OPTIMISATION OF CO-CULTURE FERMENTATION OF *Lactobacillus casei* AND *Propionibacterium jensenii* IN RICE BRAN EXTRACT

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DEDICATION

This thesis is a gift to my late father, Mohamed Esivan Mohamed Nordin and my late mother, Seringatin Shamsuri, who taught me that the best kind of knowledge to have, is the one learned for its own sake. They also taught me to persevere, finish what I have started, and never give up.

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ABSTRACT

Co-culture fermentation is a fermentation process involving two defined microorganisms growing together in the same culture. A co-culture of lactic acid-producing bacteria (LAB) and propionic acid-producing bacteria (PAB) is beneficial in producing direct-fed microbial (DFM) products. The synergistic activity between LAB and PAB in co-culture fermentation can improve the survival of LAB and the growth of PAB. On this basis, the objectives of this study are two-fold. Firstly, the optimisation of co-culture fermentation involving *Lactobacillus casei* and *Propionibacterium jensenii* in the agricultural waste extract. Secondly, the development of an artificial neural network (ANN) predictive model for predicting the cell biomass concentration and the co-culture-specific growth rate. In the preliminary phase, two different substrates, namely rice bran and banana peel, were used in this study. This step was conducted to select the suitable carbon source for *L. casei* to grow and produce lactic acid for *P. jensenii* consumption. From the observation, rice bran was found more suitable as a carbon source and fermentation medium. Next, the co-culture optimisation of *L. casei* and *P. jensenii* fermentation was conducted using the one-factor-at-a-time approach. The fermentations were optimised for rice bran at concentration of 5% to 25% w/v; incubation temperature (30℃ to 42℃); inoculation ratio (1:1 to 1:10 % v/v) and the initial pH (5.0 to 7.0). The optimum fermentation condition was obtained at 20% w/v rice bran concentration, incubated at 35℃ with an inoculation ratio of 1:4 % v/v and initial pH of 6.5. The optimum growth (2.74 g dry cell weight/L) was recorded after 96 hours of incubation. The highest viable cell counts for *L. casei* and *P. jensenii* were 9.10 log CFU/mL and 9.42 log CFU/mL, respectively. The optimum specific growth rate, μ obtained, was 0.41 h^{-1}. The growth of *L. casei* and *P. jensenii* was compared to its monoculture fermentation, and it was found that the co-culture did not affect the growth of *L. casei* but helped maintain its survival. Moreover, *P. jensenii* gained benefits in the co-culture system, as its growth improved compared to during its monoculture. The ANN predictive model was developed using the multilayer perceptron and trained using the Levenberg-Marquardt training algorithm. Five input parameters, incubation time (h), the concentration of total reducing sugar (g/L), pH culture, incubation temperature (℃) and inoculation ratio (% v/v), were used to train the network for the prediction of cell biomass concentration (g/L) and the co-culture specific growth rate, μ (h^{-1}). The model has a low mean square error and high regression coefficient (R^2) for the training and testing set, indicating the model is fit to predict the cell biomass produced and its specific growth rate during the co-culture of *L. casei* and *P. jensenii*. The structure obtained for ANN predictive model consist of five inputs, eight hidden nodes and two outputs, 5-8-2. The optimum predicted cell biomass concentration and the specific growth rate, μ, were 2.24 g dry cell weight/L and 0.51 h^{-1}, respectively. In conclusion, this work provides a strategy to produce multispecies DFM through co-culture fermentation using rice bran and presented the first predictive ANN model to predict the cell biomass concentration and the co-culture-specific growth rate of *L. casei* and *P. jensenii*.

ABSTRAK

Penapaian dwi-kultur adalah proses penapaian melibatkan dua mikroorganisma yang tumbuh bersama dalam kultur yang sama. Penapaian dwi-kultur bakteria asid laktik (LAB) dan bakteria asid propionik amat sesuai bagi tujuan penghasilan mikrob makanan (DFM). Sinergi aktiviti di antara bakteria LAB dan PAB semasa penapaian dwi-kultur mampu meningkatkan kadar jangka hayat LAB dan pertumbuhan PAB. Oleh yang demikian, kajian ini mempunyai dua objektif utama. Pertama, proses pengoptimuman penapaian dwi-kultur di antara *Lactobacillus casei* and *Propionibacterium jensenii*. Kedua, pembangunan model ramalan rangkaian saraf buatan (ANN) untuk menganggar biojisim sel dan kadar pertumbuhan tentu dwi-kultur. Dalam fasa persediaan, pemilihan dua jenis substrat iaitu dedak padi dan kulit pisang dijalankan. Pemilihan ini adalah untuk memilih substrat yang paling sesuai untuk pertumbuhan *L. casei* dan penghasilan asid laktik untuk digunakan oleh *P. jensenii*. Hasil daripada pemerhatian, didapati ekstrak dedak padi lebih sesuai digunakan sebagai substrat dan medium penapaian. Kemudian, proses pengoptimuman penapaian dwi-kultur *L. casei* dan *P. jensenii* dijalankan menggunakan kaedah satu faktor dalam satu masa. Proses pengoptimuman ini melibatkan peratus kandungan dedak padi pada kepekatan 5% hingga 20% w/v; suhu inkubasi (30°C hingga 42°C); nisbah inokulasi (1:1 hingga 1:10 % v/v) dan nilai pH awal (5.0 hingga 7.0). Pertumbuhan optimum diperoleh daripada penapaian 20% w/v kandungan dedak padi, pada suhu 35°C dengan nisbah inokulasi 1:4 % v/v dan nilai awal pH iaitu 6.5. Biojisim sel tertinggi yang diperoleh ialah 2.74 g berat sel kering/L selepas 96 jam tempoh inkubasi, dan bilangan mikrob yang hidup untuk *L. casei* ialah 9.10 log CFU/mL dan 9.42 log CFU/mL bagi *P. jensenii*. Kadar pertumbuhan tentu diperoleh ialah 0.41 j^{-1}. Pertumbuhan *L. casei* dan *P. jensenii* dibandingkan terhadap penapaian monokulturnya dan didapati bahawa penapaian dwi-kultur tidak memberikan kesan terhadap pertumbuhan *L. casei* tetapi telah membantunya kekal hidup. Selain itu, *P. jensenii* memperoleh manfaat daripada penapaian dwi-kultur kerana pertumbuhannya meningkat berbanding semasa monokultur. Model ramalan ANN yang telah dibangunkan ialah perceptron pelbagai lapisan dan menggunakan algoritma Levenberg-Marquardt. Lima parameter masukan iaitu, masa inkubasi (j), kandungan gula penurun (g/L), pH kultur, suhu inkubasi (°C) dan nisbah kepekatan inokulum (% v/v) digunakan untuk menganggar kepekatan biojisim sel dan kadar pertumbuhan tentu dwi-kultur, μ (j^{-1}). Model ini mempunyai nilai ralat min kuasa dua yang rendah dan pekali regresi (R^2) yang tinggi untuk set latihan dan set ujian, menunjukkan bahawa model yang dibangunkan mampu membuat anggaran kepekatan biojisim sel dan kadar pertumbuhan tentu dwi-kultur ketika penapaian dwi-kultur *L. casei* dan *P. jensenii*. Struktur diperoleh untuk model ramalan ANN terdiri daripada 5 masukan, 8 nod tersembunyi dan 2 keluaran, 5-8-2. Kepekatan biojisim sel ramalan optimum dan kadar pertumbuhan tentu, μ masing-masing ialah 2.24 g berat sel kering/L dan 0.51 j^{-1}. Kesimpulannya, kajian ini menawarkan satu strategi penghasilan produk DFM yang kos efektif menggunakan teknik dwi-kultur dan dedak padi, serta melaporkan model ramalan ANN yang pertama untuk menganggar kepekatan biojisim sel dan kadar pertumbuhan tentu *L. casei* dan *P. jensenii* dwi-kultur.

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ANN	-	Artificial Neural Network
LAB	-	Lactic acid-producing bacteria
LC	-	*Lactobacillus casei*
MLP	-	Multilayer Perceptron
MRS	-	De Man Rogose & Sharpe
PAB	-	Propionic acid-producing bacteria
PJ	-	*Propionibacterium jensenii*
SLA	-	Sodium lactate agar
TRS	-	Total reducing sugar

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CHAPTER 1

INTRODUCTION

1.1 Study Background

In recent years, ruminant nutritionists and microbiologists have been studying new safe alternative methods to improve ruminant production efficiency. One of the approaches is manipulating the rumen microbial system to enhance the animal nutrient utilisation and performance as an alternative for an antibiotic growth promoter (Elghandour *et al*., 2015). Safety concern about antibiotic resistance genes has arisen regarding the prolonged usage of antibiotic growth promoters. Therefore, other approaches are more desirable (Allen *et al*., 2013), including live beneficial microorganisms or direct-fed microbial in the feeding formulation.

The direct-fed microbial term refers to the live microorganisms supplemented orally for a beneficial response in the host animal (Khan *et al*., 2016). Direct-fed microbes (DFM) are a live microorganism supplementation to ruminants to improve animal health and nutrition (Kmet *et al*., 1993; Seo *et al*., 2010). DFM microbes must be safe and non-pathogenic for consumption and technologically suitable for industrial processes. The microbes must be capable of modulating the immune responses in the gut's activities, resistant to acid and bile, and producing antimicrobial substances. Accordingly, current commercial DFMs are a blending of several species to ensure efficacies and multifactorial responses (McAllister *et al*., 2011). The production of direct-fed microbes is gaining momentum due to consumers' growing awareness of food safety and quality (Rigobelo and de Ávila, 2012). These increased studies focused on improving the DFM production process by finding new approaches such as co-culture of two different microorganisms (Jangra *et al*., 2016), using new microorganisms such as dairy propionibacteria (Adams *et al*., 2008) and new carbon sources from agricultural waste (Zubaidah *et al*., 2012).

There are many types of DFM, including lactic acid-producing bacteria (LAB). LAB are more effective than other DFM types since they are environmentally friendly and can alter the environment through several mechanisms. The lactic acid produced by LAB is one of the critical factors that can change the pH of the competitor bacteria. LAB bacteria include *Streptococcus* sp., *Enterococcus* sp., *Pediacoccus* sp. and *Lactobacillus* sp. The most common strain incorporated as direct-fed microbial is *Lactobacillus casei* (Naidu, 2004; Fonteles *et al*., 2012; Huang *et al*., 2016a; Huang *et al*., 2016b; Lee *et al*., 2013; Soto *et al*., 2011, Minelli *et al*., 2004; Millette *et al*., 2007; Aguirre-Ezkauriatza *et al*., 2010; Genevois *et al*., 2016; Céspedes *et al*., 2013) from *Lactobacillus* sp. It has been suggested that LAB co-cultured with other bacteria and yeast demonstrate positive synergistic activities in many commercial products (McAllister *et al*., 2011). Synergistic activities such as improvement in growth and propagation of *Lactobacillus* sp. (Khan *et al*., 2015; Ma *et al*., 2015) and heat tolerance of *Lactobacillus* sp. against heat shock (Sánchez et al., 2013a) have been reported. Until recently, the co-culture fermentation approach has not been utilised to improve the survival of *Lactobacillus* sp. in a prolonged fermentation.

Lactic utilising bacteria, such as microbes from dairy propionibacterium, usually used as a starter culture in cheese production, has been reported to demonstrate optimal properties for DFM application (Adams *et al*., 2008; Alazzeh *et al*., 2014; Argañaraz-Martínez *et al*., 2013; Thierry *et al*., 2011). The application of dairy propionibacterium as DFM is still in the early stage. However, the reports are encouraging. The study by Adams *et al*. (2008) reported that calves supplied with live *P. jensenii* improved live weight, and the treatment showed no adverse effect on the calves' health. Adams *et al*. also suggested that this might be due to the properties owned by *Propionibacterium* sp. that are not observed in *Lactobacillus* sp. *P. jensenii* was also studied for layer chicken. It was reported that the application of the microbes in the early layer hen is safe and effective in promoting the production and quality of products in layer husbandry (Luo *et al*., 2010).

Interestingly, dairy propionibacterium is a species that prefers lactate over glucose as a carbon source and produces propionic acid as its primary product fermentation. Xie *et al*. (2019) took advantage of this preference. In his study,

Propionibacterium freudenreichii and *Lactobacillus acidophilus* was co-cultured to produce propionic acid from sugarcane molasses. *L. acidophilus* converted sugarcane molasses to lactic acid. Then, *P. freudenreichii* utilised the lactic acid for its growth and produced propionic and acetic acid. Co-culture of dairy propionibacterium also have been reported for the production of propionic acid (Ahmadi *et al.,* 2016; Farhadi *et al.,* 2013), natural folate and vitamin B12 (Hugenschmidt *et al*., 2011; Xie *et al*., 2019), bio-preservatives (Misirlilar *et al*., 2012) and functional food (Ranadheera *et al*., 2013).

The cost of carbon and nitrogen sources accounts for more than 30% of the total fermentation cost (Tufvesson *et al*., 2013). Thus, cheap and renewable sources have caught the researcher's interest in finding a viable method to reduce the fermentation cost. Recently, agricultural waste has been among the top studied as new carbon sources in the fermentation process. Pyar *et al*., (2014) used pineapple waste, and Zhang and Vadlani (2015) used corn stover to produce lactic acid. Banana waste was used in the production of bioethanol (Gabhane *et al*., 2014), cellulase (Sun *et al*., 2011), organic acid (Mufidah *et al*., 2017; Karthikeyan and Sivakumar, 2010), and glutathione (Chen *et al*., 2011). Another source of carbon is from the rice industry, whose the byproducts such as stalks, straws, husks, and bran remain, which could be used for microbial production (Seyoum *et al*., 2022; Demirci *et* al., 2017; Todhanakasem and Puanglamyai, 2012), lactic acid production (Wang *et al*., 2015), functional food (Le *et al*., 2019; Moon *et al*., 2021).

Rice bran is the most nutritious part of rice by-products, rich in protein, minerals, fatty acids, dietary fibre, and antioxidants (Zubaidah *et al*., 2012). The compositional analysis of rice bran showed that fat, protein, carbohydrate, fibre and ash content were ranged between 15.85-18.80%, 12.07-13.66%, 40.63-45.06%, 11.77-12.68%, 9.72-11.41% dry weight, respectively (Moongngarm *et al*., 2012). The high carbohydrate composition in rice bran makes it suitable to be used as a carbon source in fermentation. Wang *et al*., (2015) used rice bran to produce L-lactic acid production using *B. coagulans* and Zubaidah *et al*., (2012) cultivated *Lactobacillus casei* in rice bran to promote symbiotic effect in Wistar Rats. Saman *et al*., (2011) reported that rice bran is suitable as a carbon source for the growth of human *Lactobacillus*

plantarum while retaining the bran's functional property. Besides being cheap and easy to obtain rice bran, its nutritional properties enabled it to be used as a nitrogen source in fermentation processes. In a study by Kazeem *et al*., (2021), rice bran was supplemented as a nitrogen source for a co-culture of *Bacillus licheniformis* and *B. paralicheniformis* to produce cellulase.

Co-culture fermentation is the fermentation of two defined microbes, an artificial association of microorganisms (Zhang and Wang, 2016; Canon *et al*., 2020) grown together in the same culture under an aseptic environment (Bader *et al*., 2010). Co-culture is different from a mixed culture, as mixed culture is a self-assembled community of environmental microbes in various ecosystems (Canon *et al*., 2020). Co-culturing offered a range of improvements, such as using cheap substrates and increasing yield and product quality (Bader *et al*., 2010). It can be summarised that co-culture is used for two purposes; to enable substrate conversion and improve process performance (Canon *et al*., 2020).

In the last ten years, studies of co-culture fermentation have been on the rise. This approach has been utilised for the production of organic acid (Liang *et al*., 2016), ethanol (Chen, 2011), natural folate and vitamin B12 (Hugenschmidt *et al*., 2011), and beneficial live microorganisms such as probiotics or DFM (Ranadheera *et al*., 2013; Ranadheera *et al*., 2016; Wu *et al*., 2012; Xanthopoulos *et al*., 2012). Co-culture can be designed using the same species but different strains (multistrain), and it can also be designed using two different species of microorganisms (multispecies). Co-culturing different species have been reported to exhibit a better synergistic effect compared to a multistrain co-culture (Kumsiri *et al*., 2018; Ma *et al*., 2015; Wu *et al*., 2012). It can promote the growth and survival rate of the microbes, open opportunities using cheaper carbon sources, and improve yield and product quality (Bader *et al*., 2010). However, co-culture fermentation, due to the complexity of its dynamics, analysis and control (Katoh *et al*., 1999; Aghababaie *et al*., 2015a; 2015b), hence, understanding and predicting the interactions and the effect between two microbes is a challenge.

The Artificial Neural Network (ANN) is a biologically inspired prediction model involving computations and mathematics. ANN is also known as neural nets, artificial neural systems, parallel distributed processing systems and connectionist systems (Mitra and Dutta, 2017). ANN is developed to deal with noisy, incomplete data and non-linear problems (Zhang *et al*., 2020; Morris *et al*., 1994). Previous studies have demonstrated the capabilities of ANN in estimation, optimisation and growth kinetic. For example, Vidra and Németh (2022) applied the ANN modelling approach to simulate a batch of propionic acid fermentation process from 40 *Propionibacterium freudenreichii* fermentations result. Jafari *et al*., (2017) used neural networks to predict physicochemical and microbial properties of *Aspergillus flavus* within tomato paste containing olive leaf extract. The capabilities of ANN in optimising fermentation media were demonstrated by Velu *et al*., (2016) for xanthan gum production. Meanwhile, Baş *et al*., (2007) used neural networks to estimate the reaction rate of enzymatic reactions without using a kinetic model.

1.2 Problem Statement

DFM should be safe, technologically suitable, alive and in an adequate concentration of at least 10^7 CFU/mL. In addition, DFM should be able to modulate the composition and activities of the ruminant gut and improve its health and performance. For an example, lactic acid bacteria type of DFM was fed to favour the activities of lactate utilizing bacteria such as *Propionibacterium* sp. and promote the production of propionic acid, a significant precursor for glucose synthesis in ruminants (McAllister *et al*, 2011; Nocek *et al*., 2003; Yang *et al*., 2004; Callaway and Martin, 1997). In order to achieve this, DFM products were produced by blending various lactic acid bacteria to ensure the effectiveness of the DFM product. Thus, the production involves separate cultivation of each microbe, separate drying and a mixing process (Jangra *et al*., 2016), which is costly. Co-culture fermentation is a process that can reduce multiple operations while achieving a similar result, a mixture of two different species that confer health benefits to ruminants but at a lesser cost.

Lactobacillus casei is one of the most common DFM types; it is safe and technologically suitable. Lactic acid bacteria are fed to ruminants to improve the activities of lactate utilising bacteria and indirectly increase propionic acid production, an essential precursor in glucose synthesis in ruminants (Yang *et al*., 2004; McAllister *et al*., 2011). However, to retain the viability of the DFM to be at least 10^7 CFU/mL is a challenge, including *L. casei*. One of the methods was encapsulation. Nevertheless, the encapsulation process is an extreme environment for *L. casei* due to exposure to a high temperature and pressure that may significantly reduce activity and viability (Chávarri *et al*., 2012). Co-culture fermentation offers a survival kit for *L. casei*. Co-culturing *L. casei* with lactate utilising bacteria will help in lactic acid removal, which helps *L. casei* to maintain its viability in a long fermentation condition. At the same time, *L. casei* will slowly be exposed and adapt to a low pH environment as lactate-utilising bacteria will produce propionic acid, and it will help in *L. casei* survival in ruminant guts. Nevertheless, there is still no study addressing the survival of *L. casei* in any *Lactobacillus* sp. co-culture fermentation reports.

Lactic acid utilising bacteria is a group that converts lactate into propionic acid. *Propionibacterium jensenii* is one of the dairy propionibacteria and belongs to lactic utilising bacteria. The applications of *P. jensenii* as live beneficial microorganisms, DFM or probiotics, have been reported by Adams *et al*., (2008), Luo *et al*., (2010), Huang *et al*., (2003) and Ranadheera *et al*., (2015). *P. jensenii* has been reported co-cultured with *Lactobacillus* sp. for the production of protective cultures (Schwenninger and Meile, 2004), probiotics powder (Ranadheera *et al*., 2015), fermented dairy drink (Ranadheera *et al*., 2016), probiotic ice cream (Ranadheera *et al*., 2013) and fruit yoghurts (Ranadheera *et al*., 2012). Until recently, a co-culture of *P. jensenii* and *Lactobacillus* sp. has not been studied for DFM production.

Utilising cheap and renewable sources will reduce the production cost of DFM. Rice bran is the most nutritious part of the rice byproducts. Rice bran has been utilised as a carbon source for producing organic acid, live beneficial microorganisms and functional food (Wang *et al*., 2015; Zubaidah *et al*., 2012; Saman *et al*., 2011). It was also utilised as a nitrogen source in cellulase production (Kazeem *et al*., 2021).

Hence, this is the evidence that rice bran is rich in nutrients for fermentation and is rich in carbon and nitrogen source for DFM production.

Although studies of co-culture *Lactobacillus* sp. with different bacteria have been reported with various synergistic effects between both microbes, almost none address the survival of *Lactobacillus* sp. itself during the co-cultivation. Here, *Propionibacterium jensenii* was chosen to be co-cultured with *Lactobacillus casei* due to the synergistic effect of its preference over lactic acid as its substrate, thus eliminating the competition over simple sugar and, as a result helping in promoting the survival of *Lactobacillus casei*. Rice bran is the nutritious part of the rice byproducts. However, reports of its usage as the primary carbon source in DFM and co-culture fermentation are scarce. Co-culture fermentation is rare due to its complex combination of different species. Regardless of the ability of ANN to deal with noisy, incomplete data, and complex and non-linear problems, only one study reported the usage of ANN as a growth characteristics model for co-culture fermentation.

1.3 Research Goal

Thus, this study highlighted three main themes: the co-culture fermentation development of *L. casei* and *P. jensenii*, the usage of rice bran as the primary carbon source and the development of a predictive model using ANN.

1.3.1 Research Objectives

The objectives of the research are :

(a) To determine the feasibility of agricultural waste as the primary carbon source for DFM production.

(b) To develop and optimise the co-culture fermentation of *Lactobacillus casei* and *Propionibacterium jensenii* using agricultural waste as a carbon source.

(c) To develop an Artificial Neural Network predictive model to predict the specific growth rate and the cell biomass concentration for co-culture of *Lactobacillus casei* and *Propionibacterium jensenii*.

1.3.2 Research Scopes

In order to achieve the outlined objectives, the study was conducted as follows:

(a) Two different types of agricultural waste were chosen, rice bran a, rice byproducts and banana peel, a banana plantain waste. The feasibility of these two agricultural wastes was determined using *L. casei*. The fermentation was conducted with only *L. casei* because *L. casei* needs the carbon source to produce lactic acid so that *P. jensenii* can utilise the lactic acid as the substrate, thus eliminating the possibility of competition for the substrate. The operating conditions were based on the work by Zubaidah *et al*., (2012).

(b) Objective (b) was achieved by developing and optimising the co-culture of *L. casei* and *P. jensenii* following the method by Ahmadi *et al*., (2016). The study was conducted in batches with 300 mL working volume in a 500 mL screw-capped bottle. The fermentation media used was the extract from agriculture waste. The co-culture fermentation was optimised for carbon source concentration (% w/v), incubation temperature (°C), initial pH and inoculation ratio. The one-factor-at-a-time (OFAT) approach was used for optimisation. The co-culture was measured for cell density, cell biomass (g dry cell weight/mL), cell viability (CFU/mL), total reducing sugar (g/L), and the organic acid concentration (g/L). A mono-culture fermentation was conducted based on the optimum parameters obtained. Then, a comparative study was conducted on the performances of mono and co-culture fermentations.

(c) An ANN model was developed for co-culture fermentation of *L. casei* and *P. jensenii*. The experimental data were first normalised in the range of 0.5 to 0.95 to speed up learning and convergence. The data were divided into train and test data at a 70:30 ratio. Levenberg Marquardt algorithm was chosen as

the training algorithm. The model was developed to predict the specific growth rate of co-culture and cell biomass of *L. casei* and *P. jensenii*. The model learned about the process from train set data and then validated using test set data. Five inputs were fed to the model to be used to predict two outputs: the specific growth rate of co-culture and cell biomass. The performance of the ANN model was evaluated via mean square error (MSE), regression analysis and error histogram.

1.4 Significance of Study

This study was conducted to develop a co-culture fermentation for DFM production. From the literatures, there has been no co-culture fermentation of *L. casei* and *P. jensenii* reported for DFM application. In addition, rice bran has been utilised as the carbon source for organic acid and probiotic production, and none has utilised rice bran in co-culture fermentation. At the same time, co-culture fermentation has a complex dynamic, analysis and control. Thus, it requires a robust model tackling the complexity and non-linear interaction in co-culture fermentation. Hence, the main contributions of this study were to provide a strategy to produce multispecies DFM through co-culture fermentation using the nutritious part of rice byproduct, rice bran, as the primary carbon source. At the same time, the first predictive ANN model was developed to predict the cell biomass concentration and the co-culture-specific growth rate of *L. casei* and *P. jensenii*.

REFERENCES

Abdul-Hamid, A., Raja Sulaiman, R. R., Osman, A., and Saari, N. 2007. Preliminary study of the chemical composition of rice milling fractions stabilized by microwave heating. *Journal of Food Composition and Analysis*. 20: 627–637.

Abu-Tarboush, H. M., Al-saiady, M. Y., and Keir El-Din, A. H. 1996. Evaluation of Diet Containing Lactobacilli on Performance, Fecal Coliform, and Lactobacilli of Young Dairy Calves. *Animal Feed Science Technology*. 57: 39-49.

Abdul-Hamid, A., Raja Sulaiman, R. R., Osman, A. and Saari, N. (2007) 'Preliminary study of the chemical composition of rice milling fractions stabilized by microwave heating', *Journal of Food Composition and Analysis*, 20(7), 627–637. doi: 10.1016/j.jfca.2007.01.005

Abu-Tarboush, H. M., Al-saiady, M. Y. and Keir El-Din, A. H. (1996) 'Evaluation of diet containing lactobacilli on performance, fecal coliform, and lactobacilli of young dairy calves', *Animal Feed Science Technology*, 57(1-2), 39-49. doi: 10.1016/0377-8401(95)00850-0

Adams, M. C. and Huang, Y. (2003). *Patent No. WO2004001022 A1*. The United States Patent and Trademark Office (USPTO)

Adams, M. C., Luo, J., Rayward, D., King, S., Gibson, R. and Moghaddam, G. H. (2008) 'Selection of a novel direct-fed microbial to enhance weight gain in intensively reared calves', *Animal Feed Science and Technology*, 145(1-4): 41-52. doi: 10.1016/j.anifeedsci.2007.05.035

Adjei-Fremah, S., Ekwemalor, K., Asiamah, E. K., Ismail, H., Ibrahim, S. and Worku, M. (2018) 'Effect of probiotic supplementation on growth and global gene expression in dairy cows', *Journal of Applied Animal Research*, 46(1), 257-263. doi: 10.1080/09712119.2017.1292913

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. doi: 10.1016/j.biotechadv.2011.05.005

Aghababaie, M., Khanahmadi, M. and Beheshti, M. (2015a) 'Developing a kinetic model for co-culture of yogurt starter bacteria growth in ph controlled batch

fermentation', *Journal of Food Engineering*, 166, 72-79. doi: 10.1016/j.jfoodeng.2015.05.013

Aghababaie, M., Khanahmadi, M. and Beheshti, M. (2015b) 'Developing a detailed kinetic model for the production of yogurt starter bacteria in single strain cultures', *Food and Bioproducts Processing*, 94, 657-667. doi: 10.1016/j.fbp.2014.09.007

Aguirre-Ezkauriatza, E. J., Aguilar-Yáñez, J. M., Ramírez-Medrano, A. and Alvarez, M. M. (2010) 'Production of probiotic biomass (*Lactobacillus casei*) in goat milk whey: Comparison of batch, continuous and fed-batch cultures', *Bioresource Technology*, 101(8), 2837-2844. doi:10.1016/j.biortech.2009.10.047

Ahmadi, N., Khosravi-Darani, K., Mohammad Mortazavian, A. and Mashayekh, S.M., (2016) 'Effects of process variables on fed-batch production of propionic acid', *Journal of Food Processing and Preservation*, 41(2), e12853. doi:10.1111/jfpp.12853

Akpan, I. and Adelaja, F. A. (2004) 'Production and stabilization of amylase preparations from rice bran solid medium', *World Journal of Microbiology & Biotechnology*, 20, 47-50. doi: 10.1023/B:WIBI.0000013294.14446.cf

Alazzeh, A. Y., Smith, A. H., Beauchemin, K. A., Meale, S. J. and McAllister, T. A. (2014) 'Supplementing *Propionibacterium acidipropionici* P169 does not affect methane eproduction or volatile fatty acid profiles of different diets in *in vitro* rumen cultures from heifers', *Acta Agriculturae Scandinavica, Sectioa A - Animal Science*, 64(3), 170-177. https://doi.org/10.1080/09064702.2014.988746

Alcantara, J. Z. and Mondala, A. H. (2021) 'Optimization of slurry fermentation for succinic acid production by fungal co-culture', *Chemical Engineering Transactions*, 86, 1525-1530. doi: 10.3303/CET2186255

Aleksendrić, D., Barton, D.C. and Vasić, B. (2010) 'Prediction of brake friction materials recovery performance using Artificial Neural Networks', *Tribology International*, 43(11), 2092-2099. doi: 10.1016/j.triboint.2010.05.013

Alfano, A., Donnarumma, G., Cimini, D., Fusco, A., Marzaioli, I., Rosa, M. D. and Schiraldi, C. (2015) '*Lactobacillus plantarum*: Microfiltration experiments for the production of probiotic biomass to be used in food and nutraceutical preparations', *Biotechnology Progress*, 31(2), 325-333. doi: 10.1002/btpr.2037

Allen, H. K., Levine, U. Y., Looft, T., Bandrick, M., Casey, T. A. (2013) 'Treatment, promotion, commotion: antibiotic alternatives in food-producing animals', *Trends in Microbiology*, 21(3): 114-119. doi: 10.1016/j.tim.2012.11.001

Amor, D. R. and Bello, M. D. (2019) 'Bottom-up approachs to synthetic cooperation in microbial communities', *Life*, 9, 22. doi: 10.3390/life9010022

Angelov, A., Gotcheva, V., Hristozova, T. and Gargova, S. (2005) 'Application of pure and mixed probiotic lactic acid bacteria and yeast cultures for oat fermentation', *Journal of the Science of Food and Agriculture*, 85, 2134-2141. doi: 10.1002/jsfa.2223

Anomaly, J. (2009) 'Harm to others: The social cost of antibiotics in agriculture', *Journal of Agricultural and Environmental Ethics*, 22, 423-435. doi: 10.1007/s10806-009-9160-y

Anupama and Ravindra, P. (2001) 'Studies on production of single cell protein by *Aspergillus niger* in solid state fermentation of rice bran', *Brazilian Archives of Biology and Technology*, 44(1), 79-88. doi: 10.1590/S1516-89132001000100011

Anvari, M., Khayati, G. and Rostami, S. (2014) 'Optimisation of medium composition for probiotic biomass production using response surface methodlogy', *Journal of Dairy Research*, 81(1), 59-64. doi: 10.1017/S0022029913000733

Apata, D. F. (2008) 'Growth performance, nutrient digestibility and immune response of broiler chicks fed diets supplemented with a culture of *Lactobacillus bulgaricus*', 88(7), 1253-1258. doi: 10.1002/jsfa.3214

Argañaraz-Martínez, E., Babot, J. D., Apella, M. C. and Chaia, A. P. (2013) 'Physiological and functional characteristics of *Propionibacterium* strains of the poultry microbiota and relevance for the development of probiotic products', *Anaerobe*, 23, 27-37. doi: 10.1016/j.anaerobe.2013.08.001

Arora, T., Singh, S. and Sharma, R. K. (2013) 'Probiotics: Interaction with gut microbiome and antiobesity potential', *Nutrition*, 29, 591-596. doi: 10.1016/j.nut.2012.07.017

Artegoitia, V. M., Foote, A. P., Lewis, R. M. and Freetly, H. C. (2017) 'Rumen fluid metabolomic analysis associated with feed efficiency on crossbred steers', *Scientific Reports*, 7, 2864. doi: 10.1038/s41598-017-02856-0

Arumugam, R. and Manikandan, M. (2011) 'Fermentation of pretreated hydrolyzates of banana and mango fruit wastes for ethanol production', *Asian J. Exp. Biol. Sci*, 2(2), 246-256.

ATCC. (2016) *ATCC Animal Cell Culture Guide*. Manassas, Virginia: American Type Culture Collection (ATCC). Retrieved on 15 August 2021 Animal Cell Culture Guide | ATCC

Bader, J., Mast-Gerlach, E., Popović, M. K., Bajpai, R. and Stahl, U. (2010) 'Relevance of microbial coculture fermentations in biotechnology', *Journal of Applied Microbiology*, 109, 371-387. doi: 10.1111/j.1365-2672.2009.04659.x

Bajagai, Y. S., Klieve, A. V., Dart, P. J. and Bryden, W. L. (2016) 'Probiotics in animal nutrition-production, impact and regulation', In: Makkar, H. P. S., editor. FAO animal production and health paper No. 179. Food and Agriculture Organization of the United Nation, Rome, Italy.

Balcázar, J. L., de Blas, I., Ruiz-Zarzuela, I., Cunningham, D., Vendrell, D. and Múzquiz, J. L. (2006) 'The role of probiotics in aquaculture', *Veterinary Microbiology*, 114(3-4), 173-186. doi: 10.1016/j.vetmic.2006.01.009

Ban, Y. and Guan, L. L. (2021) 'Implication and challenges of direct-fed microbial supplementation to improve ruminant production and health', *Journal of Animal Science and Biotechnology*, 12, 109. doi: 10.1186/s40104-021-00630-x

Baş, D. and Boyacı, İ. H. (2007) 'Modeling and optimization II: Comparison of estimation capabilities of Response Surface Methodology with Artificial Neural Networks in a biochemical reaction', *Journal of Food Engineering*, 78, 846-854. doi: 10.1016/j.jfoodeng.2005.11.025

Baş, D., Dudak, F. C. and Boyacı, İ. H. (2007) 'Modeling and optimization III: Reaction rate estimation using Artificial Neural Network (ANN) without a kinetic model', *Journal of Food Engineering*, 79(2), 622-628. doi: 10.1016/j.jfoodeng.2006.02.021

Basheer, I. A. and Hajmeer, M. (2000) 'Artificial Neural Networks: Fundamentals, computing, design, and application', *Journal of Microbiological Methods*, 43(1), 3-31. doi: 10.1016/S0167-7012(00)00201-3

Berger, C., Lettat, A., Martin, C. and Noziere, P. (2014) *US Patent No. US 2014/0112889*: *Method for reducing methane production in a ruminant*

animal. Copenhagen: The United States Patent and Trademark Office (USPTO)

Bernárdez, P. F., Amado, I. R., Castro, L. P. and Guerra, N. P. (2008) 'Production of a potentially probiotic culture of *Lactobacillus casei* subsp. *casei* CECT 4043 in whey', *International Dairy Journal*, 18(10-11), 1057-1065. doi: 10.1016/j.idairyj.2008.05.004

Bidarra, S. J., Barrias, C. C., Barbosa, M. A., Soares, R., Amédée, J. and Granja, P. L. (2011) 'Phenotypic and proliferative modulation of human mesenchymal stem cells via crosstalk with endothelial cells', *Stem Cell Research*, 7(3), 186-197. doi: 10.1016/j.scr.2011.05.006

Bodie, E. A., Goodman, N. and Schwartz, R. D. (1987) 'Production of propionic acid by mixed cultures of *Propionibacterium shermanii* and *Lactobacillus casei* in autoclave-sterilized whey', *Journal of Industrial Microbiology*, 1, 349-353. doi: 10.1007/BF01569331

Borawska, J., Mikš-Krajnik, M. and Darewicz, M. (2013) 'The physiological state of *Lactococcus lactis* and *Propionibacterium freudenreichii* strains in co-cultures induced by low temperature and osmotic stress', *African Journal of Microbiology Research*, 7(29), 3794-3801. doi: 10.5897/AJMR12.2219

Britz, T. J. and Riedel, K. H. J. (1994) '*Propionibacterium* species diversity in Leerdammer cheese', *International Journal of Food Microbiology*, 22, 257-267. doi: 10.1016/0168-1605(94)90177-5

Broadbent, J. R., Neeno-Eckwall, E. C., Stahl, B., Tandee, K., Cai, H., Morovic, W., Horvath, P., Heidenreich, J., Perna, N. T., Barrangou, R. and Steele, J. L. (2012) 'Analysis of the *Lactobacillus casei* supragenome and its influence in species evolution and lifestyle adaptation', *BMC Genomics*, 13, 533. doi: 10.1186/1471-2164-13-533

Bulatović, M. L., Rakin, M. B., Bukašinović-Sekulić, M. S., Mojović, L. V. and Krunić, T. Ž. (2014) 'Effect of nutrient supplements in growth and viability of *Lactobacillus johnsonii* NRRL B-2178 in whey', *International Dairy Journal*, 34(1), 109-115. doi: 10.1016/j.idairyj.2013.07.014

Cai, H., Rodríguez, B.T., Zhang, W., Broadbent, J.R. and Steele, J.L. (2007) 'Genotypic and phenotypic characterization of *Lactobacillus casei* strains isolated from different ecological niches suggests frequent recombination and

niche specificity', *Microbiology*, 153(8), 2655-2665. doi: 10.1099/mic.0.2007/006452-0

Callaway, T. R. and Martin, S. A. (1997) 'Effects of cellobiose and monensin on *in vitro* fermentation of organic acids by mixed ruminal bacteria', *Journal of Dairy Science*, 80(6), 1126-1135. doi: 10.3168/jds.S0022-0302(97)76039-9

Callaway, T. R., Edrington, T. S. anderson, R. C, Harvey, R. B., Genovese, K. J., Kennedy, C. N., Venn, D. W. and Nisbet, D. J. (2008) 'Probiotics, prebiotics and competitive exclusion for prophylaxis against bacterial disease', *Animal Health Research Reviews*, 9(2): 217-225. doi:10.1017/S1466252308001540

Calsamiglia, S., Blanch, M., Ferret, A. and Moya, D. (2012) 'Is subacute ruminal acidosis a pH related problem? Causes and tools for its control', *Animal Feed Science and Technology*, 172(1), 42-50. doi: 10.1016/j.anifeedsci.2011.12.007

Campaniello, D., Bevilacqua, A., Sinigaglia, M. and Altieri, C. (2015) 'Screening of *Propionibacterium* spp. for potential probiotics properties', *Anaerobe*, 34, 169-173. doi: 10.1016/j.anaerobe.2015.06.003

Canon, F., Nidelet, T., Guédon, E., Thierry, A. and Gagnaire, V. (2020) 'Understanding the mechanisms of positive microbial interactions that benefit lactic acid bacteria co-cultures', *Frontiers in Microbiology*, 11, 2088. doi: 10.3389/fmicb.2020.02088

Céspedes, M., Cárdenas, P., Staffolani, M., Ciappini, M. C. and Vinderola, G. (2013) 'Performance in nondairy drinks of probiotic *L. casei* strains usually employed in dairy products', *Journal of Food Science*, 78(5), M756-M762. https://doi.org/10.1111/1750-3841.12092

Chan-Blanco, Y., Bonilla-Leiva, A. R. and Velázquez, A. C. (2003) 'Using banana to generate lactic acid through batch process fermentation', *Applied Microbiology and Biotechnology*, 63,147–152. doi: 10.1007/s00253-003-1374-8

Chantawongsa, N. and Kongkiattikajorn, J. (2013) 'Pretreatment methods for banana peel as a substrate for the bioproduction of ethanol in SHF and SSF', *International Journal of the Computer, the Internet and Management*, 21(2), 15-19.

Chávarri, M., Marañón, I. and Villarán, M. C. (2012) 'Encapsulation technology to protect probiotic bacteria', in E. C. Rigobelo (ed.), Probiotics, IntechOpen, London. doi: 10.5772/50046.

Chawachart, N., Khanongnuch, C., Watanabe, T. and Lumyong, S. (2004) 'Rice bran as an efficient substrate for laccase production from thermotolerant basidiomycete *Coriolus versicolor* strain RC3', *Fungal Diversity*, 15, 23-32.

Chegini, G. R., Khazaei, J., Ghobadian, B. and Goudarzi, A. M. (2008) 'Prediction of process and product parameters in an orange juice spray dryer using Artificial Neural Networks', *Journal of Food Engineering*, 84, 534-543. doi: 10.1016/j.jfoodeng.2007.06.007

Chen, H., Zhang, Q., Wan, H., Shu, G. and Li, H. (2015) 'Effect of total inoculum size containing *Lactobacillus acidophilus* or *Lactobacillus casei* on fermentation of goat milk', *Advance Journal of Food Science and Tecnology*, 7(3), 183-186.

Chen, X-D., Wei, G-Y., Z., J-L. and Dong, Y-Y. (2011) 'Efficient production of glutathione using hydrolyzate of banana peel as novel substrate', *Korean Journal of Chemical Engineering*, 28(7), 1566-1572. doi: 10.1007/s11814-010-0535-6

Chen, Y. (2011) 'Development and application of co-culture for ethanol production by co-fermentation of glucose and xylose: A systemic review', *Journal of Industrial Microbiology and Biotechnology*, 38(5), 581-597. doi: 10.1007/s10295-010-0894-3

Cheng, G., Hao, H., Xie, S., Wang, X., Dai, M., Huang, L. and Yuan, Z. (2014) 'Antibiotic alternatives: The substitution of antibodies in animal husbandry?', *Frontiers in Microbiology*, 5, 217. doi: 10.3389/fmicb.2014.00217

Cheroutre-Vialette, M. and Lebert, A. (2002) 'Application of Recurrent Neural Network to predict bacterial growth in dynamic conditions', *International Journal of Food Microbiology*, 73, 107-118. doi: 10.1016/S0168-1605(01)00642-0

Chiquette, J., Allison, M. J. and M. A. Rasmussen. (2008) '*Prevotella bryantii* 25A used as a probiotic in early-lactation dairy cows: Effect on ruminal fermentation characteristics, milk production, and milk composition', *Journal of Dairy Science*, 91, 3536-3543. doi: 10.3168/jds.2007-0849

Choi, J. Y., Shinde, P. L., Ingale, S. L., Kim, J. S., Kim, Y. W., Kim, K. H., Kwon, I. K. and Chae, B. J. (2011) 'Evaluation of multi-microbe probiotics prepared by submerged liquid or solid substrate fermentation and antibiotics in weaning pigs', *Livestock Science*, 138(1-3), 144-151. doi: 10.1016/j.livsci.2010.12.015

Chugh, P., Soni, R. and Soni, S. K. (2016) 'Deoiled rice bran: A substrate for co-production of a consortium of hydrolytic enzymes by *Aspergillus niger* P-19', *Waste Biomass Valorization*, 7, 513-525. doi: 10.1007/s12649-015-9477-x

Chutmanop, J., Chuichulcherm, S., Chisti, Y. and Srinophakun, P. (2008) 'Protease production by *Aspergillus oryzae* in solid-state fermentation using agroindustrial substrates', *Journal of Chemical Technology and Biotechnology*, 83(7), 1012-1018. doi: 10.1002/jctb.1907

Cole, N. A., Purdy, C. W. and Hutcheson, D. P. (1992) 'Influence of yeast culture on feeder calves and lambs', *Journal of Animal Science*, 70(6), 1682-1690. doi: Yeast Culture on Feeder Calves and Lambs

Collins, C. H., Lyne, P. M., Grange, J. M. and Falkinham III, J. O. (2004) *Collins & Lyne's Microbiological Method*. London: Arnold.

Coral, J., Karp, S. G., de Souza Vandenberghe, L. P., Parada, J. L., Pandey, A. and Soccol, C. R. (2008) 'Batch fermentation model of propionic acid production by *Propionibacterium acidipropionici* in different carbon sources', *Applied Biochemistry and Biotechnology*, 151, 333-341. doi: 10.1007/s12010-008-8196-1

Costa, M. G. M., Fonteles, T. V., de Jesus, A. L. T. and Rodrigues, S. (2013) 'Sonicated pineapple juice as substrate for *L. casei* cultivation for probiotic beverage development: Process optimisation and product stability', *Food Chemistry*, 139(1-4), 261–266. doi: 10.1016/j.foodchem.2013.01.059

Cousin, F. J., Louesdon, S., Maillard, M. -B., Parayre, S., Falentin, H., Deutsch, S. -M., Boudry, G. and Jan, G. (2012) 'The first dairy product exclusively fermented by *Propionibacterium freudenreichii*: A new vector to study probiotic potentialities *in vivo*', *Food Microbiology*, 32, 135-146. doi: 10.1016/j.fm.2012.05.003

Dalloul, R. A., Lillehoj, H. S., Shellem, T. A. and Doerr, J. A. (2003) 'Intestinal immunomodulation by vitamin A deficiency and *Lactobacillus*-based probiotic in *Eimeria acervulina*-infected broiler chickens', *Avian Diseases*, 47(4), 1313–1320. doi: 10.1637/6079

Dam, M. and Saraf, D.N. (2006) 'Design of Neural Networks using genetic algorithm for on-line property estimation of crude fractionator products. *Computers and Chemical Engineering*, 30: 722-729. doi: 10.1016/j.compchemeng.2005.12.001

Das, S., Bhattacharya, A., Haldar, S., Ganguly, A., Gu, S., Ting, Y. P. and Chatterjee, P. K. (2015) 'Optimization of enzymatic saccharification of water hyacinth biomass for bio-ethanol: Comparison between Artificial Neural Network and Response Surface Methodology', *Sustainable Materials and Technologies*, 3, 17-28. doi: 10.1016/j.susmat.2015.01.001

Dave, R. I. and Shah, N. P. (1997) 'Viability of yoghurt and probiotic bacteria in yoghurts made from commercial starter cultures', *International Dairy Journal*, 7(1), 31-41. doi: 10.1016/S0958-6946(96)00046-5

Davidson, C. A. and Rehberger, T. G. (1995) 'Characterization of *Propionibacterium* isolated from the rumen of lactating dairy cows', Presented at *American Society for Microbiology*.

Dawood, M. A. O., Koshio, S. K., Abdel-Daim, M. M. and Van Doan, H. (2019) 'Probiotic application for sustainable aquaculture', *Reviews in Aquaculture*, 11(3), 907-924. doi: 10.1111/raq.12272

Demirci, A. S., Muhammet Arici, and Gumus, T. (2012) 'Xanthan gum production from hydrolyzed rice bran as a carbon source by *Xanthomonas* spp.', *Korean Journal of Microbiology and Biotechnology*, 40(4), 356-363. doi: 10.4014/kjmb.1205.05023

Deng, Q., Odhiambo, J. F., Farooq, U., Lam, T., Dunn, S. M. and Ametaj, B. N. (2016) 'Intravaginal probiotics modulated metabolic status amd improved milk production and composition of transition dairy cows', *Journal of Animal Science*, 94(2), 760-770. doi: 10.2527/jas.2015-9650

Dietz, D., Sabra, W. and Zeng, A. P. (2013) 'Co-cultivation of *Lactobacillus zeae* and *Veillonella criceti* for the production of propionic acid', *AMB Express*, 3, 29. doi: 10.1186/2191-0855-3-29

Dimitrovski, D., Velickova, E., Dimitrovski, M., Langerholc, T. and Winkelhausen, E. (2016) 'Synbiotic dunctional drink from Jerusalem artichoke juice fermented by probiotic *Lactobacillus plantarum* PCS26', *Journal of Food Science and Technology*, 53(1), 766-774. doi: 10.1007/s13197-015-2064-0

Dimitrovski, D., Velickova, E., Langerholc, T. and Winkelhausen, E. (2015) 'Apple juice as a medium for fermentation by the probiotic *Lactobacillus plantarum* PCS 26 strain', *Annals of Microbiology*, 65, 2161-2170. doi: 10.1007/s13213-015-1056-7

Dorota, Z., Danuta, K. -K., Antoni, G. and Motyl, I. (2014) 'Predictive Modelling of *Lactobacillus casei* KN291 Survival in Fermented Soy Beverage', *Journal of Microbiology*, 52(2), 169-178. doi: 10.1007/s12275-014-3045-0

Du, D., Wu, C., Luo, X. and Zuo, X. (2006) 'Delay time identification and dynamic characteristics study on ANN soft sensor. *Proceedings of the Sixth International Conference on Intelligent Systems Design and Applications (ISDA '06),* (pp. 42-45). doi: 10.1109/ISDA.2006.131

Du, Y. C. and Stephanus, A. (2018) 'Levenberg-Marquardt Neural Network algorithm for degree of arteriovenous fistula stenosis classification using a dual optical photoplethysmography sensor', *Sensors*, 18, 2322, doi: 10.3390/s18072322

Dulf, E. -H., Vodnar, D. C., Danku, A., Martău, A. G., Teleky, B. -E., Dulf, F. V., Ramadan, M. F. and Crisan, O. (2022) 'Mathematical modeling and optimization of *Lactobacillus* species single and co-culture fermentation processes in wheat and soy dough mixtures', *Frontiers in Bioengineering and Biotechnology*', 10, 888827. doi: 10.3389/fbioe.2022.888827

Ekinci, F. and Gurel, M. (2008) 'Effect of using propionic acid bacteria as an adjunct culture in yogurt production', *Journal of Dairy Science*, 91(3), 892-899. doi: 10.3168/jds.2007-0244

Elam, N. A., Gleghorn, J. F., Rivera, J. D., Galyean, M. L., Defoor, P. J., Brashears, M. M. and Younts-Dahl, S. M. (2003) 'Effects of live cultures of *Lactobacillus acidophilus* (strains NP45 and NP51) and *Propionibacterium freudenreichii* on performance, carcass, and intestinal characteristics, and *Escherichia coli* strains O157 shedding of dinishing beef steers', *Journal of Animal Science*, 81(11), 2686-2698. doi: 10.2527/2003.81112686x

Elghandour, M. M. Y., Salem, A. Z. M., Castñeda, J. S. M., Camacho, L. M., Kholif, A. E., Chagoyán, J. C. V. (2015) 'Direct-fed microbes: A tool for improving the utilization of low quality roughages in ruminants', *Journal of Integrative Agriculture*, 14(3), 526-533. doi: 10.1016/S2095-3119(14)60834-0

El-Shafei, K., Abd El-Gawad, M. A. M., Dabiza, N., Sharaf, O. M. and Effat, B. A. (2008) 'A mixed culture of *Propionibacterium theonii* P-127, *Lactobacillus rhamnosus* and *Lactobacillus plantarum* as protective cultures in Kareish cheese', *Polish Journal of Food and Nutrition Sciences*, 58(4), 433-441.

Emaga, T. H. andrianaivo, R. H., Wathelet, B., Tchango, J. T. and Paquot, M. (2007) 'Effects of the stage of maturation and varieties on the chemical composition

of banana and plantain peels', *Food Chemistry*, 103(2), 590-600. doi: 10.1016/j.foodchem.2006.09.006

Emaga, T. H., Robert, C., Ronkart, S. N., Wathelet, B. and Paquot, M. (2008) 'Dietary fibre components and pectin chemical features of peels during ripening in banana and plantain varieties', *Bioresource Technology*, 99, 4346-4354. doi: 10.1016/j.biortech.2007.08.030

Esnoz, A., Periago, P.M., Conesa, R. and Palop, A. (2006) 'Application of Artificial Neural Networks to describe the combined effect of pH and NaCl on the heat resistance of *Bacillus stearothermophilus*', *International Journal of Food Microbiology*, 106(2), 153-158. doi: 10.1016/j.ijfoodmicro.2005.06.016

Espirito-Santo, A. P. d., Mouquet-Rivier, C., Humblot, C., Cazevieille, C., Icard-Verniére, C., Soccol, C. R. and Guyot, J-. P. (2014) 'Influence of cofermentation by amylolytic *Lactobacillus* strains and probiotic bacteria on the fermentation process, viscosity and microstructure of gruels made of rice, soy milk and passion fruit fiber', *Food Research International*, 57, 104-113. doi: 10.1016/j.foodres.2014.01.028

Essien, J. P., Akpan, E. J. and Essien, E. P. (2005) 'Studies on mould growth and biomass production using waste banana peel', *Bioresource Technology*, 96(13), 1451-1456. doi: 10.1016/j.biortech.2004.12.004

Evdokimova, S. A., Nokhaeva, V. S., Karetkin, B. A., Shakir, I. V. and Panfilov, V. I. (2022) 'A model for symbiotic activity evaluation: Static and continuous co-culture fermentation of *Bifidobacterium adolescentis* ATCC 15703 and *Bacillus cereus* ATCC 9634', in *8th Scientific and Practical Conference "Biotechnology: Science and Practice"*, KnE Life Sciences, pp.393–403. doi: 10.18502/kls.v7i1.10148

Fajardo, P., Pastrana, L., Méndez, J., Rodríguez, I., Fuciños, C. and Guerra, P. (2012) 'Effects of feeding of two potentially probiotic preparations from lactic acid bacteria on the performance and faecal microflora of broiler chickens', *The Scientist World Journal*, Article ID 562635. doi: :10.1100/2012/562635

Famularo, G., De Simone C., MAtteuzi, D. and Pirovano, F. (1999) 'Traditional and high potency probiotics preparations for oral bacteriotherapy', *BioDrugs*, 12, 455-470. doi: 10.2165/00063030-199912060-00005

Farhadi, S., Khosravi-Darani, K., Mashayekh, M., Mortazavian, A. M., Mohammadi, A. and Shahraz, F. (2013) 'Production of propionic acid in a fermented dairy

beverage', *International Journal of Dairy Technology*, 6(1), 127-134. doi: 10.1111/1471-0307.12004

Farias, N., Soares, M. and Gouveia, E. (2016) 'Enhancement of the viability of *Lactobacillus rhamnosus* ATCC 7469 in passion fruit juice: Application of a central composite rotatable design', *LWT–Food Science and Technology*, 71, 149-154. doi: 10.1016/j.lwt.2016.03.014

Fernando, W. M. A. D. B., Flint, S., Zou, M., Brennan, C. S., Ranaweera, K. K. D. S. and Bamunuarachchi, A. (2011) 'The effect of rice fibre fractions on the growth of co-cultures of probiotics', *Journal of Food Science and Technology,* 48(1), 14-25. doi: 10.1007/s13197-010-0147-5

Fonteles, T. V., Costa, M. G. M., de Jesus, A. L. T. and Rodrigues, S. (2012) 'Optimization of the fermentation of cantaloupe juice by *Lactobacillus casei* NRRL B-442', *Food and Bioprocess Technology*, 5, 2819-2826. doi: 10.1007/s11947-011-0600-0

Fortuna, L., Graziani, S. and Xibilia, M. G. (2005) 'Soft sensors for product quality monitoring in debutanizer distillation columns', *Control Engineering Practice*, 13, 499-508. doi: 10.1016/j.conengprac.2004.04.013

Frizzo, L. S., Sotto, L. P., Zbrun, M. V., Bertozzi, E., Sequeira, G., Armesto, R. R. and Rosmini, M. R. (2010) 'Lactic acid bacteria to improve growth performance in young calves fed milk replacer and spray-dried whey powder', *Animal Feed Science and Technology,* 157(3-4): 159-167. doi: 10.1016/j.anifeedsci.2010.03.005

Fuller, R. 1995. Probiotics: their development and use, in Probiotics: Prospects of Use in Opportunistic Infections (eds R. Fuller, P.J. Heidt, V. Rusch and D. Van der Waaij), Institute for Microbiology and Biochemistry, Old Herborn University, Herborn Dill, pp. 1–8.

Gabhane, J., Prince William, S. P. M., Gadhe, A., Rath, R., Vaidya, A. N. and Wate, S. (2014) 'Pretreatment of banana agricultural waste for bio-ethanol production: Individual and interactive effects of acid and alkali pretreatments with autoclaving, microwave heating and ultrasonication', *Waste Management*, 34(2), 498-503. doi: 10.1016/j.wasman.2013.10.013

Gao, M-T., Kaneko, M., Hirata, M., Toorisaka, E. and Hano, T. (2008) 'Utilization of rice bran as nutrient source for fermentative lactic acid production',

Bioresource Technology, 99(9), 3659-3664. doi: 10.1016/j.biortech.2007.07.025

Garcés, L., Vásquez, C., Contreras, E., Urra, J., Diez, M. C., Guerrero, L. and Palma, C. (2012) 'An alternative, banana peel-based medium used to investigate the catalytic properties of peroxidase from a fungus, I*nonotus* sp SP2, recently isolated in Southern Chile', *Biotechnology and Bioprocess Engineering*, 17, 972-980. doi: 10.1007/s12257-012-0295-8

Gardner, N. and Champagne, C. P. (2005) 'Production of *Propionibacterium shermanii* biomass and vitamin B12 on spent media', *Journal of Applied Microbiology*, 99(5), 1236-1245. doi: 10.1111/j.1365-2672.2005.02696.x

Garro, M.S., de Valdez, G.F. and de Giori, G.S. (2004) 'Temperature effect on biological activity of *Bifidobacterium longum* CRL 849 and *Lactobacillus fermentum* CRL 251 in pure and mixed cultures grown in soymilk', *Food Microbiology*, 21(5), 511–518. doi: 10.1016/j.fm.2004.01.001

Gasser, F. (1994) 'Safety of lactic acid bacteria and their occurrence in human clinical infections', *Bull. Inst. Pasteur*, 92, 45–67.

Gebresemati, M. and Gebregergs, M. (2015) 'Optimization of banana peels hydrolysis for the production of bioethanol: Response Surface Methodology', *International Letters of Natural Sciences*, 48, 53-60.

Genevois, C., Flores, S. and de Escalada, P. M. (2016) 'Byproduct from pumpkin (*Cucurbita moschata* Duchesne ex poiret) as a substrate and vegetable matrix to contain *Lactobacillus casei*', *Journal of Functional Foods*, 23, 210-219. doi: 10.1016/j.jff.2016.02.030

Ghorbani, G. R., Morgavi, D. P., Beauchemin, K. A. and Leedle, J. A. Z. (2014) 'Effects of bacterial direct-fed microbials on ruminal fermentation, blood variables, and the microbial populations of feedlot cattle, *Journal of Animal Science*, 80(7), 1977-1985. doi: 10.2527/2002.8071977x

Goers, L., Freemont, P. and Polizzi, K. M. (2014) 'Co-culture systems and technologies: Taking synthetic biology to the next level' *Journal of The Royal Society*, 11, 20140065. doi: 10.1098/rsif.2014.0065

Goh, C. S., Tan, K. T., Lee, K. T. and Bhatia, S. (2010) 'Bio-ethanol from lignocellulose: Status, perspectives and challenges in Malaysia', *Bioresource Technology*, 101(13), 4834-4841. doi: 10.1016/j.biortech.2009.08.080

Gomes, S., Vieira, B., Barbosa, C. and Pinheiro, R. (2020) 'Evaluation of mature banana peel flour on physical, chemical, and texture properties of a gluten-free *Rissol*', *Journal of Food Processing and Preservation*, e14441. doi: 10.1111/jfpp.14441

Goñi, S. M., Oddone, S., Segura, J. A., Mascheroni, R. H. and Salvadori, V. O. (2008) 'Prediction of foods freezing and thawing times*:* Artificial Neural Networks and Genetic Algorithm approach', *Journal of Food Engineering,* 84(1), 164-178. doi: 10.1016/j.jfoodeng.2007.05.006

Gorret, N., Maubois, J. L. and Ghoul, M. (2001) 'Study of the effects of temperature, pH and yeast extract on growth and exopolysaccharides production by *Propionibacterium acidi-propionici* on milk microfiltrate using a response surface methodology', *Journal of Applied Microbiology,* 90(5), 788-796. doi: 10.1046/j.1365-2672.2001.01310.x.

Goud, K. G., Chaitanya, K. and Reddy, G. (2013) 'Enhanced production of β-D-fructofuranosidase by *Saccharomyces cerevisiae* using agro-industrial wastes as substrate', *Biocatalysis and Agricultural Biotechnology*, 2(4), 385-392. doi: 10.1016/j.bcab.2013.08.001

Grumet, L., Tromp, Y. and Stiegelbauer, V. (2020) 'The development of high-quality multispecies probiotic formulations: From bench to market', *Nutrients,* 12, 2453. doi: 10.3390/nu12082453

Gueguim-Kana, E. B., Oloke, J. K., Lateef, A. and Zebaze-Kana, M. G. (2007) 'Novel optimal temperature profile for acidification process of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* in yoghurt fermentation using Artificial Neural Network and Genetic Algorithm', *Journal of Industrial Microbiology and Biotechnology,* 34(7), 491-496. doi: 10.1007/s10295-007-0220-x

Gulbe, G., Valdovska, A., Saulite, V. and Jermolales, J. (2015) 'In vitro assessment for antimicrobial activity of *Lactobacillus helveticus* and its natural glycopeptides against mastitis causing pathogens in dairy cattle', *The Open Biotechnology Journal,* 9: 61-66. doi: 10.2174/1874070701509010061

Guo, Y., Yang, R., Zhang, Z., Wang, X., Ye, X. and Chen, S. (2018) 'Synergy of carbon and nitrogen removal of a co-culture of two aerobic denitrifying bacterial strains, *Acinetobacter* sp. GA and *Pseudomonas* sp. GP', *RSC Advances,* 8, 21558-21565. doi: 10.1039/C8RA02721H

Gupta, S., Abu-Ghannam, N. A. and Scannell, A. G. M. (2011) 'Growth and kinetics of *Lactobacillus plantarum* in the fermentation of edible Irish brown seaweeds', *Food and Bioproducts Processing*, 89(4), 346-355. doi: 10.1016/j.fbp.2010.10.001

Hagan, M. T. and Menhaj, M. B. (1994) 'Training feedforwards networks with the Marquardt Aagorithm', *IEEE Transactions on Neural Networks*, 5(6), 989-993. doi: 10.1109/72.329697

Hall, B. G., Acar, H., Nandipati, A. and Barlow, M. (2014) 'Growth rates made easy', *Molecular Biology and Evolution*', 31(1), 232-238. doi: 10.1093/molbev/mst187

Hammes, W. P. and Hertel, C. (2009) Genus I. Lactobacillus Beijerinck 1901, 212^{AL}. In: Book De Vos, P., Garrity, G. M., Jones, D., Krieg, N. R., Ludwig, W., Rainey, F, A., Schleifer, K-. H. and Whitman, W. B., eds. *Bergey's Manual® of Systematic Bacteriology, Vol. 3, The Firmicutes*. 2nd ed. New York, USA: Springer Science+Business Media, pp 465-532.

Hassan, H. F., Hassan, U. F., Usher, O. A., Ibrahim, A. B. and Tabe, N. N. (2018) 'Exploring the potentials of banana (*Musa sapietum*) peels in feed formulation', *International Journal of Advanced Research in Chemical Science (IJARCS)*, 5(5), 10-14. doi: 10.20431/2349-0403.0505003

Hatherell, K., Couraud, P-. O., Romero, I. A., Weksler, B. and Pilkington, G. J. (2011) 'Development of a three-dimensional, all-human *in vitro* model of the blood-brain barrier using mono-, co-, and tri-cultivation Transwell models', *Journal of Neuroscience Methods*, 199(2), 223-229. doi: 10.1016/j.jneumeth.2011.05.012

Hedayati, R., Hosseini, M. and Nafpour, G. D. (2020) 'Optimization of semi-anaerobic vitamin B12 (cyanocobalamin) production from rice bran oil using *Propionibacterium freudenreichii* PTCC1674', *Biocatalysis and Agricultural Biotechnology*, 23, 101444. doi: 10.1016/j.bcab.2019.101444

Herzog, M. A., Marwala, T. and Heyns, P. S. (2009) 'Machine and component residual life estimation through the application of Neural Networks', *Reliability Engineering and System Safety*, 94(2), 479-489. doi: 10.1016/j.ress.2008.05.008

Ho, P. -H., Luo, J. B. and Adams, M. C. (2009) '*Lactobacilli* and dairy *Propionibacterium* with potential as biopreservatives against food fungi and

yeast contamination', *Applied Biochemistry and Microbiology*, 45(4), 414-418. doi: 10.1134/S0003683809040115

Houston, D.F., (1972) *Rice bran and Polish*. Houston, D.F.E. (Eds). *Rice: Chemistry and Technology*. AACC Publications, Minnesota.

Huang, S., Cauty, C., Dolivet, A., Le Loir, Y., Chen. X. D., Schuck, P., Jan, G. and Jeantet, R. (2016a) 'Double use of highly concentrated sweet whey to improve the biomass production and viability of spray-dried probiotic bacteria', *Journal of Functional Foods*, 23, 453-463. http://dx.doi.org/10.1016/j.jff.2016.02.050

Huang, S., Rabah, H., Jardin, J., Briard-Bion, V., Parayre, S., Maillard, M. -B., Le Loir, Y., Chen, X. D., Schuck, P., Jeantet, R. and Jan, G. (2016b) 'Hyperconcentrated sweet whey, a new culture medium that enhances *Propionibacterium freudenreichii* stress tolerance', *Applied and Environmental Microbiology*, 82(15), 4641-4651. doi: 10.1128/AEM.00748-16

Huang, Y., Kotula, L. and Adams, M. C. (2003) 'The in vivo assessment of safety and gastrointestinal survival of an orally administeres novel probiotic, *Propionibacterium jensenii* 702, in a male Wistar rat model', *Food and Chemical Technology*, 41(12), 1781-1787. doi: 10.1016/S0278-6915(03)00215-1

Hugenschmidt, S., Schwenninger, S. M. and Lacroix, C. (2011) 'Concurrent high production of natural folate and vitamin b12 using co-culture process with *Lactobacillus plantarum* SM39 and *Propionibacterium freudenreichii* DF13', *Process Biochemistry*, 46, 1063-1070. doi: 10.1016/j.procbio.2011.01.021

Huse, S. M., Ye, Y., Zhou, Y. and Fodor, A. A. (2012) 'A core human microbiome as viewed through 16S rRNA sequence clusters', *PloS One*, 7(6): e34242. doi: 10.1371/journal.pone.0034242

Idris, A. and Suzana, W. (2006) 'Effect of sodium alginate concentration, bead diameter, initial pH and temperature on lactic acid production from pineapple waste using immobilized *Lactobacillus delbrueckii*', *Process Biochemistry*, 41(5), 1117-1123. doi: 10.1016/j.procbio.2005.12.002

Ilori, M. O., Adebusoye, S. A., lawal, A. K. and Awotiwon, O. A. (2007) 'Production of biogas from banana and plantain peels', *Advances in Environmental Biology*, 1(1), 33–38.

Jafari, S. M., Ghanbari, V., Dehnad, D. and Ganje, M. (2017) 'Neural Networks modeling of *Aspergillus flavus* growth in tomato paste containing microencapsulated olive leaf extract', *Journal of Food Safety*, 38, e12396. doi: 10.1111/jfs.12396

Jangra, M., Belur, P. D., Oriabinska, L. B., Dugan, O. M. (2016) 'Multistrain probiotic production by co-culture fermentation in a lab-scale bioreactor', *Engineering in Life Sciences*, 16(3), 247-253. doi: 10.1002/elsc.201500069

Jimenez-Gutierrez, J. M., Verlinden, R. A. J., van der Meer, P. C., van der Wielen, L. A. M. and Straathof, A. J. J. (2021) 'Liquid hot water pretreatment of lignocellulosic biomass at lab and pilot scale', *Processes*, 9, 1518. doi: 10.3390/pr9091518

John, R. P., Sukumaran, R. K., Nampoothiri, K. M., Pandey, and A. (2007) 'Statistical optimization of simultaneous saccharification and L(+)-lactic acid fermentation from cassava bagasse using mixed culture of lactobacilli by Response Surface Methodology', *Biochemical Engineering Journal*, 36, 262-267. doi: 10.1016/j.bej.2007.02.028

Joo, D. S., Choi, D. J. and Park, H. (2000) 'The effects of data preprocessing in the determination of coagulant dosing rate', *Water Research*, 34(13), 3295-3302. doi: 10.1016/S0043-1354(00)00067-1

Karthikeyan, A. and Sivakumar, N. (2010) 'Citric acid production by Koji fermentation using banana peel as a novel substrate', *Bioresource Technology*, 101(14), 5552-5556. doi: 10.1016/j.biortech.2010.02.063

Katoh, T., Yuguchi, D., Yoshii, H., Shi, H. and Shimizu, K. (1999) 'Dynamics and modeling on fermentative production of poly (ß-hydroxybutyric acid) from sugars via lactate by a mixed culture of *Lactobacillus delbrueckii* and *Alcaligenes eutrophus*', *Journal of Biotechnology*, 67(2-3), 113-134. doi: 10.1016/S0168-1656(98)00177-1

Kazeem, M. O. O., Ajijolakewu, K. A. and Abdul Rahman, N. A. (2021) 'Cellulase production by co-culture of *Bacillus licheniformis* and *B. paralicheniformis* over monocultures on microcrystallin cellulose and chicken manure-supplemented rice bran media', *Bioresources*, 16(4), 6850-6869. Retrieved from https://ojs.cnr.ncsu.edu/index.php/BioRes/article/view/BioRes_16_4_6850_Kazeem_Monoculture_Rice_Bran_Media

Kelkar, S. T. and Mahanwar, P. A. (2015) 'Production of lactic acid from tamarind kernel by *Lactobacillus casei*', *International Journal of Technology Enhancements and Emerging Engineering Research*, 3(5), 25-31.

Kembabazi, B., Ondiek, J. O. and Migwi, P. K. (2021) 'Effect of single or mixed strain probiotics on milk yield of dairy cows', *Livestock Research for Rural Development*, 33, Article #7. Retrieved July 20, 2022, from http://www.lrrd.org/lrrd33/1/brend3307.html

Khan, R. U., Naz, S., Dhama, K., Karthnik, K., Tiwari, R., Abdelrahman, M. M., Alhidary, I. A., Zahoor, A. (2016) 'Direct-Fed Microbial: Beneficial applications, modes of action and prospects as a safe tool for enhancing ruminant production and safeguarding health', *International Journal of Pharmacology*, 12(3), 220-231. doi: 10.3923/IJP.2016.220.231

Kiani, M. D. K., Ghobadian, B., Tavakoli, T., Nikbakht, A. M. and Najafi, G. (2010) 'Application of Artificial Neural Networks for the prediction of performance and exhaust emissions in si engine using ethanol-gasoline blends', *Energy*, 35(1), 65-69. doi: 10.1016/j.energy.2009.08.034

Klaenhammer, T. R. and Kullen, M. J. (1999) 'Selection and design of probiotics', *International Journal of Food Microbiology*, 50(1-2), 45-57. doi: 10.1016/S0168-1605(99)00076-8

Kleen, J. L., Hooijer, G. A., Rehage, J. and Noordhuizen, J. P. T. M. (2003) 'Subacute ruminal acidosis (SARA): A review', *Journal of Veterinary Medicine Series A*, 50(8), 406-414. doi: 10.1046/j.1439-0442.2003.00569.x

Kmet, V., Flint, H. J., Wallace, R. J. (1993) 'Probiotics and manipulation of rumen development and function', *Archives of Animal Nutrition*, 44(1), 1-10. doi: 10.1080/17450399309386053

Kook, M. C., Seo, M. J., Cheigh, C. I., Pyun, Y. R. Cho, S. C. and Park, H. (2010) 'Enhanced production of γ-aminobutyric acid using rice bran extracts by *Lactobacillus sakei* B2-16', *Journal of Microbiology and Biotechnology*, 20(4): 763-766.

Kos, B., Beganović, J., Jurašić, L. and Švađumović, M. (2011) 'Coculture-inducible bacteriocin biosynthesis of different probiotic strains by dairy starter culture *Lactococcus lactis', Mljekarstvo*, 61(4), 273-282.

Kośmider, A., Drożdżyńska, A., Blaszka, K., Leja, K., Czaczyk, K., Leja, K. and Czaczyk, K. (2010) 'propionic acid production by *Propionibacterium*

freudenreichii ssp. *shermanii* using crude glycerol and whey lactose industrial wastes. *Polish Journal of Environmental Studies*, 19(6), 1249-1253.

Kourkoutas, Y., Kanellaki, M. and Koutinas, A. A. (2006) 'Apple pieces as immobilization support of various microorganisms', *LWT- Food Science and Technology*, 39(9), 980–986. doi: 10.1016/j.lwt.2006.02.024

Kumar, M., Jain, A. K., Ghosh, M. and Ganguli, A. (2012) 'Industrial whey utilization as a medium supplement for biphasic growth and bacteriocin production by probiotic *Lactobacillus casei* LA-1', *Probiotics and Antimicrobial Proteins*, 4, 198-207. doi: 10.1007/s12602-012-9104-0

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. doi: 10.1021/ie801542g

Kumar, S., Sharma, H. K. and Sarkar, B. C. (2011) 'Effect of Substrate and Fermentation Conditions on Pectinase and Cellulase Production by *Aspergillus niger* NCIM 548 in Submerged (SmF) and Solid State Fermentation (SSF)', *Food Science and Biotechnology*, 20(5), 1289-1298. doi: 10.1007/s10068-011-0178-3

Kumsiri, B., Pekkoh, J., Pathom-aree, W., Lumyong, S. and Pumas, C. (2018) 'Synergistic effect of co-culture of microalga and actinomycete in diluted chicken manure digestate for lipid production', *Algal Research*, 33, 239-247. doi: 10.1016/j.algal.2018.05.020

Kung, L., Jr. (n.d.) (2006). Direct Fed Microbials and Enzymes for Ruminants. Retrieved October, 7, 2013 from http://ag.udel.edu/anfs/faculty/kung/articles/direct_fed_microbials_and_enzyme.htm.

Kwan, T. H., Vlysidia, A., Wu, Z., Hu, Y., Koutinas, A. and Lin, C. S. K. (2017) 'Lactic acid fermentation modelling of *Streptococcus thermophilus* Y1-B1 and *Lactobacillus casei* Shirota using food waste derived media', *Biochemical Engineering Journal*, 127, 97-109. doi: 10.1016/j.bej.2017.08.012

Lambo, M. T., Chang, X. and Liu, D. (2021) 'The recent trend in the use of multistrain probiotics in livestock production: An overview', *Animals*, 22, 2805. doi: 10.3390/ani11102805

Le Lay, C., Coton, E., Le Blay, G., Chobert, J. M., Haertlé, T., Choiset, Y., Long, N. N. V., Meslet-Cladière, L. and Mounier, J. (2016) 'Identification and quantification of antifungal compounds produced by lactic acid bacteria and propionibacteria. *International Journal of Food Microbiology*, 239, 79-85. doi: 10.1016/j.ijfoodmicro.2016.06.020

Lee, B. H., Kim, B. K., Lee, Y. J., Chung, C. H. and Lee, J. W. (2010) 'Industrial scale of optimization for the production of carboxymethylcellulase from rice bran by a marine bacterium, *Bacillus subtilis* subsp. *subtilis* A-53', *Enzyme and Microbial Technology*, 46, 38-42. doi: 10.1016/j.enzmictec.2009.07.009

Lee, J., Seo, E., Kweon, D. H., Park, K. and Jin, Y. S. (2009) 'Fermentation of rice bran and defatted rice bran for butanol production using *Clostridium beijerinckii* NCIMB 8052', *Journal of Microbiology and Bitechnology*, 19(5), 482-490. doi: 10.4014/jmb.0804.275

Lee, P. -R., Boo, C. X. and Liu, S. -Q. (2013) 'Fermentation of coconut water by probiotic strains *Lactobacillus acidophilus* L10 and *Lactobacillus casei* L26', *Annals of Microbiology*, 63, 1441-1450. doi: 10.1007/s13213-013-0607-z

Lehloenya, K. V., C. R. Krehbiel, K. J. Mertz, T. G. Rehberger and L. J. Spicer. (2008) 'Effects of propionibacteria and yeast culture fed to steers on nutrient intake and site and extent of digestion', *Journal of Dairy Science*, 91(2), 653-662. doi: 10.3168/jds.2007-0474

Lewis, V. P. and Yang, S-. T. (1992) 'Propionic acid fermentation by *Propionibacterium acidipropionici*: Effect of growth substrate', 37, 437-442. doi: 10.1007/BF00180964

Li, B. and Li, L. (2006) 'Artificial Neural Network based software sensor for yeast biomass concentration during industrial production', *Computational Intelligence and Security, 2006 International Conference*. 3-6 November. Guangzhou: IEEE, 955-958. doi: 10.1109/ICCIAS.2006.295402

Li, G. and Shi, J. (2010) 'On comparing three Artificial Neural Networks for wind speed forecasting', *Applied Energy*, 87(7), 2313-2320. doi: 10.1016/j.apenergy.2009.12.013

Li, Y., Lin, J., Meng, D., Lu, J., Gu, G. and Mao, Z. (2006) 'Effect of pH, cultivation time and substarte concentration on the endoxylanase production by *Aspergillus awamori* ZH-26 under submerged fermentation using central

composite rotary design', *Food Technology and Biotechnology*, 44(4), 473-477.

Li, Z., Lu, J., Yang, Z., Han, L. and Tan, T. (2012) 'Utilization of white rice bran for production of L-lactic acid', *Biomass & Bioenergy*, 39, 53-58. doi: 10.1016/j.biombioe.2011.12.039

Liang, S., Gliniewicz, K., Gerritsen, A. T. and McDonald, A. G. (2016) 'Analysis of microbial community variation during the mixed culture fermentation of agricultural peel wastes to produce lactic acid', *Bioresource Technology*, 208, 7-12. doi: 10.1016/j.biortech.2016.02.054

Lim, J., Kim, T. and Hwang, S. (2003) 'Treatment of fish-processing wastewater by co-culture of *Candida rugopelliculosa* and *Brachionus plicatilis*', *Water Research*, 37, 2228-2232. doi: 10.1016/S0043-1354(02)00586-9

Lin, B., Recke, B., Knudsen, J. K. H. and Jørgensen, S. B. (2007) 'A systematic approach for soft sensor development', *Computers and Chemical Engineering*', 31(5-6), 419-425. doi: 10.1016/j.compchemeng.2006.05.030

Linko, S., Luopa, J. and Zhu, Y.-H. (1997) 'Neural Networks as 'Software Sensor' in Enzyme production', *Journal of Biotechnology*, 52(3), 257-266. doi: 10.1016/s0168-1656(96)01650-1

Liu, J. A. P. and Moon, N. J. (1982) 'Commensalistic interaction between Lactobacillus *acidophilus* and *Propionibacterium shermanii', Applied and Environmental Microbiology*, 44(3), 715-722. doi: 10.1128/aem.44.3.715-722.1982

Liu, L., Zhu, Y., Li, J., Wang, M., Lee, P., Du, G. and Chen, J. (2012) 'Microbial production of propionic acid from propionibacteria: Current state, challenges and perspectives', *Critical Reviews in Biotechnology*, 32(4), 374-381. doi: 10.3109/07388551.2011.651428

Liu, Y-T., Luo, Z-Y., Long, C-N., Wang, H-D., Long, M-N. and Hu, Z. (2011) 'Cellulase production in a new mutant strain of *Penicillium decumbens* ML-017 by solid state fermentation with rice bran', *New Biotechnology*, 28(6), 733-737. doi: 10.1016/j.nbt.2010.12.003

Lopitz-Otsoa, F., Rementeria, A., Elguezabal, N. and Garaizar, J. (2006) 'Kefir: A symbiotic yeasts-bacteria community with alleged healthy capabilities', *Rev Iberoam Micol*, 23(2), 67-74. doi: 10.1016/s1130-1406(06)70016-x

Luo, J., King, S. and Adams, M. C. (2010) 'Effect of probiotic *Propionibacterium jensenii* 702 supplementation on layer chicken performance', *Beneficial Microbes*, 1(1), 53-60. https://doi.org/10.3920/bm2009.0017

Lv, C., Xing, Y., Zhang, J., Na, X., Li, Y. and Liu, T. (2018) 'Levenberg-Marquardt backpropagation training of multilayer neural networks for state estimation of a safety critical cyber-physical system', *IEEE Transactions on Industrial Informatics*, 14(8), 3436-3446. doi: 10.1109/TII.2017.2777460

Ma, C., Ma, A., Gong, G., Liu, Z., Wu, Z., Guo, B. and Chen, Z. (2015) 'Cracking *Streptococcus thermophilus* to stimulate the growth of *Lactobacillus casei* in co-culture', *INternational Journal of Food Microbiology*, 210(1), 42-46. https://doi.org/10.1016/j.ijfoodmicro.2015.04.034

Maier, R. N. and Pepper, I A. (2015) 'Chapter 3 – Bacterial Growth', In Pepper, I. L., Gerba, C. P. and Gentry, T. J. (eds.) *Environmental Microbiology (Third Edition)*. Academic Press, pp. 37-56. doi: 10.1016/B978-0-12-394626-3.00003-X

Malik, A. C., G. W. Reinbold, and E. R. Vedamuthu. (1968) 'An evaluation of taxonomy of *Propionibacterium*', *Canadian Journal of Microbiology*, 14(11),1185–1191. doi: 10.1139/m68-199

Malik, R. and S. Bandla. (2010) 'Effect of source and dose of probiotics and exogenous fibrolytic enzymes (EFE) on intake, feed efficiency, and growth of male buffalo (*Bubalus bubalis*) calve', *Tropical Animal Health and Production*, 42,1263-1269. doi: 10.1007/s11250-010-9559-5

Maragkoudakis, P. A., Chingwaru, W., Gradisnik, L., Tsakalidou, E., Cencic, A. (2010) 'Lactic acid bacteria efficiently protect human and animal intestinal epithelial and immune cells from enteric virus infection. *International Journal of Microbiology*. 141: 591-597. https://doi.org/10.1016/j.ijfoodmicro.2009.12.024

Marini, F. (2009) 'Artificial Neural Networks in foodstuff analyses: Trends and perspectives a review', *Analytica Chimica Acta*, 635(2), 121-131. doi: 10.1016/j.aca.2009.01.009

McAllister, T. A., Beauchemin, K. A., Alazzeh, A. Y., Baah, J., Teather, R. M., Stanford, K. (2011) 'Review: The use of direct fed microbials to mitigate pathogens and enhance production in cattle', *Canadian Journal of Animal Science*, 91(2), 193-211. doi: 10.4141/cjas10047

McCoun, M., Oyebade, A., Estrada-Reyes, Z. M., Pech-Cervantes, A. A. and Ogunade, I. M. (2021) 'Effects of multi-species direct-fed microbial producst on ruminal metatrascriptome and carboxyl-metabolome of beef steers', *Animals*, 11, 72. doi: 10.3390/ani11010072

Meena, G. S., Majumdar, G. C., Banerjee, R., Kumar, N., Meena, P. K. (2014) 'Growth characteristics modeling of mixed culture of *Bifidobacterium bifidum* and *Lactobacillus acidophilus* using Response Surface Methodology and Artificial Neural Network. *Brazilian Archives of Biology and Technology*, 57(6), 962-970.

Melo-Bolívar, J. F., Pardo, R. Y. R., Hume, M. E. and Díaz, L. M. V. (2021) 'Multistrain probiotics use in main commercially cultured freshwater fish: A systematic review of evidence', *Reviews in Aquaculture*, 13(4), 1758-1780. doi: 10.1111/raq.12543

Milessi, T. S. S., Antunes, F. A. F., Chandel, A. K., Silva, S. S. (2013) 'Rice bran extract: an inexpensive nitrogen source for the production of 2G ethanol from sugarcane bagasse hydrolysate', *3 Biotech*. 3, 373-379. doi: 10.1007/s13205-012-0098-9

Miller, G. L. (1959) 'Use of dinitrosalicylic acid reagent for determination of reducing sugar', *Analytical Chemistry*, 31(3), 426-428.

Millette, M., Luquet, F. M. and Lacroix, M. (2007) '*In vitro* growth control of selected pathogens by *Lactobacillus acidophilus*- and *Lactobacillus casei*-fermented milk', *Letters in Microbiology*, 44(3), 314-319. doi: 10.1111/j.1472-765x.2006.02060.x

Minelli, E. B., Benini, A., Marzotto, M., Sbarbati, A., Ruzzenente, O., Ferraio, R., Hendriks, H. and Dellaglio, F. (2004) 'Assesment of novel probiotic *Lactobacillus casei* strains for the production of functional dairy foods', *International Dairy Journal*, 14(8), 723-736. doi: 10.1016/j.idairyj.2004.01.007

Misirlilar, F., Kinik, Ö. and Yerlİkaya, O. (2012) 'Effect of protective culture and biopreservatives on strained yoghurt quality', *African Journal of Microbiology Research*, 6(22), 4696-4701. doi: 10.5897/AJMR11.1319

Mitra, R. and Dutta, D. (2018) 'Growth profiling, kinetics and substrate utilization of low-cost dairy waste for production of ß-cryptoxanthin by *Kocuria marina* DAGII', *Royal Society Open Science*, 5, 172318. doi: 10.1098/rsos.172318

Mohamad Roff, M. N., Tengku Abdul Malik, T. M. and Sharif, H. (2012) 'Challenges to banana production in Malaysia: A threat to food security', *The Planter, Kuala Lumpur*, 88, 20-30.

Moongngarm, A., Daomukda, N. and Khumpika, S. (2012) 'Chemical compositions, phytochemicals, and antioxidant capacity of rice bran, rice bran layer, and rice germ', *APCBEE Procedia*, 2, 73-79. doi: 10.1016/j.apcbee.2012.06.014

Morris, A. J., Montague, G. A. and Willis M. J. (1994) 'Artificial Neural Networks – Studies in-process modeling and control', *Chemical Engineering Research & Design*, 72(1), 3-19.

Moussavi, M. and Adams, M. C. (2010) 'An in vitro study on bacterial growth interactions and intestinal epithelial cell adhesion characteristics of probiotic combinations', *Current Microbiology*, 60, 327–335. doi: 10.1007/s00284-009-9545-1

Mufidah, E., Prihanto, A. A. and Wakayama, M. (2017) 'Optimization of L-lactic acid production from banana peel by multiple parallel fermentation with *Bacillus licheniformis* and *Aspergillus awamori*', *Food Science and Technology Research*, 23(1), 137-143. doi:10.3136/fstr.23.137

Muthangya, M., Mshandete, A. M., Kivaisi, A. K. (2009) 'Two-stage fungal pre-treatment for improved biogas production from sisal leaf decortication residues', *International Journal of Molecular Sciences*', 10, 4805-4815. doi: 10.3390/ijms10114805

Nachaiwieng, W., Lumyong, S., Yoshioka, K., Watanabe, T. and Khanongnuch, C. (2015) 'Bioethanol production from rice husk under elevated temperature simultaneous saccharification and fermentation using *Kluyveromyces marxianus* CK8', *BIocatalysis and Agricultural Biotechnology*, 4(4), 543-549. doi: 10.1016/j.bcab.2015.10.003

Naidu, A. S. Probiotic Composition Containing *Lactobacillus casei* Strain ATCC PTA-3945. US 6,797,266 B2. 2004.

Najafi, G., Ghobadian, B., Yusaf, T. F. and Rahimi, H. (2007) 'Combustion analysis of a ci engine performance using waste cooking biodiesel fuel with and Artificial Neural Network aid', *American Journal of Applied Sciences*, 4(10), 756-764. doi: 10.3844/ajassp.2007.759.767

Nehme, N., Florence, M., Patricia, T. (2010) 'Impact of the co-culture of *Saccharomyces cerevisiae–Oenococcus oenion* malolactic fermentation and

partial characterization of a yeast-derived inhibitory peptidic fraction', *Food Microbiology*, 27(1), 150-157. doi: 10.1016/J.FM.2009.09.008

Ng, I. S., Li, C. W., Chan, S. P., Chir, J. L., Chen, P. T., Tong, C. G., Yu, S. M., Ho, T. H. D. (2010) 'High-level production of a thermoacidophilic β-glucosidase from *Penicillium citrinum* YS40-5 by solid-state fermentation with rice bran', *Bioresource Technology*, 101(4), 1310-1317. doi: 10.1016/j.biortech.2009.08.049

Ngome, M. T., Alves, J. G. L. F., Piccoli, R. H., Domingo, E. d. C., Pinto, S. A., Bernal, O. L. M. (2017) 'Inoculum concentration and inoculation time for propionic acid production from whey using mixed culture of *Lactobacillus helveticus* and *Propionibacterium freudenreichii* PS-1', *Acta Scientiarum. Technology*, 39, 543-550. doi: 10.4025/actascitechnol.v39i5.29479

Nocek, J. E. and W. P. Kautz. (2006) 'Direct-fed microbial supplementation on ruminal digestion, health, and performance of pre- and postpartum dairy cattle', *Journal of Dairy Science,* 89(1), 260-266. doi: 10.3168/jds.S0022-0302(06)72090-2

Nocek, J. E., Kautz, W. P., Leedle, J. A. Z. and Block, E. (2003) 'Direct-fed microbial supplementation on the performance of dairy cattle during the transition period', *Journal of Dairy Science,* 86(1), 331-335. doi: 10.3168/jds.S0022-0302(03)73610-8

Nocek, J. E., W. P. Kautz, J. A. Z. Leedle and J. G. Allman. (2002) 'Ruminal supplementation of direct-fed microbials on diurnal pH variation and in situ digestion in dairy cattle', *Journal of Dairy Science*, 85(2), 429-433. doi: 10.3168/jds.S0022-0302(02)74091-5

Norgaard, M., Ravn, O., Poulsen, N. and Hansen, L. (2000) 'Neural Networks for modelling and control of dynamic systems', UK: Springer-Verlag, London.

Oberoi, H. S., Vadlani, P. V., saida, L., Bansal, S., Hughes, J. D. (2011) 'Ethanol production from banana peels using statistically optimized simultaneous saccharification and fermentation process', *Waste Management*, 31(7), 1576-1584. doi: 10.1016/j.wasman.2011.02.007

Oetzel, G. R., K. M. Emery, W. P. Kautz and J. E. Nocek. (2007) 'Direct-fed microbial supplementation and health and performance of pre- and postpartum dairy cattle: A field trial', *Journal of Dairy Science*, 90(4), 2058-2068. doi: 10.3168/jds.2006-484

Ogunade, I. M., McCoun, M., Idowu, M. D. and Peters, S. O. (2020) 'Comparative effects of two multispecies direct-fed mcirobial products on energy status, nutrient digestibility, and ruminak fermentation, bacterial community, and metabolome of beef steers', *Ruminant Nutrition*, 29(9), 1-11. doi: 10.1093/jas/skaa201

Olchowy, T. W. J., Soust, M. and Alawneh, J. (2019) 'The effect of a commercial probiotic product on the milk quality of dairy cows', *Journal of Dairy Science,* 102(3), 2188-2195. doi: 10.3168/jds.2018-15411

Oliveira, M. d. S., FEddern, V., Kupski, L., Cipolatti, E. P., Badiale-Furlong, E. and de Souza-Soares, L. A. (2010) 'Physico-chemical characterization of fermented rice bran biomass', *Cyta-Journal of Food*, 8(3), 229-236. doi: 10.1080/19476330903450274

Oliveira, R. P. D. S., Parego, P., Converti, A. and De Oliveira, M. N. (2009) 'Effect of inulin on growth and acidification performance of different probiotic bacteria in co-cultures and mixed culture with *Streptococcus thermophilus*', *Journal of Food Engineering*', 91(1), 133-139. doi: 10.1016/j.jfoodeng.2008.08.013

Oliveira, R. P. d. S., Torres, B. R., Perego, P., de Oliveira M. N. and Converti, A. (2012) 'Co-metabolic models of *Streptococcus thermophilus* in co-culture with *Lactobacillus bulgaricus* or *Lactobacillus acidophilus*', *Biochemical Engineering Journal*, 62, 62-69. doi: 10.1016/j.bej.2012.01.004

Oshoma, C. E. and Ikenebomeh, M. J. (2005) 'Production of *Aspergillus niger* biomass from rice bran', *Pakistan Journal of Nutrition*, 4(1), 32-36.

Osma, J. F., Herrera, J. L. T., Couto, S. R. (2007) 'Banana skin: A novel waste for laccase production by *Trametes pubescens* under solid-state conditions. Application to synthetic dye decolouration', *Dyes and Pigments*, 75(1), 32-37. doi: 10.1016/j.dyepig.2006.05.021

Otero, M. C., Morelli, L., Nader-Macías, M. E. (2006) 'Probiotic properties of vaginal lactic acid bacteria to prevent metritis in cattle', *Letters in Applied Microbiology*, 43, 91-97. doi: 10.1111/j.1472-765X.2006.01914.x

Pagnini, C., Saeed, R., Bamias, G., Arseneau, K. O., Pizarro, T. T. and Cominello, F. (2010) 'Probiotics promote gut health through stimulation of epithelial innate immunity', *Proceedings of the National Academy of Sciences of the United States of America*, 107(1), 454-459. doi: 10.1073/pnas.0910307107

Palframan, R. J., Gibson, G. R., Rastall, R. A. (2002) 'Effect of pH and dose on the growth of gut bacteria on prebiotic carbohydrates *in vitro*', *Anaerobe*', 8, 287-292. doi: 10.1006/anae.2002.0434

Panesar, P. S., Kennedy, J. F., Knill, C. J., Kosseva, M. (2010) 'Production of L(+) lactic acid using *Lactobacillus casei* from whey', *Brazilian Archives of Biology and Technology*, 53(1): 219-226.

Parvez, S., Malik, K. A., As Kang, S. and Kim, H.-Y. (2006) 'Probiotics and their fermented food products are beneficial for health', *Journal of Applied Microbiology*, 100(6), 1171-1185. doi: 10.1111/j.1365-2672.2006.02963.x

Patrick, S. and McDowell, A. (2012) Genus I. *Propionibacterium* Orla-Jensen 1909. In *Bergey's Manual of Systematic Bacteriology* Vol. 5, 2nd Edn. Pg, 1138-1188.

Piveteau, P. (1999) 'Metabolism of lactate and sugars by dairy propionibacteria: A review', *Lait*, 79, 23-41.

Piveteau, P. G., Condon, S., Cogan, T. M. (1995) 'Interactions between lactic and propionic acid bacteria', Lait, 75(4-5), 331-343. doi: 10.1051/lait:19954-525

Poolman, B. and Konings, W. N. (1988) 'Relation growth of *Streptococcus lactis* and *Streptococcus cremoris* to amino acid transport', *Journal of Bacteriology*, 170(2), 700-707. doi: 10.1128/jb.170.2.700-707.1988

Poppi, L. B., Rivaldi, J. D., Coutinho, T. S., Astolfi-Ferreira, C. S., Piantino-Ferreira, A. J., Mancilha, I. M. (2015) 'Effect of *Lactobacillus* sp. isolates supernatant on Escherichia coli O157:H7 enhances the role of organic acids production as a factor for pathogen control', *Pesq. Vet. Bras.* 35(4): 353-359. doi: 10.1590/S0100-736X2015000400007

Pyar, H., Liong, M. T. and Peh, K. K. (2014) 'Potentials of pineapple waste as growth medium for *Lactobacillus* species', *International Journal of Pharmacy and Pharmaceutical Sciences*, 6(1), 142-145.

Qi, B. and Yao, R. (2007) 'L-lactic acid production from *Lactobacillus casei* by solid state fermentation using rice straw', *BioResources*, 2(3), 419-429.

Qu, Y., Feng, Y., Wang, X., Logan, B. E. (2012) 'Use of a coculture to enable current production by *Geobacter sulfurreducens*', *Applied and Environmental Microbiology*. 78(9): 3484-3487. doi: 10.1128/AEM.00073-12

Rafiq, M. Y., Bugmann, G. and Easterbrook, D. J. (2001) 'Neural Network design for engineering applications', *Computers and Structures*. 79: 1541-1552. doi: 10.1016/S0045-7949(01)00039-6

Ranadheera, C. S., Evans, C. A, Adams, M. C. and Baines, S. K. (2013) 'Production of probiotic ice cream from goat's milk and effect of packaging materials on product quality', *Small Ruminant Research*, 112, 174-180. doi: 10.1016/j.smallrumres.2012.12.020

Ranadheera, C. S., Evans, C. A., Adams, M. C. and Baines, S. K. (2015) 'Microencapsulation of *Lactobacillus acidophilus* LA-5, *Bifidobacterium animalis* subsp. *lactis* BB-12 and *Propionibacterium jensenii* 702 by spray drying in goat's milk', *Small Ruminant Research*, 123(1), 155-159. doi: 10.1016/j.smallrumres.2014.10.012

Ranadheera, C. S., Evans, C. A., Adams, M. C. and Baines, S. K. (2012) 'Probiotic viability and physico-chemical and sensory properties of plain and stirred fruit yogurts made from goat's milk', *Food Chemistry*, 135(3), 1411-1418. doi: 10.1016/j.foodchem.2012.06.025

Ranadheera, C. S., Evans, C. A., Adams, M., Baines, S. K. (2016) 'Co-culturing of probiotics influences the microbial and physico-chemical properties but not sensory quality of fermented dairy drink made from goat's milk', *Small Ruminant Research*, 136, 104-108. doi: 10.1016/j.smallrumres.2016.01.016

Rashid, R., Jamaluddin, H., Saidina Amin, N. A. (2006) 'Empirical and Feed Forward Neural Networks Models of Tapioca Starch Hydrolysis', *Applied Artificial Intelligence*, 20(1): 79-97. doi: 10.1080/08839510500191422

Rathore, S., Salmerón, I. and Pandiella, S. S. (2012) 'Production of potentially probiotic beverages using single and mixed cereal substrates fermented with lactic acid bacteria cultures', *Food Microbiology*, 30, 239-244. doi: 10.1016/j.fm.2011.09.001

Ratnadewi, A. A. I., Zain, M. H. A., Kusuma, A. A. N. N., Handayani, W., Nugraha, A. S. and Siswoyo, T. A. (2020) '*Lactobacillus casei* fermentation towards xylooligosaccharide (XOS) obtained from coffee peel enzymatic hydrolysate', *Biocatalysis and Agricultural Biotechnology*, 23, 101466. doi: 10.1016/j.bcab.2019.101446

Rigobelo, E. C. and de Ávila, F. A. (2012) 'Protective Effects of Probiotics Strains in Ruminants', In (Ed.), Probiotic in Animals. *IntechOpen*. 33-54. doi: 10.5772/50054

Ringø, E., Hoseinifar, S. H., Ghosh, K., Doan, H. V., Beck, B. R. and Song, S. K. (2018) 'Lactic acid bacteria in finfish – An update', *Frontiers in Microbiology*, 9, 1818. doi: 10.3389/fmicb.2018.01818

Rosniyana, A., Hashifah, M. A. and Sharifah Norin, S. A. (2009) 'Nutritional content and storage stability of stabilized rice bran – MR 220', *J. Trop. Agric. and Fd. Sc*, 37(2), 163–170.

Rossi, F., S. Torriani, and F. Dellaglio. (1998) 'Identification and clustering of dairy propionibacteria by RAPD-PCR and CGE-REA methods', *Journal of Applied Microbiology*, 85, 956–964. doi: 10.1111/j.1365-2672.1998.tb05259.x

Ruiz, L., Sánchez, B., de los Reyes-Gavilán, C. G., Gueimonde, M., Margolles, A. (2009) 'Coculture of *Bifidobacterium longum* and *Bifidobacterium breve* alters their protein expression profiles and enzymatic activities', *International Journal of Food Microbiology*, 133, 148-153. doi: 10.1016/j.ijfoodmicro.2009.05.014

Ruiz-Barba, J. K., Caballero-Guerrero, B., Maldonado-Barragán, A., Jiménez-Díaz, R. (2010) 'Coculture with specific bacteria enhances survival of *Lactobacillus plantarum* NC8, an autoinducer-regulated bacteriocin producer, in olive fermentations', *Food Microbiology*, 27, 413-417. doi:10.1016/j.fm.2009.10.002

Saarela, M. H., Alakomi, H. -L., Puhakka, A. and Mättö, J. (2009) 'Effect of the fermentation pH on the storage stability of *Lactobacillus rhamnosus* preparations and suitability of *in vitro* analyses of cell physiological functions to predict it', *Journal of Applied Microbiology*, 106(4), 1204-1212. doi: 10.1111/j.1365-2672.2008.04089.x

Sabra, W., Dietz, D., Zeng, A. P. (2013) 'Substrate-Limited Co-culture for Efficient Production of Propionic Acid from Flour Hydrolysate', *Applied Microbiology and Biotechnology*, 97, 5771-5777. doi: 10.1007/s00253-013-4913-y

Sadi, T. (2021) 'The challenges in repurposing food wastes and other residuals for agriculture', *Food and Fertilizer Technology Center for the Asian and Pacific Region*, https://ap.fftc.org.tw/article/2785 Retrieved on 1 July 2022.

Sadler, G. D. and Murphy, P. A. (2017) 'pH and titratable acidity', In: Nielsen, S.S. (eds) Food Analysis. Food Science Text Series. Springer, Cham. doi: 10.1007/978-3-319-45776-5_22

Saman, P., Fuciños, P., Vázquez, J. A., Pandiella, S. S. (2011) 'Fermentability of brown rice and rice bran for growth of human *Lactobacillus plantarum* NCIMB 8826', *Food Technology and Biotechnology*, 49(1), 128-132.

Sánchez, B., Burns, P., Ruiz, L., Binetti, A., Vinderola, G., Reinheimer, J., Margolles, A., Ruas-Madiedo, P. and de los Reyes-Gavilán, C. G. (2013a) 'Co-culture affects protein profile and heat tolerance of *Lactobacillus delbrueckii* subsp. *lactis* and *Bifidobacterium longum*', *Food Research International*, 54, 1080-1083. doi: 10.1016/j.foodres.(2013)01.026

Sánchez, B., Ruiz, L., Gueimonde, M. and Margolles, A. (2013b) 'omics for the study of probiotic microorganisms', *Food Research International*. 54, 1061-1071. doi: 10.1016/j.foodres.2013.01.029

Santoyo, M. C., Loiseau, G., Sanoja, R. R. and Guyot, J. P. (2003) 'Study of starch fermentation at low pH by *Lactobacillus fermentum* Ogi E1 reveals uncoupling between growth and α-amylase production at pH 4.0', *International Journal of Food Microbiology*, 80, 77-87. doi: 10.1016/s0168-1605(02)00140-x

Saranya Devi, E., Vijayendra, S. V. N. and Shamala, T. R. (2012) 'Exploration of rice bran, an agro-industry residue, for the production of intra- and extra-cellular polymers by *Sinorhizobium meliloti* MTCC 100', *Biocatalysis and Agricultural Biotechnology*, 1(1), 80-84. doi: 10.1016/j.bcab.2011.08.014

Saratale, R. G., Cho, S. -K., Kadam, A. A., Ghodake, G. S., Kumar, M., Bharagava, R. N., Varjani, S., Nair, S., Kim, D. -S., Shin, H. -S. and Saratale, G. D. (2022) 'Developing microbial co-culture system for enhanced polyhydroxyalkanoates (PHA) production using acid pretreated lignocellulosic biomass', *Polymers*, 14, 726. doi: 10.3390/polym14040726

Saravanan, P., Pakshirajan, K., Saha, P. K. (2008) 'Kinetics of growth and multi substrate degradation by an indigenous mixed microbial culture isolated from a wastewater treatment plant in Guwahati, India', *Water Science & Technology – WST*, 58(5), 1101-1106. doi: 10.2166/wst.2008.463

Saxami, G., Ypsilantis, P., Sidira, M., Simopoulos, C., Kourkoutas, Y., Galanis, A. (2012) 'Distinct adhesion of probiotic strain *Lactobacillus casei* ATCC 393 to

rat intestinal mucosa', *Anaerobe*, 18, 417-420. doi: 10.1016/j.anaerobe.2012.04.002

Saxelin, M., Rautelin, H., Salminen, S., Mäkelä, P. H. (1996) 'Safety of commercial products with viable *Lactobacillus* strains', *Infectious Diseases in Clinical Practice*, 5(5), 331-335.

Saykhedkar, S. S. and Singhal, R. S. (2004) 'Solid-state fermentation for production of griseofulvin on rice bran using *Penicillium griseofulvum*', *Biotechnology Progress*, 20(4), 1280-1284. doi: 10.1021/bp0343662

Schepers, A. W., Thibault, J. and Lacroiz, C. (2002) '*Lactobacillus helveticus* growth and lactic acid production during pH-controlled batch cultures in whey permeate/yeast extract medium. Part I. Multiple factor kinetic analysis', *Enzyme and Microbial Technology*, 30(2), 176-186. doi: 10.1016/S0141-0229(01)00466-5

Schiraldi, C., Adduci, V., Valli, V., Maresca, C., Giuliano, M., Lamberti, M., Cartení, M. and De Rosa, M. (2003) 'High cell density cultivation of probiotics and lactic acid production', *Biotechnology and Bioengineering*, 82(2), 213-222. doi: 10.1002/bit.10557

Schwenninger, S. M. and Meile, L. (2004) 'A mixed culture of *Propionibacterium jensenii* and *Lactobacillus paracasei* subsp. *paracasei* inhibits food spoilage yeasts', *Systematic and Applied Microbiology*, 27(2), 229-237. doi: 10.1078/072320204322881853

Schwenninger, S. M., Lacroix, C., Truttmann, S., Jans, C., Spörndli, C., Bigler, L. and Meile, L. (2008) 'Characterization of low-molecular-weight antiyeast metabolites produced by a food-protective *Lactobacillus-Propionibacterium* coculture', *Journal of Food Protection*, 71(12), 2481-2487. doi: 10.4315/0362-028x-71.12.2481

Seo, J. K., Kim, S. W., Kim, M. H., Upadhaya, S. D., Kam, D. K. and Ha, J. K. (2010) 'Direct-fed Microbial for Ruminant Animals', *Asian-Aust. J. Anim. Sci.* 23(12): 1657-1667.

Seyoum, Y., Humblot, C., Baxter, B. A., Nealon, N. J., Weber, A. M and Ryan, E. P. (2022) 'Metabolomics of rice bran differentially impacted by fermentation with six probiotics demonstrates key nutrient changes for enhancing gut health', *Frontiers in Nutrition*, 8:795334. doi: 10.3389/fnut.2021.795334

Shahravy, A., Tabandeh, F., Bambai, B., Zamanizadeh, H. R. and Mizani, M. (2012) 'Optimization of probiotic *Lactobacillus casei* ATCC 334 production using date powder as carbon source', *Chemical Industry & Chemical Engineering Quarterly*, 18(2), 273-282. doi: 10.2298/CICEQ110709004S

Sharma, N., Kalra, K. L., Oberoi, H. S. and Bansal, S. (2007) 'Optimization of fermentation parameters for production of ethanol from kinnow waste and banana peels by simultaneous saccharification and fermentation', *Indian Journal of Microbiology*, 47, 310-316. doi: 10.1007/s12088-007-0057-z

Shi, J., Ebrik, M. A. and Wyman, C.E. (2011) 'Sugar yields from dilute sulfuric acid and sulfur dioxide pretreatments and subsequent enzymatic hydrolysis of switchgrass', *Bioresource Technology*, 102(11), 8930–8938. doi: 10.1016/j.biortech.2011.07.042

Shortt, C. (1999) 'The probiotic century: Historical and current perspectives', *Trends in Food Science & Technology*, 10(12), 411-417. doi: 10.1016/S0924-2244(00)00035-2

Shu, G., Li, C., Chen, H. and Wang, C. (2014) 'Effect of inoculum and temperature on the fermentation of goat yogurt', *Advance Journal of Food Science and Technology*, 6(1), 68-71. doi: 10.19026/ajfst.6.3032

Sidira, M., Karapetsas, A., Galanis, A., Kanellaki, M. and Kourkoutas, Y. (2014) 'Effective survival of immobilized *Lactobacillus casei* during ripening and heat treatment of probiotic dry-fermented sausages and investigation of the microbial dynamics', *Meat Science*. 96: 948-955. doi: 10.1016/j.meatsci.2013.09.013

Silveira, M. S., Fontes, C. P. M. L., Guilherme, A. A., Fernandes, F. A. N. and Rodrigues, S. (2012) 'Cashew apple juice as substrate for lactic acid production', *Food and Bioprocess Technology*, 5, 947-953. doi: 10.1007/s11947-010-0382-9

Singh, A. K., Rath, S., Kumar, Y., Masih, H., Peter, J. K., Benjamin, J. C., Singh, P. K., Dipuraj, and Singh, P. (2014) 'Bio-ethanol production from banana peel by simultaneous saccharification and fermentation process using cocultures *Aspergillus niger* and *Saccharomyces cerevisiae*', *International Journal of Current Microbiology and Applied Sciences*, 3(5), 84-96.

Smid, E. J. and Lacroix, C. (2013) ‘Microbe–microbe interactions in mixed culture food fermentations’, *Current Opinion in Biotechnology*, 24(2), 148-154. doi: 10.1016/j.copbio.2012.11.007

Soto, L. P., Frizzo, L. S., Avataneo, E., Zbrun, M. V., Bertozzi, E., Sequeira, G., Signorini, M. L. and Rosmini, M. R. (2011) 'Design of Macrocapsules to Improve Bacterial Viability and Supplementation with a Probiotic for Young Calves', *Animal Feed Science and Technology*, 165, 176-183. doi: 10.1016/j.anifeedsci.2011.03.001

Speranza, P., Carvalho, P. d. O. and Macedo, G. A. (2011) ‘Effects of different solid state fermentation substrate on biochemical properties of cutinase from *Fusarium* sp.’, *Journal of Molecular Catalysis B: Enzymatic*, 72(3-4), 181-185. doi: 10.1016/j.molcatb.2011.06.003

Stackebrandt, E., Cummins, C. S., Johnson, J. L. (2006) ‘Family Propionibacteriaceae: The genus *Propionibacterium*’, *Prokaryotes*, 3, 400-418. doi: 10.1007/0-387-30743-5_19

Stein, D. R., Allen, D. T., Perry, E. B., Bruner, J. C., Gates, K. W., Rehberger, T. G., Mertz, K., Jones, D. and Spicer, L. J. (2006) ‘Effects of feeding propionibacteria to dairy cows on milk yield, milk components, and reproduction, *Journal of Dairy Science*, 89(1), 111-125. doi: 10.3168/jds.S0022-0302(06)72074-4

Sun, H. Y., Li, J., Zhao, P. and Peng, M. (2011) ‘Banana peel: A novel substrate for cellulase production under sol-state fermentation’, *African Journal of Biotechnology*, 10(77), 17887-17890. doi: 10.5897/AJB10.1825

Sun, Y. and Cheng, J. (2002) ‘Hydrolysis of lignocellulosic materials for ethanol production: A review’, *Bioresource Technology*, 83(1), 1-11. doi: 10.1016/S0960-8524(01)00212-7

Sunphorka, S., Chalermsinsuwan, B. and Piumsomboon, P. (2017) ‘Artificial Neural Network model for the prediction of kinetic parameters of biomass pyrolysis from its constituents’, *Fuel*, 193, 142-158. doi: 10.1016/j.fuel.2016.12.046

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. doi: 10.3390/ijms9091621

Tanaka, T., Hoshina, M., Tanabe, S., Sakai, K., Ohtsuba, S. and Taniguchi, M. (2006) ‘Production of D-lactic acid from defatted rice bran by simultaneous

saccharification and fermentation', *Bioresource Technology*, 97(2), 211-217. doi: 10.1016/j.biortech.2005.02.025

Tesfaw, A. and Assefa, F. (2014) 'Co-culture: A great promising method in single cell protein production', *Biotechnology and Molecular Biology Reviews*, 9(2), 12-20. doi: 10.5897/BMBR2014.0223

Thierry, A., Deutsch, S.-M., Falentin, H., Dalmasso, M., Cousin, F.J. and Jan, G. (2011) 'New insights into physiology and metabolism of *Propionibacterium freudenreichii*', *International Journal of Food Microbiology*, 149(1), 19–27. doi: 10.1016/j.ijfoodmicro.2011.04.026

Timmerman, H. M., Koning, C. J. M., Mulder, L., Rombouts, F. M. and Beynen, A. C. (2004) 'Monostrain, multistrain and multispecies probiotics – A comparison of functionality and efficacy', *International Journal of Food Microbiology*, 96(3), 219-233. doi: 10.1016/j.ijfoodmicro.2004.05.012

Tock, J. Y., Lai, C. L., Lee, K. T., Tan, K. T., Bhatia, S. (2010) 'Banana biomass as potential renewable energy resource: A Malaysian case study', *Renewable and Sustainable Energy Reviews*, 14(2), 798-805. doi: 10.1016/j.rser.2009.10.010

Todhanakasem T, and Puanglamyai, N. (2012) 'Use of rice hull hydrolyzate in the cultivation of *Lactobacillus acidophilus*', *KKU Research Journal*, 17, 778-786.

Todhanakasem, T., Narkmit, T., Areerat, K., Thanonkeo, P. (2015) 'Fermentation of rice bran hydrolysate to ethanol using *Zymomonas mobilis* biofilm immobilization on DEAE-cellulose', *Electronic Journal of Biotechnology Fermentation*, 18(3), 196-201. doi: 10.1016/j.ejbt.2015.03.007

Tsapatsaris, S. and Kotzekidou, P. (2004) 'Application of central composite design and response surface methodology to the fermentation of olive juice by *Lactobacillus plantarum* and *Debaryomyces hansenii*', *International Journal of Food Microbiology*, 95: 157-168. doi: 10.1016/j.ijfoodmicro.2004.02.011

Tsen, J. -H., Lin, Y. -P. and King, V. A. -E. (2004) 'Fermentation of banana media by using κ-carrageenan immobilized *Lactobacillus acidophilus*', *International Journal of Food Microbiology*, 91(2), 215-220. doi: 10.1016/S0168-1605(03)00376-3

Tsigie, Y. A., Wang. C. Y., Kasim, N. S., Diem, Q. D., Huynh, L. H., Ho, Q. P., Truong, C. T. and Ju, Y. H. (2012) 'Oil production from *Yarrowia lipolytica*

Po1g using rice bran hydrolysate', *Journal of Biomedicine and Biotechnology*', Vol. 2012, Article 378384, 10 pages. doi: 10.1155/2012/378384

Tufvesson, P., Ekman, A., Sardari, R. R. R., Engdahl, K. and Tufvesson, L. (2013) 'Economic and environmental assessment of propionic acid production by fermentation using different renewable raw materials', *Bioresource Technology*, 149, 556-564. doi: 10.1016/j.biortech.2013.09.049

Uppada, S. R., Balu, A., Gupta, A. K. and Dutta, J. R. (2014) 'Hybrid Neural Network based optimization of process parameters and application of Taguchi method for lipase production from co-culture of *Lactobacillus brevis* and *Lactobacillus plantarum*', *International Journal of PharmTech Research*', 6(7), 2074-2082.

Valente, E., Rocha, I. and Rocha, M. (2009) 'Modelling fed-batch fermentation processes: An approach based on Artificial Neural Networks', *IWPACBB 2008*, ASC 49: pp 30-39.

Velu, S., Velayutham, V. and Manickkam, S. (2016) 'Optimization of fermentation media for xanthan gum production from *Xanthomonas campestris* using Response Surface Methodology and Artificial Neural Network techniques', *Indian Journal of Chemical Technology*, 23, 353-361.

Vidra, A. and Németh, Á. (2022) 'Applicability of Neural Networks for the fermentation of propionic acid by *Propionibacterium acidipropionici*', *Periodica Polytechnica Chemical Engineering*, 66(1), 10-19. doi: 10.3311/PPch.18283

Vinderola, C. G., Mocchiutti, P. and Reinheimer, J. A. (2002) 'Interactions among lactic acid starter and probiotic bacteria used for fermented dairy products', *Journal of Dairy Science*, 85(4), 721-729. doi: 10.3168/jds.S0022-0302(02)74129-5

Vyas, D., McGeough, E. J., Mohammed, R., McGinn, S. M., McAllister, T. A. and Beauchemin, K. A. (2014) 'Effects of *Propionibacterium* strains on ruminal fermentation, nutrient digestibility and methane emissions in beef cattle fed a corn grain finishing diet', *Animal*, 8(11), 1807-1815. doi: 10.1017/S1751731114001657

Wadhwa, M. and Bakshi, M. P. S. (2013) 'Utilization of fruit and vegetable wastes as livestock feed and as substrates for generation of other value-added products', *RAP Publication*, Vol. 04. http://www.fao.org/docrep/018/i3273e/i3273e00.htm

Wang, P., Jiao, Y., Liu, S. (2014) 'Novel fermentation process strengthening strategy for production of propionic acid and vitamin B12 by *Propionibacterium freudenreichii*', *Journal of Industrial Microbiology and Biotechnology*, 41(12), 1811-1815. doi: 10.1007/s10295-014-1513-5

Wang, Y., Cai, D., He, M., Wang, Z., Qin, P. and Tan, T. (2015) 'Open fermentative production of L-lactic acid using white rice bran by simultaneous saccharification and fermentation', *Bioresource Technology*, 198, 664-672. doi: 10.1016/j.biortech.2015.09.010

Watanabe, M., Makino, M., Kaku, N., Koyama, M., Nakamura, K., Sasano, K. (2013) 'Fermentative L-(+)-lactic acid production from non-sterilized rice washing drainage containing rice bran by a newly isolated lactic acid bacteria without any additions of nutrients', *Journal of Bioscience and Bioengineering*, 115(4), 449-452. doi: 10.1016/j.jbiosc.2012.11.001

Watanabe, M., Takahashi, M., Sasano, K., Kashiwamura, T., Ozaki, Y., Tsuiki, T., Hidaka, H. and Kanemoto, S. (2009) 'Bioethanol production from rice washing drainage and rice bran', *Journal of Bioscience and Bioengineering*', 108(6), 524-526. doi: 10.1016/j.jbiosc.2009.06.014

Weathers, P. J., Towler, M. J. and Wyslouzil, B. E. (2012) 'Beyond cells: culturing complex plant tissues for the production of metabolites and elite genotypes', In *Fermentation microbiology and biotechnology* (eds E. M. T. El-Mansi, C. F. A. Bryce, A. L. Demain, A. R. Allman), 3rd edn, pp. 295–312. Boca Raton, FL: CRC Press.

Weiss, W. P., D. J. Wyatt and T. R. McKelvey. (2008) 'Effect of feeding propionibacteria on milk production by early lactation dairy cows', *Journal of Dairy Science*, 91(2), 646-652. doi: 10.3168/jds.2007-0693

Wiemann, M. (2003) 'How do probiotic feed additives work?', *International Poultry Producer*, 11, 7-9.

Wu, Q. Q., You, H. J., Ahn, H. J., Kwon, B. and Ji, G. E. (2012) 'Changes in growth and survival of *Bifidobacterium* by coculture with *Propionibacterium* in soy milk, cow's milk, and modified MRS medium', *International Journal of Food Microbiology*, 157(1), 65-72. doi: 10.1016/j.ijfoodmicro.2012.04.013

Xanthopoulos, V., Ipsilandis, C. G., Tzanetakis, N. (2012) 'Use of a selected multi-strain potential probiotic culture for the manufacture of set-type yogurt from

caprine milk', *Small Ruminant Research*, 106, 145-153. doi: 10.1016/j.smallrumres.2012.05.005

Xie, C., Coda, R., Chamlagain, B., Varmanen, Piironen, V., Katina, K. (2019) Co-fermentation of *Propionibacterium freudenreichii* and *Lactobacillus brevis* in Wheat Bran for in situ Production of Vitamin B12. *Frontiers in Microbiology*. Vol. 10: Article 1541.

Yang, F., Hou, C., Zeng, X. and Qiao, S. (2015) 'The use of lactic acid bacteria as a probiotic in swine diets', *Pathogens*, 4(1), 34-45. doi: 10.3390/pathogens4010034

Yang, W. Z., Beauchemin, K. A., Vedres, D. D., Ghorbani, G. R., Colombatto, D. and Morgavi, D. P. (2004) 'Effects of direct-fed microbial supplementation on ruminal acidosis, digestibility, and bacterial protein synthesis in continuous culture', *Animal Feed Science and Technology*, 114(1-4), 179-193. doi: 10.1016/j.anifeedsci.2003.12.010

Yeoman, C. J. and White, B. A. (2014) 'Gastrointestinal tract microbiota and probiotics in production animals', *Annual Review of Animal Bioscience*, 2(1), 469–486. doi: 10.1146/annurev-animal-022513-114149

Yeoman, C. J., Chia, N., Jeraldo, P., Sipos, M., Goldenfeld, N. D. and White, B. A. (2012) 'The microbiome of the chicken gastro-intestinal tract', *Animal Health Research Reviews*, 13(1), 89–99. doi: 10.1017/S1466252312000138

Yerlikaya, O. and Ozer, E. (2014) 'Production of probiotic fresh white cheese using co-culture with *Streptococcus thermophilus*', *Food Sci. Technol. Campinas*, 34(3), 471-477.

Yoon, K. Y., Woodams, E. E. and Hang, Y. D. (2006) 'Production of probiotic cabbage juice by lactic acid bacteria', *Bioresource Technology*, 97(12), 1427-1430. doi: 10.1016/j.biortech.2005.06.018

Yu, Q., Zhuang, X., Lv, S., He, M., Zhang, Y., Yuan, Z., Qi, W., Wang, Q., Wang, W. and Tan, X. (2013) 'Liquid hot water pretreatment of sugarcane bagasse and its comparison with chemical pretreatment methods for the sugar recovery and structural changes', *Bioresource Technology*, 129, 592-598. doi: 10.1016/j.biortech.2012.11.099

Yun, J. S., Wee, Y. J., Kim, J. N., Ryu, H. W. (2004) 'Fermentative production of DL-lactic acid from amylase-treated rice and wheat brans hydrolyzate by a novel

lactic acid bacterium, *Lactobacillus* sp.', *Biotechnology Letters*, 26 (20), 1613-1616. doi: 10.1023/B:BILE.0000045826.97010.82

Zahid Anwar, Muhammad Gulfraz, and Muhammad Irshad. (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. doi: 10.1016/j.jrras.2014.02.003

Zahid, H. F., Ranadheera, C. S., Fang, Z. and Ajlouni, S. (2021) 'Utilization of mango, apple and banana peels as prebiotics and functional ingredients', *Agriculture,* 11(7), 584. doi: 10.3390/agriculture11070584

Zeidan, A. A., Rådström, P. and van Niel, E. W. J. (2010) 'Stable coexistence of two *Caldicellulosiruptor* species in a *de novo* constructed hydrogen-producing co-culture', *Microbial Cell Factories*, 9, 102. doi: 10.1186/1475-2859-9-102

Zhang, C., Brandt, M. J., Schwab, C., Gänzle, M. G. (2010) 'Propionic acid production by cofermentation of *Lactobacillus buchneri* and *Lactobacillus diolivorans* in sourdough', *Food Microbiology*, 27, 390-395. doi: 10.1016/j.fm.2009.11.019

Zhang, H. and Wang, X. (2016) 'Modular co-culture engineering, a new approach for metabolic engineering', *Metabolic Engineering*, 37, 114-121. doi: 10.1016/j.ymben.2016.05.007

Zhang, Q., Deng, D., Dai, W., Li, J. and Jin, X. (2020) 'Optimization of culture conditions for differentiation of melon based on artificial neural network and genetic algorithm', *Scientific Reports*, 10, 3524. doi: 10.1038/s41598-020-60278-x

Zhang, Y. and Vadlani, P. V. (2015) 'Lactic acid production from biomass-derived sugars via co-fermentation of Lactobacillus brevis and *Lactobacillus plantarum*', *Journal of Bioscience and Bioengineering*, 119(6), 649-699. doi: 10.1016/j.jbiosc.2014.10.027

Zhang, Y. and Padlani, P. V. (2015) 'Lactic acid production from biomass-derived sugars via co-fermentation of *Lactobacillus brevis* and *Lactobacillus plantarum*', *Journal of Bioscience and Bioengineering*, 119(6), 694-699. doi: 10.1016/j.jbiosc.2014.10.027

Zhu, Y., Li, J., Tan, M., Liu, L., Jiang, L., Sun, J., Lee, P., Du, G. and Chen, J. (2010) 'Optimization and scale-up of propionic acid production by propionic acid-tolerant *Propionibacterium acidipropionici* with glycerol as the carbon

source', *Bioresource Technology*, 101(22), 8902-8906. doi: 10.1016/j.biortech.2010.06.070

Zhuge, X., Liu, L., Shin, H., Li, J., Du, G. and Chen, J. (2014) 'Improved propionic acid production from glycerol with metabolically engineered *Propionibacterium jensenii* by integrating fed-batch culture with a pH-shift control strategy', *Bioresource Technology*, 152, 519-525. doi: 10.1016/j.biortech.2013.11.063

Zubaidah, E., Nurcholis, M., Wulan, S. N. and Kusuma, A. (2012) 'Comparative Study on Synbiotic Effect of Fermented Rice Bran by Probiotic Lactic Acid Bacteria *Lactobacillus casei* and Newly Isolated *Lactobacillus plantarum* B_2 in Winstar rats', *APCBEE Procedia*. 2: 170-177. ICBFS 2012: April 7-8, 2012, Bangkok, Thailand.

LIST OF PUBLICATIONS

Indexed Journal

1. **Mohamed Esivan, S. M.,** Rashid, R., Zaharudin, N. A. and Nik Mahmood, N. A. (2016) 'Growth and survival of *Lactobacillus casei* in rice bran and banana peel medium', *International Journal of Nano and Biomaterials*, 6(3/4), 151-161. doi: https://dx.doi.org/10.1504/IJNBM.2016.086107 (**Indexed by SCOPUS)**

2. **Mohamed Esivan, S. M.,** Rashid, R., Azmi, N. A., Zaharudin, N. A. and Othman, N. (2015) 'Effects of the initial rice bran concentration on the production of *Lactobacillus* as digestive bio-regulator', *Jurnal Teknologi (Sciences & Engineering*), 74(7), 25-18. doi: https://doi.org/10.11113/jt.v74.4691 (**Indexed by SCOPUS and ESCI-WOS**)

Indexed Conference Proceedings

1. **Mohamed Esivan, S. M.,** Rashid, R., Jati, A., Zaharudin, N. A. (2021). Growth of *Lactobacillus casei* and *Propionibacterium jensenii* in different glucose concentration and incubation temperature', In: Abdul Karim, S.A., Abd Shukur, M.F., Fai Kait, C., Soleimani, H., Sakidin, H. (eds) *Proceedings of the 6th International Conference on Fundamental and Applied Sciences*. Springer Proceedings in Complexity. Springer, Singapore. doi: https://doi.org/10.1007/978-981-16-4513-6_9 (**Indexed by SCOPUS**)

Non-Indexed Conference Proceedings

1. **Mohamed Esivan, S. M.,** Rashid, R., Zaharudin, N. A., Mohamad, M. (2018). Fermentation variables in the cultivation of *Lactobacillus* sp. and

Propionibacterium sp. *7th International Conference on Biotechnology for the Wellness Industry*. 27-28 August 2018. 79.

2. **Mohamed Esivan, S. M.,** Rashid, R. and Zaharudin, N. A. (2018). Production of *Lactobacillus casei* as direct-fed microbial in rice bran extract: Effect of incubation time and inoculation size. *International Graduate Conference on Engineering, Science and Humanities (IGCESH 2018)*. 13-15 August 2018. Johor. 292-294.

3. **Mohamed Esivan, S. M.,** Rashid, R. and Zaharudin, N. A. (2017). Effect of temperature and initial pH on the growth of direct-fed microbial *Lactobacillus casei* in rice bran extract. *International Postgraduate Symposium in Biotechnology 2017*. 21-22 August 2017, Johor Bahru.

4. **Mohamed Esivan, S. M.,** Rashid, R., Zaharudin, N. A., Nik Mahmood, N. A. and Rahman, R. A. (2016). Growth *Propionibacterium jensenii* in rice bran and banana peel extract. *6th International Conference on Biotechnology for the Wellness Industry 2016 (ICBWI 2016)*. 16-17 August 2016, Melaka. 22-27.

5. **Mohamed Esivan, S. M.,** Rashid, R., Zaharudin, N. A. and Nik Mahmood, N. A. (2015). Growth and survival of *Lactobacillus casei* in rice bran and banana peel medium. *International Conference on Innovation in Science and Technology (IICIST 2015)*. 20-21 April 2015, Kuala Lumpur. 67-72.