwiche, M. (2008). Personal communication at University of California. *Davis, CA, USA*.

Zheng, Y., Lee, C., Yu, C., Cheng, Y.-S., Zhang, R., Jenkins, B. M. and VanderGheynst, J. S. (2013). Dilute acid pretreatment and fermentation of sugar beet pulp to ethanol. *Applied Energy*. 105, 1-7.

Zheng, Y., Pan, Z. and Zhang, R. (2009). Overview of biomass pretreatment for cellulosic ethanol production. *International journal of agricultural and biological engineering*. 2(3), 51-68.

Zhou, X., Li, W., Mabon, R. and Broadbelt, L. J. (2017). A critical review on hemicellulose pyrolysis. *Energy Technology*. 5(1), 52-79.

Zhu, L., O'Dwyer, J. P., Chang, V. S., Granda, C. B. and Holtzapple, M. T. (2008). Structural features affecting biomass enzymatic digestibility. *Bioresource Technology*. 99(9), 3817-3828.

Zhuang, X., Wang, W., Yu, Q., Qi, W., Wang, Q., Tan, X., Zhou, G. and Yuan, Z. (2016). Liquid hot water pretreatment of lignocellulosic biomass for bioethanol production accompanying with high valuable products. *Bioresource technology*. 199, 68-75.

Zulkarnain, A., Bahrin, E. K., Ramli, N., Phang, L. Y. and Abd-Aziz, S. (2018). Alkaline hydrolysate of oil palm empty fruit bunch as potential substrate for biovanillin production via two-step bioconversion. *Waste and Biomass Valorization*. 9(1), 13-23.

LIST OF PUBLICATIONS

Journal with Impact Factor

1. **Galadima**, A. I., Salleh, M. M., Hussin, H., Safri, N. M., Noor, R. M., Chong, C. S., & Naser, M. A. (2019). One-Step Conversion of Lemongrass Leaves Hydrolysate to Biovanillin by *Phanerochaete chrysosporium* ATCC 24725 in Batch Culture. *Waste and Biomass Valorization*, 1-14. https://doi.org/10.1007/s12649-019-00730-w. **(Q2, IF: 2.358)**

2. **Galadima**, A. I., Salleh, M. M., Hussin, H., Chong, C. S., Yahya, A., Mohamad, S. E.,& Al-Junid, A. F. M. (2019). Biovanillin: production concepts and prevention of side product formation. *Biomass Conversion and Biorefinery*, 1-21.. https://doi.org/10.1007/s13399-019-00418-0. **(Q2, IF: 2.326)**.

3. **Galadima**, Ahmed Ibrahim. Madihah Md Salleh. Huszalina Hussein. Chong Chun Siong. Adibah Yahaya. Shaza Eva M. Suraini A. Nor Nadiah Mohamad Yusof. Muhammad. Feisal Merican Al-Junid. pH control strategy for biovanillin production from lemongrass leave hydrolysate using *Phanerochaete chrysosporium* ATCC 24725 in Batch Culture. Processes **(Q2, IF:1.963)**. **Accepted for Publication.**

Conference Proceedings

1. **Galadima**, Ahmed Ibrahim, Madihah Md Salleh, Huszalina Hussein, Norulsazyani Mohd Safri, Chong Chun Siong, Adibah Yahaya, Shaza Eva M, Suraini Abdul-Aziz., Nor Nadiah Mohamad Yusof, Muhammad Abu Naser, Amir Feisal Merican Al-Junid. Optimization of Ferulic Acid Recovery from Lemongrass Leave Hydrolysate Using Central Composite Design. Asian Federation of Biotechnology (AFOB, 2018). Pullman hotels and Resorts Kuching, Serawak, Malaysia.

2. Huszalina H, **Galadima** I, Sazyani S., Madihah M.S, Chong Chun Siong. Adibah Yahaya. Shaza Eva M. Suraini A. Nor Nadiah Mohamad Yusof. Muhammad Abu Naser. Amir Feisal Merican Al-Junid. Utilization of Lemongrass Biomass for Biovanillin Production by Phanerochaete chrysosporium. 13th Asian Congress on Biotechnology 2017. Bioinnovation and Bioeconomy. Pullman Khon Kaen Raja Orchid Hotel, Khon Kaen, Thailand.

3. **Galadima**, Ahmed Ibrahim. Madihah Md Salleh. Huszalina Hussein. Chong Chun Siong. Adibah Yahaya. Shaza Eva M. Suraini Abdul-Aziz. Potential Application of Lemongrass leaves for one stage fermentation of Biovanillin Production by *Phanerochaete chrysosporium* ATCC 24725. AFOB International Symposium, 2017 and 11th AFOB Board Meeting (2017).