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THE EFFECTS OF DIFFERENT LEAVES ON MICROFLORA, PHYTOCHEMISTRY AND ITS SENSORY ACCEPTABILITY OF GULAI TEMPOYAK PASTE

MOHD HAFIZ ABDUL ARIS

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By

MOHD HAFIZ ABDUL ARIS

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Chairman : Assoc. Prof. Nor Ainy Mahyudin, PhD
Faculty : Food Science and Technology

Antimicrobial activity of Vietnamese coriander, turmeric, and *asam gelugor* leaves were determined via *in vitro* using agar well diffusion test and minimum inhibitory concentration (MIC). The leaves of these plants have continuously applied in the food system, and in this case, *gulai tempoyak* paste (GTP) had been chosen as the food subject to evaluate the effectiveness of these leaves in controlling microbial growth through the study of storage condition. Apart from that, the phytochemistry and the sensory properties of GTP were determined to identify the differences between nil addition of plant leaves (control sample) and with addition of Vietnamese coriander, turmeric, and *asam gelugor* leaves. Based on agar well diffusion test result, a concentration of 2 mg/mL of Vietnamese coriander leaves extract in distilled water showed strong antibacterial effect with (17.20 ± 5.42 mm) at inhibition zone. As for antifungal activity, extract of turmeric leaves in distilled water resulted strong activity (15.13 ± 0.17 mm) at inhibition zone compared to other solvents. Meanwhile, as for MIC, 2 mg/mL was the lowest concentration needed from all extracts of leaves to inhibit growth of microbial, as shown in Vietnamese coriander, turmeric, and *asam gelugor* leaves extracts towards selected spoilage microorganisms. On the other hand, GTP without addition of leaves was treated as control and all the prepared GTPs were stored at 30 °C for 2 days before analyses had been carried out using total plate count (TPC) and yeast and mould count (YMC). The addition of *asam gelugor* leaves to GTP for 5 minutes of the cooking period significantly ($p<0.05$) reduced TPC ($\log_{10}$ 3.54 CFU/g) compared to Vietnamese coriander ($\log_{10}$ 4.67 CFU/g) and turmeric leaves ($\log_{10}$ 4.70 CFU/g). Apart from that, this study also demonstrated that TPC and YMC for GTP with plant leaves reduced significantly within 14 days when stored at 4 ºC, and up to 8 days when stored at 30 ºC, thus, emphasize the microbiological evaluation of GTP. Moreover, the phytochemistry properties of the GTP samples demonstrated

significant differences ($p<0.05$) in pH, moisture, ash, crude fat, crude fibre and carbohydrate between the control sample and the treated samples. Higher level of crude fibre content was demonstrated in GTP added with Vietnamese coriander (4.42 ± 0.23%). Based on sensory evaluation test, the addition of plant leaves slightly affected the acceptability of eating and the physical quality scores of GTP. Nevertheless, there was insignificant difference ($p>0.05$) in colour, viscosity/consistency, spiciness, and aftertaste. GTP added with Vietnamese coriander leaves resulted in better aroma mean score, and at once produced significantly higher result for overall acceptability. In conclusion, these three types of plant leaves exhibited antimicrobial activity of against selected spoilage bacteria and the addition of plant leaves in GTP possibly improved the microbial safety by inhibiting microbial growth. Furthermore, there were significant effects on microbiological safety of GTP when added with Vietnamese coriander, turmeric, and *asam gelugor* leaves at different exposure time based on TPC and YMC. Besides, the phytochemistry and the sensory properties of the GTP samples with addition of plant leaves also improved in terms of crude fibre content as well as enhanced sensory attributes for colour, aroma, taste, and overall acceptability of the product.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk Ijazah Sarjana Sains

KESAN DAUN BERBEZA KE ATAS MIKROFLORA, FITOKIMIA DAN PENERIMAAN SENSORI PES GULAI TEMPOYAK

Oleh

MOHD HAFIZ ABDUL ARIS

Mei 2015

Pengerusi : Prof. Madya Nor Ainy Mahyudin, PhD
Fakulti : Sains dan Teknologi Makanan

Aktiviti antimikrobial daun kesum, kunyit dan asam gelugor ditentukan secara *in vitro* menggunakan agar ujian penyebaran keseluruhan dan kepekatan perencatan minimum. Daun tumbuhan ini terus digunakan dalam sistem makanan dalam kes ini, makanan yang dijadikan subjek ialah pes gulai tempoyak (GTP) untuk menilai tahap keberkesanan dalam mengendalikan pertumbuhan mikroorganisma oleh kajian keadaan penyimpanan. Selain itu, sifat fitokimia dan sensori GTP dikaji bagi menentukan perbezaan samaada penambahan daun tumbuhan (kesum, kunyit dan asam gelugor) memberi kesan kepada produk. Berdasarkan hasil ujian penyebaran keseluruhan, pada kepekatan 2 mg/mL ekstrak daun kesum dalam air memberikan anti-bakteria yang kuat dengan (17.20 ± 5.42 mm) zon perencatan. Untuk anti-kulat, ekstrak daun kunyit dalam air memberikan aktiviti yang kuat bagi zon perencatan (15.13 ± 0.17 mm) berbanding dengan pelarut lain. Bagi MIC, 2 mg/mL adalah kepekatan yang paling rendah yang ekstrak tumbuhan menghambat pertumbuhan yang ditunjukkan oleh ekstrak daun kesum, kunyit dan asam gelugor terhadap mikroorganisma perosak yang dipilih. Sementara itu, GTP tanpa penambahan daun dianggap sebagai kawalan dan semua GTP siap disimpan pada 30 °C selama 2 hari sebelum dianalisis menggunakan pengiraan plat total (TPC) dan pengiraan yis dan kulat (YMC). Penambahan daun asam gelugor untuk GTP yang di masukkan pada 5 minit masa memasak secara signifikan ($p<0.05$) mengurangkan TPC ($\log_{10}$ 3.54 CFU/g) berbanding daun kesum ($\log_{10}$ 4.67 CFU/g) dan daun kunyit ($\log_{10}$ 4.70 CFU/g). Selain daripada itu, kajian ini juga menunjukkan bahawa TPC dan YMC untuk GTP apabila ditambah dengan daun tumbuhan dapat mengurangkan dengan signifikan dalam masa 14 hari apabila disimpan pada 4 ºC dan sehingga 8 hari apabila disimpan pada 30 ºC. Selain itu, sifat-sifat fitokimia sampel GTP menghasilkan perbezaan yang signifikan ($p<0.05$) untuk ujian pH, kadar air, abu, lemak kasar, serat kasar dan karbohidrat antara

sampel kawalan dan sampel rawatan. Kandungan serat kasar yang lebih tinggi ditunjukkan dalam GTP yang ditambah dengan daun kesum (4.42 ± 0.23%). Berdasarkan ujian penilaian deria, penambahan daun tumbuhan sedikit mempengaruhi penerimaan panel dan skor kualiti fizikal GTP. Tidak terdapat perbezaan yang signifikan ($p>0.05$) dalam warna, kelikatan/konsistensi, kepedasan, dan *after taste*. GTP ditambah dengan daun kesum menghasilkan skor min aroma yang lebih tinggi skor sekaligus menghasilkan penerimaan keseluruhan yang lebih tinggi daripada panel. Kesimpulannya, ketiga-tiga jenis daun tumbuhan mempamerkan aktiviti antimikrobial terhadap bakteria perosak makanan yang dipilih dan penambahan daun tumbuhan dalam GTP dapat meningkatkan keselamatan mikrobiologi dengan mengawal pertumbuhan mikroorganisma dan ada kesan signifikan terhadap keselamatan mikrobiologi GTP apabila ditambah dengan daun kesum, kunyit dan asam gelugor pada masa pendedahan semasa dimasak yang berbeza berdasarkan TPC dan YMC. Selain itu, sifat-sifat fitokimia dan sensori sampel GTP yang ditambah dengan daun tumbuhan juga bertambah baik pada kadar kandungan serat kasar selain meningkatkan sifat-sifat deria untuk warna, aroma, rasa dan penerimaan keseluruhan produk.

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I certify that a Thesis Examination Committee has met on 7 May 2015 to conduct the final examination of Mohd Hafiz Abdul Aris on his thesis entitled "**THE EFFECTS OF DIFFERENT LEAVES ON MICROFLORA, PHYTOCHEMISTRY AND ITS SENSORY ACCEPTABILITY OF *GULAI TEMPOYAK* PASTE**" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Son Radu, PhD
Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Chairman)

Yaya Rukayadi, PhD
Associate Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Internal Examiner)

Alfi Khatib, PhD
Associate Professor
International Islamic University Malaysia
Malaysia
(External Examiner)

ZULKARNAIN ZAINAL, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of Supervisory Committee were as follows:

Nor Ainy Mahyudin, PhD
Associate Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Chairman)

Hazrina Ghazali, PhD
Senior Lecturer
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

Norhayati Hussain, PhD
Senior Lecturer
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

ZULKARNAIN ZAINAL, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

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LIST OF ABBREVIATIONS

AG	*asam gelugor*
ANOVA	Analysis of Variance
AOAC	Association of Official Agricultural Chemists
BHA	Butylated hydroxanisole
CFU/g	Colony Form Unit per gram
cm	centimeter
CRD	Completely Randomized Design
Cu	copper
DMRT	Duncan's Multiple Range Test
DMSO	dimethyl sulfoxide
DNA	deoxyribonucleic acid
DW	distilled water
g	gram
GTP	*gulai tempoyak* paste
H	hexane
H_2SO_4	sulphuric acid
HCl	hydrochloric acid
HIV	Human Immunodeficiency Virus
ICMSF	International Committee on Microbiological Specification for Food
MIC	Minimum Inhibitory Concentration
min	minute
mm	milimeter
mL	mililiter
NaCl	sodium chloride
NaOH	sodium hydroxide
RTE	ready-to-eat
RTEC	ready to end-cook
RTC	ready to cook
RTH	ready to heat
TL	turmeric leaf
TPC	total plate count
UKFG	United Kingdom Food Grade
VC	Vietnamese coriander
v/v	volume per volume
WHO	World Health Organization
YMC	yeast and mould count
µg	microgram
µg/mL	microgram per mililiter

CHAPTER 1

INTRODUCTION

Fermented food are food substrates that are invaded or overgrown by edible microorganisms whose enzymes, particularly amylases, protease and lipases hydrolyse polysaccharides, proteins and lipids to non-toxic products with development of unique flavours, aromas and textures pleasant and attractive to the human consumer. Indigenous fermented foods make up an important contribution to the human diet in many developing countries (Murty and Kumar, 1995; Steinkraus, 1996). Some of these foods form the essential diet components of certain populations and are consumed either as main dishes or as condiments (Steinkraus, 1996). Fermented durian pulp or locally known as 'tempoyak' is a popular side dish and a condiment in Malaysia. This product is creamy, yellow whitish in colour, and has a strong distinctive aroma. During fermentation, the texture of the durian pulp changes from solid to a semisolid mass accompanied by a strong flavour, the flavour is a result of a unique combination of various sugars, organic acids as well as various volatile organic compounds (Yuliana and Garcia, 2009). Although, fermented durian pulp is recognized as product of lactic acid fermentation, the microbiological and sensory quality of the product made from *tempoyak* is still undescribed.

Gulai tempoyak is a traditional dish that uses fermented durian pulp as its main ingredient and mixed together with fresh turmeric, chilies, water, salt, and some herbs, such as Vietnamese coriander (*Persicaria odorata*) cooked with freshwater fish. Besides, versatility of Malay dish makes it very unique, as it is know that Malaysia includes a variety of plants in its vast dishes. The plants that are used in cooking can be of various parts, such as leaves, fruits, bark, stem, seed, flower, root, and tuber. *Gulai tempoyak* is usually prepared from scratch, but nowadays, ready-made pastes are becoming more popular due to busy lifestyles and convenience purposes. In order to meet consumers' demands for healthy and free of additive food, they plays a major role in the modification of our food supply and their demand is currently driven towards foods that are "natural" and free of additives, yet safe for consumption and convenient for use (Rhodehamel, 1992). Consequently, essential oils and plant extracts are the natural antimicrobial constituents in highest demand (Burt, 2004). In addition, the search for natural antimicrobials has led food scientists to investigate the effectiveness of inhibitory compounds to be apply in processed food such as organic acids, essential oils, bacteriocins, dried fermentation-based products, and bioactive compounds (Lemay *et al*., 2002).

Furthermore, various synthetic chemical preservatives have been applied to food preservation despite the common low temperature preservation applications. Organic substances like boric acid, sulphite derivatives, sodium bisulphate, sodium metabisulphite, and a variety of chemical additives are

applied considerably to control the growth of spoilage microorganisms in food products (Abu Bakar *et al*., 2008; Nirmal and Benjakul, 2011). Thus, the safety aspects of chemical or synthetic food additives toward our health have been questioned and argued among consumers. As researchers and consumers have increasing concern about potential health issues associated with chemical and synthetic food additives, they continuously focusing on the utilize of plant products as alternatives to synthetic ones. With that, the demand for natural preservatives has increased worldwide (Pundir and Jain, 2010). The exploration and the investigation of novel antimicrobial agents from natural resources are inclusive of plants or plant based products and others that have been used mainly for food safety and food preservation purposes (Fajimi and Taiwo, 2005; Tagoe *et al*., 2010). Owing to the antimicrobial and antioxidant properties of fruits and vegetables, their extracts have significant consideration to be used in foods as food additives or natural preservatives (Nanasombat and Lohasupthawee, 2005; Nkambule, 2008; Amrita *et al*., 2009; Pundir and Jain, 2010).

Application of natural antimicrobial as a natural agent to control microbiological quality of food products have been reported in many country that own their traditional and native plants. In Thailand, green curry and acidic paste are develops to control microbial quality of ready to cook white shrimp (Siripongvutikorn *et al*., 2012). While in Canada, Lemay *et al*. (2002) studied on effect of natural antimicrobial as a preservative in a cooked and acidified chicken model. There are study done by Gutierrez *et al*. (2008) focusing on antimicrobial efficacy of plant essential oil combinations and interactions with food ingredients. Apart from that, comprehensive review has made on natural additives in wheat based pasta and noodle products that using natural antimicrobial. (Li *et al*., 2014).

On top of that, a large variety of plants is known to contain phytochemicals and phytonutrients that give benefits to mankind. They are abundant in biologically active compounds, including flavonoids, polyphenols, alkaloids, and polysaccharides, which have been well recognized for their pharmacological properties, such as antioxidant, antimicrobial, antifungal, anti-inflammatory, sedative, antimutagenic, antidiabetic, antiaging, hypotensive, anti-stress, and anticancer activities (Mauri *et al*., 1998). The bioactive compounds that are contained in the plants can be extracted from various parts, including leaf, stem, bark, root, flower, fruit, and seed.

Vietnamese coriander, which is scientifically termed as *Persicaria odorata* is locally known as *kesum* or *laksa* leaves. Meanwhile, turmeric (*Curcuma longa*) leaf is very common in Malay cuisine as it is used for its aroma, colour, and flavour. *Garcinia atroviridis*, locally known as *asam gelugor*, is used for flavouring agent and its leaf and fruit have always been added in cooking practices. These three types of plant leaves are widely used in Malay cooking, as well as for alternative medicine. Additionally, the extracts of

those plant leaves are also known to exhibit antimicrobial properties against various microorganisms. Fresh and dry leaves extracts from Vietnamese coriander essential oil and solvent extraction exhibited antimicrobial activity against several microorganisms (Sasangko *et al*., 2011; Ridzuan *et al*., 2013).

In addition, literature has proved the antimicrobial activity of turmeric leaves (Pundir and Jain, 2010; Arutselvi *et al*., 2012) against several microorganisms, while the crude extracts of *Garcinia atroviridis* from various plant parts have been reported with prominent antimicrobial activity, especially against bacterial microorganisms (Mackeen *et al*., 2000). Besides, to date, there has been no report on any comparative study concerning leaves of Vietnamese coriander, turmeric, and *asam gelugor* that employed the extraction method to look into antimicrobial activity against food spoilage related microorganisms as these fresh plant leaves are utilized as natural preservatives for *gulai tempoyak* paste (GTP).

Therefore, the objectives of this study are:

1. To determine the antimicrobial activity of Vietnamese coriander (*Persicaria odorata*), turmeric (*Curcuma longa*), and *asam gelugor* (*Garcinia atroviridis*) leaves.
2. To investigate the microbiological safety of *gulai tempoyak* paste (GTP) added with Vietnamese coriander (*Persicaria odorata*), turmeric (*Curcuma longa*), and *asam gelugor* (*Garcinia atroviridis*) leaves.
3. To determine the phytochemistry and sensory properties of *gulai tempoyak* paste (GTP) added with Vietnamese coriander (*Persicaria odorata*), turmeric (*Curcuma longa*), and *asam gelugor* (*Garcinia atroviridis*) leaves.

BIBLIOGRAPHY

Abadias, M., Usall, J., Anguera, M., Solsona, C. and Vinas, I. (2007). Microbiological quality of fresh, minimally-processed fruit and vegetables, and sprouts from retail establishment. *International Journal of Food Microbiology* 123: 121-129.

Abd Aziz, S.M., Low, C.N., Chai, L.C., Abd Razak, S.S.N., Selamat, J., Son, R., Sarker, M.Z.I. and Khatib, A. (2011). Screening of selected Malaysian plants against several food borne pathogen bacteria. *International Food Research Journal* 18(3): 1195-1201.

Aboaba, O., Smith, S. and Olude, F. (2006). Antibacterial effect of edible plant extract on *Escherichia coli* 0157: H7. *Pakistan Journal of Nutrition* 5(4): 325-327.

Abu Bakar, F., Salleh, A.B., Abdul Razak, C.N., Basri, M., Ching, M.K. and Radu, S. (2008). Microbiological quality of freshwater prawns during storage. *International Food Research Journal* 15(3): 853-863.

Agatemor, C. (2009). Antimicrobial activity of aqueous and ethanol extracts of nine Nigerian spices against four food borne bacteria. *Electronic Journal of Environmental, Agricultural and Food Chemistry* 8: 195-200.

Ahn, J., Grün, I.U. and Mustapha, A. (2007). Effects of plant extracts on microbial growth, colour change and lipid oxidation in cooked beef. *Food Microbiology* 24: 7-14.

Aibinu, I., Adenipekun, T., Adelowotan, T., Ogunsanya, T. and Odugbemi, T. (2007). Evaluation of the antimicrobial properties of different parts of *Citrus aurantifolia* (lime fruit) as used locally. *African Journal of Traditional Complementary Alternative Medicines* 4(2): 185-195.

Ait-Ouazzou, A., Loran, S., Arakrak, A., Laglaoui, A., Rota, C., Herrera, A., Pagan, R. and Conchello, P. (2012). Evaluation of the chemical composition and antimicrobial activity of *Mentha pulegium*, *Juniperus phoenicea*, and *Cyperus longus* essential oils from Morocco. *Food Research International* 45(1) 313-319.

Albright, S.N., Kendall, P.A., Avens, J.S. and Sofos, J.N. (2003). Pretreatment effect on inactivation of *Escherichia coli* O157:H7 inoculated beef jerky. *LWT - Food Science and Technology* 36: 381-389.

Amiza, M.A, Zakiah, J., Ng, L.K. and Lai, K.W. (2006). Fermentation of tempoyak using isolated tempoyak culture. *Research Journal of Microbiology* 5(6): 530-541.

Amrita, V., Sonal, D. and Shalini, R. (2009). Antibacterial effect of herbs and spices extract on *Escherichia coli*. *Electronic Journal of Biology* 5(2): 40-44.

Ankri, S. and Mirelman, A. (1999). Antimicrobial properties of allicin from garlic. *Microbes and Infections* 2: 125-129.

AOAC, (2002). Official methods of analysis (17th ed.). Washington, DC: Association of Official Analytical Chemists.

Arutselvi, R., Balasaravanan, T., Ponmurugan, P., Muthu Saranji, N. and Suresh, P. (2012). Phytochemical screening and comparative study of antimicrobial activity of leaves and rhizomes of turmeric varieties. *Asian Journal of Plant Science and Research* 2(2): 212-219.

Aziz, A.A. (2008). The effects of malay herbs on the storage stability of chilled 'keropok lekor', Bsc thesis, Universiti Teknologi Mara, Shah Alam, Malaysia.

Bassole, I.H.N., Ouattara, A.S., Nebie, R., Ouattara, C.A.T., Kabore, Z.I. and Traore, S.A. (2003). Chemical composition and antibacterial activities of the essential oils of *Lippia chevalieri* and *Lippia multiflora* from Burkina Faso. *Phytochemistry* 62: 209-212.

Bell, C., Neaves, P. and Williams, A.P. (2005). Food Microbiology and Laboratory Practice, pp. 18-29. United Kingdom. Blackwell Science.

Benitez, D.E., Cadwallader, K.R. and Suriyaphan, O. (2001) Aroma-active components of Vietnamese Coriander (*Polygonum odoratum*). In IFT Annual Meeting. Louisiana, New Orlands.

Beuchat, L.R. and Golden, D.A. (1989). Antimicrobials occurring naturally in foods. *Food Technology* 43: 134–142.

Bose, A., Gupta, J.K., Dash, G.K., Ghosh, T., Si, S. and Panda, D.S. (2007). Diuretic and antibacterial activity of aqueous extract of *Cleome rutidosperma* D.C. *Indian Journal of Pharmalogical Sciences* 69: 292-294.

Barbour, E.K., Al Sharif, M. Sagherian, V.K., Habre, A.N., Talhouk, R.S. and Talhouk, S.N. (2004). Screening of selected indigenous plants of Lebanon for antimicrobial activity. *Journal of Ethnopharmacology* 93: 1-7.

Burdock, G.A. (1995). Fenaroli's handbook of flavor ingredients: Adapted from the Italian Language Works of Giovanni Fenaroli, 3rd Ed. Boca Raton: CRC Press.

Burt, S. (2004). Essential oils: Their antibacterial properties and potential applications in foods: A review. *International Journal of Food Microbiology* 94: 223–253.

Careaga, M., Fernández, E., Dorantes, L., Mota, L., Jaramillo, M.E. and Hernandez-Sanchez, H. (2003). Antibacterial activity of Capsicum extract against *Salmonella* typhimurium and *Pseudomonas aeruginosa* inoculated in raw beef meat. *International Journal of Microbiology* 83(3): 331-335.

Corbo, M., Speranza, B., Filippone, A., Granatiero, S., Conte, A., Sinigaglia, M. and Del Nobile, M. (2008). Study on the synergic effect of natural compounds on the microbial quality decay of packed fish hamburger. *International Journal of Food Microbiology* 127(3): 261-267.

Chan, E.W.C., Wong, S.K., Lim, Y.Y., Lim, K.K., Tan, S.P., Lianto, F.S. and Yong, M.Y. (2009). Effects of different drying methods on the antioxidant properties of leaves and tea of ginger species. *Food Chemistry* 113(1): 166-172.

Chan, Y-S., Cheng, L-N., Wu, J-H., Chan, E., Kwan, Y-W., Lee, S.M-Y., Leung, G.P-H., Yu, P.H-F. and Chan, S.W. (2010). A review of the pharmacological effects of *Arctium lappa* (burdock). *Inflammopharmacology* DOI: 10.1007/s/10787-010-0062-4.

Chang, C.Y., Yu, T.H., Lin, L.Y. and Yen, Y.H. (1998). The effect of drying treatment on the flavour and quality of longan fruit. *Food Flavours*: Formation, Analysis and Packaging Influences.

Chanthaphon, S., Chanthachum, S. and Hongpattarakere, T. (2008). Antimicrobial activities of essential oils and crude extracts from tropical *Citrus* spp. against food-related microorganisms. *Songklanakarin Journal of Science and Technology* 30: 125-130.

Chaudhari, L.K.D., Jawale, B.A., Sharma, S., Sharma, H., Kumar, C.D.M. and Kulkarni, P.A. (2012). Antimicrobial activity of commercially availabe essential oils against *Streptococcus mutans*. *The Journal of Contemporary Dental Practice* 13(1): 71-74.

Chen, H., Wang, C., Ye, J., Zhou, H. and Chen, X. (2012). Antimicrobial activities of phenethyl isothiocyanate isolated from horseradish. *Natural Product Research* 26(11): 1016-1021.

Christian, S., Ludmila, L., Yvan, N., Eric, P. and Didier, R. (2006). Comparison of volatile constituents of *Persicaria odorata* (Lour.) Sojak (*Polygonum odaratum* Lour.) and *Persicaria hydropiper* L. Spach (*Polygonum hydropiper* L.,). *Journal of Agricultural and Food Chemistry* 54(8): 3067-3071.

Chohan, M., Forster-Wilkins, G. and Opara, E. (2008). Determination of the antioxidant capacity of culinary herbs subjected to various cooking and storage processes using ABTS*+ radical cation assay. *Plant Foods for Human Nutrition* 63: 47–52.

CLSI. (2011). Performance Standards for Antimicrobial Susceptibility Testing. Clinical and Laboratory Standard Institute: M100-S21.

Corner, E.J.H. (1988). Mangosteen family. In: Wayside Trees of Malaysia, *Malayan Nature Society* Vol. I. pp. 349-357. Kuala Lumpur.

Costa, A.I.A., Dekker, M., Beumer, R.R., Rombouts, F.M. and Jongen, W.M.F. (2001). A consumer-oriented classification system for home meal replacements. *Food Quality and Preference* 12(4): 229-242.

Cowan, M.M. (1999). Plant products as antimicrobial agents: A review. *Clinical Microbiology Reviews*: 564-582.

Dash, B.K., Faruquee, H.M., Biswas, S.K., Alam, M.K., Sisir, S.M. and Prodhan, U.K. (2011). Antibacterial and antifungal activities of several extracts of *Centella asiatica* L. against some human pathogenic microbes. *Life Sciences and Medicine Research* 35: 1-5.

Datta, A., Ghoshdastidar, S. and Singh, M. (2011). Antimicrobial property of *Piper betel* leaf against clinical isolates of bacteria. *International Journal of Pharmceutical Sciences and Research* 2(3): 104-109.

De Man, J.M. (1999). Principles of Food Chemistry, pp. 23-30. 3rd Ed.

Devalaraja, S., Jain, S. and Yadav, H. (2011). Exotic fruits as therapuetic complements for diabetes, obesity and metabolic syndrome. *Food research International* 44: 1856-1865.

Di Pasqua, R., De Feo, V., Villani, F. and Mauriello, G. (2005). *In vitro* antimicrobial activity of essential oils from Mediterranean Apiaceae, Verbenaceae, and Lamiaceae against foodborne pathogens and spoilage bacteria. *Annals of Microbiology* 55(2): 139-143.

Djeridane, A., Yousfi, M., Nadjemi, B., Boutassouna, D., Stocker, P. and Vidal, N. (2006). Antioxidant activity of some Algerian medicinal plants extracts containing phenolic compounds. *Food Chemistry* 97: 654–660.

Dorman, H.J.D. and Deans, S.G. (2000). Antimicrobial agents from plants: Antibacterial activity of plant volatile oils. *Journal of Applied Microbiology* 88: 308-316.

Doulgeraki, A.I., Ercolini, D., Villani, F. and Nychas, G.J. (2012). Spoilage microbiota associated to the storage of raw meat in different

conditions. *International Journal of Food Microbiology* 157(2): 130-141.

Du, W-X., Olsen, C.W., Avena-Bustillos, R.J., McHugh, T.H., Levin, C.E. and Friedman, M. (2009). Effects of allspice, cinnamon, and clove bud essential oils in edible apple films on physical properties and antimicrobial activities. *Journal of Food Science* 74(7): 372-378.

Fajimi, A. and Taiwo, A. (2005). Herbal remedies in animal parasitic diseases in Nigeria: A review. *African Journal of Biotechnology* 4(4): 303-307.

Faridah, A. (2008). Effects of herbal marinades on the shelf-life of chilled chicken 'Satay', Bsc thesis, Universiti Teknologi Mara, Shah Alam, Malaysia.

Fernandez-Lopez, J., Zh, N., Aleson-Carbonell, L., Pérez-Alvarez, J.A. and Kuri, V. (2005). Antioxidant and antimicrobial activities of natural extracts: Application in beef meatballs. *Meat Science* 69: 371-380.

Fontana, A.J. (2001). Measurement of water activity. In fundamentals of water activity. IFT Continuing Education Committee, June 14–15, Anaheim, CA, USA.

Friedman, M., Henika, P.R., Levin, C.E. and Mandrell, R.E. (2004). Antibacterial activities of plant essential oils and their components against *Escherichia coli* O157:H7 and *Salmonella enterica* in apple juice. *Journal of Agricultural and Food Chemistry* 52: 6042–6048

.

Gandjar, I. (2000). Fermentations of the Far East, In: Robinson, R.K., Batt, C.A. and Patell, P.D., pp.767-773, Eds, *Encyclopecial of Food Microbiology*, London, Academic Press.

Gorinstein, S., Poovarodom, S., Leontowicz, H., Leontowicz, M., Namiesnik, J. and Verasilp, S. (2011). Antioxidant properties and bioactive constituents of some rare exotic Thai fruits and comparison with conventional fruits in vitro and in vivo studies. *Food Research International* 44: 2222-2232.

Gram, L., Ravn, L., Rasch, M., Bruhn, J.B., Christensen, A.B. and Givskov, M. (2002). Food spoilage interactions between food spoilage bacteria. *International Journal of Food Microbiology* 78(1): 79-97.

Grosvenor, P.W., Supriono, A. and Gray, D.O. (1995). Medicinal plants from Riau province, Sumatra, Indonesia. Part 2: antibacterial and antifungal activity. *Journal of Ethnopharmacology* 45: 97–111.

Gutierrez, J., Barry-Ryan, C. and Bourke, P. (2008). The antimicrobial efficacy of plant essential oil combinations and interactions with food ingredients. *International Journal of Food Microbiology* 124: 91-97.

Halliday, J. (2007). EU Parliament votes for tougher additives regulation. FoodNavigator.com

Hao, Y.Y., Brackett, R.E. and Doyle, M.P. (1998). Efficacy of plant extracts in inhibiting *Aeromonas hydrophila* and *Listeria monocytogenes* in refrigerated cooked poultry. *Food Microbiology* 15: 367-378.

Hassan, W.E. (2006). Healing Herbs of Malaysia. Kuala Lumpur: Federal Land Development Agency.

Himejima, M., Hobson, K.R., Otsuka, T., Wood, D.L. and Kubo, I. (1992). Antimicrobial terpenes from oleoresin of ponderosa pine tree Pinus pon-derosa: a defense mechanism against microbial invasion. *Journal of Chemical Ecology* 18: 1809–1818.

Hirasa, K. and Takemasa, M. (1998). Spice science and technology. New York: Dekker Inc.

Ho, L.H. and Bhat, R. (2015). Exploring the potential nutraceutical values of durian (*Durio zibethinus* L.) - An exotic tropical fruit. *Food Chemistry* 168: 80-89.

Holley, R.A. and Patel, D. (2005). Improvement in shelf-life and safety of perishable foods by plant essential oils and smoke antimicrobials. *Food Microbiology* 22: 273-292.

Huda-Faujan, N., Noriham, A., Norrakiah, A.S. and Babji, A.S. (2007). Antioxidative activities of water extracts of some Malaysian herbs. *ASEAN Food Journal* 14: 61-68.

Iinuma, M., Tosa, H., Tanaka, T. and Riswan, S. (1996). Three new xanthones from the bark of *Garcinia dioica*. *Chemical Pharmaceutical Bulletin* 44: 232–234.

Ikan Patin Masak Tempoyak Recipe. (2013, April 28). Retrieved from http://www.mpt.gov.my/en/masakan

Jayana, B.L., Prasai, T., Singh, A. and Yami, K.D. (2010). Study of antimicrobial activity of lime juice against *Vibrio cholerae*. *Scientific World* 8(8): 44-46.

Johnny, L., Yusuf, U.K. and Nulit, R. (2011). Antifungal activity of selected plant leaves crude extracts against a pepper anthracnose fungus, *Colletotrichum capsici* (Sydow) butler and bisby (Ascomycota: Phyllachorales). *African Journal of Biotechnology* 10: 4157-4165.

Jorgensen, J.H. and Ferraro, M.J. (1998). Antimicrobial susceptibility testing: General principles and contemporary practices. *Clinical Infectious Disease* 26: 973-980.

Julio, G., Isidro, S.M., Belen, G.P. and Pilar, B.B. (1990). Flavanoids from *Polygonum minus*. *Phytochemistry Journal* 29(11): 3687-3689.

Kafaru, E. (1994). Immense help from nature's workshop: Guidelines on how to use herbs to achieve healthy living. pp. 6-10.

Keskin, D. and Toroglu, S. (2011). Studies on antimicrobial activities of solvent extracts of different spices. *Journal of Environmental Biology* 32: 251-256.

Kilcast, D. and Subramaniam, P. (2000). The stability and shelf-life of food. pp. 197-212. Boca Raton Boston New York Washington, DC: CRC Press.

King, T., Dykes, G. and Krishtianti, R. (2008). Comparative evaluation methods commonly used to determine antimicrobial susceptibility to plant extracts and phenolic compounds. *Journal of AOAC International* 91: 6-15.

Lambert, R.J.W., Skandamis, P.N., Coote, P.J. and Nychas, G.J.E. (2001). A study of minimum inhibitory concentration and mode of action of oregano essential oil, thymol and carvacrol. *Journal of Applied Microbiology* 91: 453–462.

Lawless, H.T. and Heymann, H. (1998). Sensory evaluation of food: Principles and practices. New York: Chapman and Hall.

Lemay, M.J., Choquette, J., Delaquis, P.J., Garièpy, C., Rodrigue, N. and Saucier, L. (2002). Antimicrobial effect of natural preservatives in a cooked and acidified chicken meat model. *International Journal of Food Microbiology* 78: 217-226.

Li, M., Zhu, K-X., Guo, X-N., Brijs, K. and Zhou, H-M. (2014). Natural additives in wheat-based pasta and noodle products: opportunities for enhanced nutritional and functional properties. *Comprehensive Reviews in Food Science and Food Safety* 13: 347-357.

Mackeen, M.M., Ali, A.M., Lajis, N.H., Kawazu, K., Hassan, Z., Amran, M., Habsah, M., Mooi, L.Y. and Mohamed, S.M. (2000). Antimicrobial, antioxidant, antitumour-promoting and cytotoxic activities of different plant part extracts of *Garcinia atroviridis* Griff. ex T. Anders. *Journal of Ethnopharmacology* 72: 395-402.

MacKenzie, F.M., Bruce, J., Van Looveren, M., Cornaglia, G., Gould, I.M., Goossens, H. and the ARPAC Steering Group. (2006). Antimicrobial

susceptibility testing in European hoospitals: Report from the ARPAC study. *Clinical Microbiology and Infection* 12: 1185-1192.

Mahanom, H., Azizah, A.H. and Dzulkifly, M.H. (1999). Effect of different drying methods on concentrations of several phytochemicals in herbal preparation of 8 medicinal plants leaves. *Malaysia Journal of Nutrition* 5: 47–54.

Mahdavi, B., Yaacob, W.A., Laily, B.D. and Nazlina, I. (2012). Antimicrobial activity of consecutive extracts of *Etlingera brevilabrum*. *Sains Malaysia* 41(10): 1233-1237.

Maity, P., Hansda, D., Bandyopadhyay, U. and Mishra, D.K. (2009). Biological activities of crude extracts and chemical constituents of Bael, *Aegle marmelos* (L.) Corr. *Indian Journal of Experimental Biology* 47: 849-861.

Man, D. (2002). Shelf Life. Blackwell Science Ltd. London. p.3.

Martinez-Hernandez, G.B., Artes-Hernandez, A., Colares-Souza, F., Gomez, P.A., Garcia-Gomez, P. and Artes, F. (2012). Innovative cooking techniques for improving the overall quality of a kailan-hybrid broccoli. *Food and Bioprocess Technology* 10: 1007.

Mauri, P., Pietta, P. and Simonetti, P. (1998). Antioxidant activity of selected medicinal plants. *Journal of Agricultural and Food Chemistry* 46 (11): 4487–4490.

Mazumder, M., Mendiratta, T., Mondal, S.C. and Mazumder, A. (2000). Antimicrobial potency of the leaf – Stalk extract of *Curcuma longa* (LINN). *Ancient Science of Life* 1&2: 92-96.

Meilgaard, M.C., Civille, G.V. and Carr, B.T. (1999). Sensory evaluation techniques. 3rd edition, Boca Raton. Florida: CRC Press.

Merican, Z. (1977). Malaysia tempoyak. In: Steinkraus, K.H. Ed., Handbook of Indigenous Fermented Foods. pp. 147-148. New York: Marcel Dekker Inc.

Mohanraj, R. (2014). Plant based antibacterial agents. *Research Signpost* 37(2): 1-19.

Murakami, A., Ali, A.M., Mat-Salleh, K., Koshimizu, K. and Ohigashi, H. (2000). Screening for the *in vitro* anti-tumor-promoting activities of edible plants from Malaysia. *Bioscience, Biotechnology and Biochemistry* 64: 9-16.

Murty, D.S. and Kumar, K.A. (1995). Traditional uses of sorghum and millets. In: Dendy, D. A. V. Ed., Sorghum and Millets: Chemistry

and Technology, pp. 185-221. American Association of Cereal Chemists, St. Paul, Minnesota.

Musa, N., Wei, L.S., Seng, C.T., Wee, W. and Leong, L.K. (2008). Potential of edible plants as remedies of systemic bacterial disease infection in cultured fish. *Global Journal of Pharmacology* 2: 31-36.

Najiah, M., Nadirah, M., Laith, A.A., Arief, Z., Zahrol, S., Tee, L.W., Ranzi, A.D., Amar, S., Maryam, M., Suzana, S. and Aida, R.J. (2011). Antibacterial activity of Malaysian edible herbs extracts on fish pathogenic bacteria. *Research Journal of Medicinal Plant* 5:722-778.

Nanasombat, S. and Lohasupthawee, P. (2005). Antibacterial activity of crude ethanolic extracts and essential oils of spices against *Salmonellae* and other enterobacteria. *Science and Technology Journal* 5(3): 527-538.

Narang, S.P. (2004). Food Microbiology Method of Enumeration, pp. 22-166. New Delhi: A.P.H Publishing Corporation.

Nascimento, G.G.F., Locatelli, J., Freitas, P.C. and Silva, G.L. (2000). Antibacterial activity of plant extracts and phytochemicals on antibiotic-resistant bacteria. *Brazilian Journal of Microbiology* 31(4): 247-256.

Negi, P.S. (2012). Plant extracts for the control of bacterial growth: Efficacy, stability and safety issues for food application. *International Journal of Microbiology* 156: 7-17.

Nirmal, N.P. and Benjakul, S. (2011). Inhibition of melanosis formation in Pacific white shrimp by the extract of lead (*Leucaena leucocephala*) seed. *Food Chemistry* 128(2): 427-432.

Nkambule, T.P. (2008). Antimicrobial properties of selected Asian herbs. Master thesis. University of Florida.

O'Bryan, C.A., Crandall, P.G., Chalova, V.I. and Ricke, S.C. (2008). Orange essential oils antimicrobial activities against *Salmonella* spp. *Journal of Food Science* 73(6): 264-274.

Odebunmi, O. (2011). What are the benefits of turmeric leaves?. Article reviewed by Duran, G. http://www.livestrong.com/article/405988-what-are-the-benefits-of-turmeric-leaves. [Accessed 21 January 2013]

Onkar, D., Jham, G.N., Barcelos, R.C., Mendonca, F.A. and Ghiviriga, I. (2007). Isolation and identification of principal fungitoxic component of turmeric essential oil. *Journal of Essential Oil Research* 19(4): 387-391.

Othman, M., Loh, H.S., Wiart, C., Khoo, T.J., Lim, K.H. and Ting, K.N. (2011). optimal methods for evaluating antimicrobial activities from plant extracts. *Journal of Microbiological Methods* 84(2): 161-166.

Oussalah, M., Caillet, S., Saucier, L. and Lacroix, M. (2007). Inhibitory effects of selected plant essential oils on the growth of four pathogenic bacteria: *E. coli* O157:H7, *Salmonella* Typhimurium, *Staphylococcus aureus* and *Listeria monocytogenes*. *Food Control* 18(5): 414-420.

Ozcan, B., Esen, M., Sangun, M.K., Coleri, A. and Caliskan, M. (2010). Effective antibacterial and antioxidant properties of methanolic extract of *Laurus nobilis* seed oil. *Journal of Environmental Biology* 31(5): 637-641.

Panda, S.K., Dutta, S.K. and Bastia, A.K. (2010). Antibacterial activity of *Croton roxburghii* balak. against the enteric pathogens. *Journal of Advanced Pharmaceutical Technology and Research* 1: 419-422.

Parasa, L.S., Tumati, S.R., Kumar, L.C.A., Chigurupati, S.P. and Rao, G.S. (2011). *In vitro* antimicrobial activity of cashew (*Anacardium occidentale*, L.) nuts shell liquid against methicillin resistant *Staphylococcus aureus* (MRSA) clinical isolates. *International Journal of Pharmacy and Pharmaceutical Sciences* 3(4): 436-440.

Pazos, M., Alonso, A., Sanchez, I. and Medina, I. (2008). Hydroxytyrosol prevents oxidative deterioration in foodstuffs rich in fish lipids. *Journal of Agricultural and Food Chemistry* 56: 3334-3340.

Pradeep, S., Munglu, M., Dhar, D.R., Shweta, P., Shilpi, C., Shekhar, V. and Tanushree, C. (2011). Natural plant products with potential antimicrobial activity. *Research Journal of Pharmacognosy and Phytochemistry* 3(1): 1-9.

Pundir, R.K. and Jain, P. (2010). Comparative studies on the antimicrobial activity of black pepper (*Piper nigrum*) and turmeric (*Curcuma longa*) extracts. *International Journal of Applied Biology Pharmaceutical Technology* 1(2): 492-501.

Quynh, C.T., Iijima, Y. and Morimitsu, Y. (2009). Aliphatic aldehyde reductase activity related to the formation of volatile alcohols in Vietnamese coriander leaves. *Bioscience, Biotechnology and Biochemistry* 73: 641-647.

Rhodehamel, E.J. (1992). FDA's concerns with *sous vide* processing. *Food Technology* 46(12): 73-76.

Ridzuan, P.M., Hairul Aini, H., Norazian, M.H., Shah, A., Roesnita, and Aminah, K.S. (2013). Antibacterial and antifungal properties of

Persicaria odorata leaf against pathogenic bacteria and fungi. *The Open Conference Proceedings Journal* 4(2): 71-74.

Roby, M.H.H., Sarhan, M.A., Selima, K.A-H. and Khalel, K.I. (2012). Antioxidant and antimicrobial activities of essential oil and extracts of fennel (*Foeniculum vulgare* L.) and chamomile (*Matricaria chamomilla* L.). *Industrial Crops and Products*: 1-9.

Saadabi, M.A.A. (2007). Evaluation of *Lawsonia inermis* Linn. (Sudanese Henna) leaf extracts as an antimicrobial agent. *Research Journal of Biological Sciences* 2(4): 419-423.

Sadashiva, C.T.P., Sharanappa, A.B., Remashree Raghu, A.V., Udayan, P.S. and Balachandran, I. (2010). Chemical composition and antimicrobial activity of essential oil from bark of *Pittosporum dasycaulon* Miq. *Advanced Biology Research* 4(6): 301-304.

Saidin, I. (2000). *Sayuran tradisional ulam dan penyedap rasa*. Kuala Lumpur: CABI Publishing.

Sallam, K.I., Isioroshi, M. and Samejima, K. (2004). Antioxidant and antimicrobial effects of garlic in chicken sausage. *LWT - Food Science and Technology* 37: 849-855.

Sasangko, P., Laohankunjit, N. and Kerdchoechuen, O. (2011). Antibacterial activity of the essential oil from *Persicaria odorata* leaves. *Journal of Agricultural Science* 42(2): 105-108.

Sagwan, S.D.V.R. and Sharma, R.A. (2012). *In vivo* and *in vitro* proportional antimicrobial activity in Karanj (*Pongamia pinnata*): An imperative leguminous tree. *International Journal of Research and Reviews in Pharmacy and Applied Science* 2(6): 981-995.

Scorzoni, L., Benaducci, T.I., Almeida, A.M.F., Silva, D.H.S., Bolzani, V.S. and Mendes-Giannini, M.J.S. (2007). Comparative study of disc diffusion and microdilution methods for evaluation of antifungal activity of natural compounds against medical yeasts *Candida* spp and *Cryptococcus* sp. *Revista de Ciencias Farmaceuticas Basica e Aplicada* 28: 25-34.

Shahram, S. (2011). Pyrethrum, Coltsfoot and Dandelion: Important medicinal plants from Asteraceae family. *Australian Journal of Basic and Applied Sciences* 5(12): 1787-1791.

Shavandi, M.A., Zahra, H. and Ismail, M.H.S. (2013). *Eryngium foetidum* L. *Coriandrum sativum* and *Persicaria odorata* L.: Review. *Journal of Asian Scientific Research* 2(8): 410-426.

Silva, F., Ferreira, S., Queiroz, J.A. and Domingues, F.C. (2011). Coriander (*Coriandrum sativum* L.) essential oil: its antibacterial activity and mode of action evaluated by flow cytometry. *Journal of Medical Microbiology*: 1-14.

Siripongvutikorn, S., Usawakesmanee, W., Wittaya, T., Koonpaew, B. and Pengseng, N. (2012). Combined effect of low acid paste and modified atmospheric condition on quality changes of white shrimp, *Litopenaeus vannamei* during chilled storage. *International Food Research Journal* 19(4): 1573-1580.

Smith-Palmer, A., Stewart, J. and Fyfe, L. (1998). Antimicrobial properties of plant essential oils and essences against five important food-borne pathogens. *Letters in Applied Microbiology* 26: 118-122.

Solomakos, N., Govaris, A., Koidis, P. and Botsoglou, N. (2007). The antimicrobial effect of thyme essential oil, nisin and their combination against *Escherichia coli* O157:H7 in minced beef during refrigerated storage. *Meat Science* 80: 159-166.

Steinkraus, K.H. (1996). Handbook of Indigenous Fermented Foods. 2nd Ed. Marcel Dekker, Inc., New York.

Stone, H. and Sidel, J.L. (1993). Sensory Evaluation Practices. 2nd Ed. New York, Academic Press.

Suan, C.J. (1996). Chemical composition of tempoyak, Steinkraus K.H., Handbook of Indigenous Fermented Foods, pp. 148. New York: Marcel Dekker.

Syaru, N.B., Hamidun, B., Maaruf, A., Wan Aida, W.M. and Normah, M.N. (2010). Analysis of the chemical composition of the essential oil of *Polygonum minus* Huds. using two-dimensional gas chromatography-time-of-flight mass spectrometry (GC-TOFMS). *Molecules Journal* 15(10): 7006-7015.

Tagoe, D., Baidoo, S., Dadzie, I., Kangah, V. and Nyarko, H. (2010). A comparison of the antimicrobial (antifungal) properties of garlic, ginger and lime on *Aspergillus flavus*, *Aspergillus niger* and *Cladosporium herbarum* using organic and water base extraction methods. *The Internet Journal of Tropical Medicine* 7(1): DOI: 10.5580/1099.

Tahira, J.J., Khan, S.N., Suliman, R. and Anwar, W. (2010). Weed flora of *Curcuma longa* fields of district Kasur, Pakistan. *Pakistan Journal of Weed Science Research* 16(2): 241-246.

Tajkarimi, M., Ibrahim, S. and Cliver, D. (2010). Antimicrobial herb and spice compounds in food. *Food Control* 21(9): 1199-1218.

Tan, B.K.H. and Vanitha, J. (2004). Immunomodulatory and antimicrobial effects of some traditional Chinese medicinal herbs: A Review. *Current Medicinal Chemistry* 11: 1423-1430.

The International Codex Alimentarius Standard for Food Grade Salt. (2011). [Accessed 7 January 2013]

The International Commission on Microbiological Specifications for Food (ICMSF): Microorganisms in Foods 5-Characteristics of Microbial Pathogen (Springer, New York, 2006).

The Seattle Times. (2001). The Salt of Southeast Asia. http://seattletimes.com [Accessed 10 January 2013]

The UK Food Guide 2003 – 2013. E numbers and food additives, E102 Tartrazine and E951 Aspartame. http://www.ukfoodguide.net/ [Accessed 7 January 2013]

Tiwari, B.K., Valdramidis, V.P., O'Donnel, C.P., Muthukumarappan, K., Bourke, P. and Cullen, P.J. (2009). Application of natural antimicrobials for food preservation. *Journal of Agricultural and Food Chemistry* 57: 5987-6000.

Tona, L.K., Ngimbi, N., Cimanga, K. and Vlitink, A.J. (1998). Antiamoebic and phytochemical screening of some conaplese medicinal plants. *Journal of Ethnorpharmalogy* 10(4): 55-61.

Traub, L.G. and Odland, D.D. (1979). Convenience foods and home prepared foods. USDA/ERS AER No. 429.

Vaclavik, V.A. and Christian, E.W. (2007) Essentials of Food Science (Food Science Texts Series), pp. 46, New York, NY: Springer.

Vaughan, J.G. (1997). The New Oxford Book of Food Plants, pp. 25. New York: Oxford University Press Inc.

Walsh, S.E., Maillard, J.Y., Russell, A.D., Catrenich, C.E., Charbonneau, A.L. and bartolo, R.G. (2003). Activity and mechanisms of action of selected biocidal agents on gram-positive and gram-negative bacteria. *Journal of Applied Microbiology* 94: 240-247.

Wan Norhana, M.N., Mohd Nor Azman, A., Poolec, S.E., Deetha, H.C. and Dykes, G.A. (2009). Effects of bilimbi (*Averrhoa bilimbi* L.) and tamarind (*Tamarindus indica* L.) juice on *Listeria monocytogenes* Scott A and *Salmonella* Typhimurium ATCC 14028 and the sensory properties of raw shrimps. *International Journal of Food Microbiology* 136(1): 88-94.

Wendakoon, C., Calderon, P. and Gagnon, D. (2012). Evaluation of selected medicinal plants extracted in different ethanol concentrations for antibacterial activity against human pathogens. *Journal of Medicinally Active Plants* 1(2): 60-68.

William, C.F. and Dennis, C.W. (1988). Food Microbiology, pp. 354. Singapore: McGraw- Hill.

Yaacob, K. (1987). *Kesom* oil- A natural source of aliphatic aldehydes. *Perfume and Flavour Journal* 12: 443-449.

Yano, Y., Satomi, M. and Oikawa, H. (2006). Antimicrobial effects of spices and herbs on *Vibrio parahaemolyticus*. *International Journal of Food Microbiology* 111: 6-11.

Yan S. and Asmah, R. (2010). Comparison of total phenolic contents and antioxidant activities of turmeric leaf, pandan leaf and torch ginger flower. *International Food Research Journal* 17: 417-423.

Yuliana, N. and Garcia, V.V. (2009). Influence of *Pediococcus acidilactiti* as a starter on the flavour of *tempoyak* (fermented durian). *Indian Journal of Biotechnology* 8: 304–310.

Zakaria, Z.A., Zakaria, M.L., Amom, Z. and Desa, M.N.M. (2011). Antimicrobial activity of the aqueous extract of selected Malaysian herbs. *African Journal of Microbiology Research* 5(30): 5379-5383.

Zhang, H., Kong, B., Xiong, Y.L. and Sun, X. (2009). Antimicrobial activities of spice extracts against pathogenic and spoilage bacteria in modified atmosphere packaged fresh pork and vacuum packaged ham slices stored at 4 °C. *Meat Science* 81(4): 686-692.

Zheng, L., Bae, Y-M., Jung, K-S., Heu, S. and Lee, S-Y. (2013). Antimicrobial activity of natural antimicrobial substances against spoilage bacteria isolated from fresh product. *Food Control* 32(2): 665-672.

APPENDICES

APPENDIX A

Figures

Ingredients needed for preparing GTP and three different leaves used; *asam gelugor*, turmeric, and Vietnamese coriander

Storage of GTP in air tight container

Sensory evaluation of GTP

Sample preparation and sensory evaluation being conducted

APPENDIX B

RESPONDENT'S CONSENT

Please read the following information carefully and do not hesitate to discuss any questions you may have with the researcher.

STUDY TITLE : DEVELOPMENT OF *GULAI TEMPOYAK* PASTE ADDED WITH VIETNAMESE CORIANDER, TURMERIC, AND *ASAM GELUGOR* LEAVES AND THEIR EFFECTS ON MICROBIOLOGICAL QUALITY AND ACCEPTABILITY.

CONSENT

I …… Identity Card No. ……

address……

……...

……..hereby voluntarily agree to take part in the research stated above *(clinical /drug trial/video recording/ focus group/interview-based/ questionnaire-based).

I understand that I have the right to withdraw from this research at any time without giving any reason whatsoever. I also understand that this study is confidential and all information provided with regard to my identity will remain private and confidential.

I* wish / do not wish to know the results related to my participation in the research

I agree/do not agree that the images/photos/video recordings/voice recordings related to me be used in any form of publication or presentation (if applicable)

* delete where necessary

Signature ……..……
(Respondent)

Date :……..

No.Tel/Email :……..

I confirm that I have explained to the respondent the nature and purpose of the above-mentioned research.

Date ……..... Signature …….....

(Researcher)

APPENDIX C
Consumer acceptance test score sheet

Panelist no.: _____

Sex : _____

Age : _____

Race : _____

Instructions:

1. You are given four different samples.
2. Place a cross (X) on the horizontal line together with the sample code on the top of it that best describe your overall opinion for each sample. However, for aftertaste attribute you need to circle the number that best describe your overall opinion and put the sample code on the top of your opinion.
3. Prior the evaluation ensures the sample should be stir well.
4. Please use the spoon provided to test each sample.
5. Evaluate the sample without rice (carrier) first then continue to test with rice.
6. Please drink the water provided to rinse your palate before evaluates each sample.
7. Wait at least 30 seconds to start with another samples.
8. Do not eat chewing gum one hour before starts evaluate the sample.
9. Please evaluate the samples according to the code provided.

Appearance: Colour (Warna)

Dislike extremely — Neither like or dislike — Like extremely

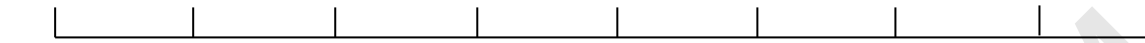
Viscosity/Consistency(Kepekatan)

Dislike extremely — Neither like or dislike — Like extremely

Aroma

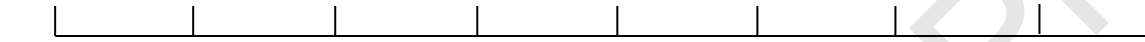
Dislike extremely — Neither like or dislike — Like extremely

Taste: Sweetness (Kemanisan)



Dislike extremely Neither like or dislike Like extremely

Taste: Saltiness (Kemasinan)



Dislike extremely Neither like or dislike Like extremely

Taste: Sourness (Kemasaman)

Dislike extremely Neither like or dislike Like extremely

Taste: Herbal (Rasa herba)

Dislike extremely Neither like or dislike Like extremely

Taste: Spicy (Kepedasan)

Dislike extremely Neither like or dislike Like extremely

Aftertaste

0 1 2 3 4 5

Not detected Strong

Overall acceptability (Penerimaan keseluruhan)

Dislike extremely Neither like or dislike Like extremely

Comments:

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----------THANK YOU----------

APPENDIX D

Sensory evaluation flyers

SENSORY EVALUATION TEST

'The authentic of Gulai Tempoyak dish'

'Gulai Tempoyak' is the famous traditional Malay dish originated from Temerloh, Pahang which have delicate taste of fermented durian paste (tempoyak).

DATE: 11 JUNE 2014 (WEDNESDAY)
TIME: 10 a.m –4 p.m
VENUE: Sensory Lab, Food 3, FSTM

Lets have a try and feel it authentic taste!!!

Prize will be given to all participant

FOR MORE INFORMATION CONTACT 0199892995 (Hafiz)