PROCESSING PARAMETERS OF OVEN AND MICROWAVE DRYING ON PROPERTIES OF READY-TO-EAT MEAL TO HEAL (M2H)

THAIBAH BINTI ALI

A dissertation submitted in fulfillment of the
requirements for the award of the degree of
Master of Engineering

Faculty of Chemical and Energy Engineering
Universiti Teknologi Malaysia

AUGUST 2017

Dedicated to my beloved mother, HAWA BINTI HUSAIN and late father, ALI BIN AHMAD, brothers, friends and lecturers who have been involved in this study, who gave everlasting inspiration, never-ending encouragements and priceless support towards the success of this study.

Thanks for everything.

ACKNOWLEDGEMENT

My most gratitude to Allah S.W.T, the Almighty for giving me the great chance to enhance my knowledge and to complete this research.

I would like to express my appreciation to my respected research supervisors Dr. Dayang Norulfairuz binti Abang Zaidel, Prof. Dr. Ida Idayu binti Mohamad and Dr. Yanti Maslina binti Mohd Jusoh, Dr Eraricar binti Saleh and Dr. Khir bin Baharom. Their helpful and valuable advice, constant encouragement and effective support did help me much in making this research possible and complete.

I heartily grateful to Dr Dayang Norulfairuz and Dr. Yanti Maslina for guide my experimental work until successfully accomplished. I highly value the support from all staff including admin to technical staffs and fellow friends of Food and Biomaterial Engineering Research Group for their valuable assistance and efforts did much effort to ensure smooth running of this project.

Also I would like to my beloved family members especially my mother and brothers, Puan Hawa binti Husain, Shukri bin Ali and Mohd Zaki bin Ali for giving me endless support, loves and encouragement.

Finally, again I would like to express my sincere gratitude to all who involve in completing this research. Only Allah will reciprocate your goodness.

ABSTRACT

The increasing of natural disasters recently, are raising an awareness to develop a well-balanced with a longer shelf life of dried ready-to-eat meal to heal (M2H). During the natural disaster periods, the victims are lacking of basic nutrition due to inadequate food and clean water supply, leading to gradually weaken the body immune system. Drying operation conditions and methods are critical determinant in the preparation of instant or ready-to-eat meal rice because each parameter plays important role in achieving the desired quality. Therefore, the objective of this study was to investigate and analyse the effect of drying conditions of combined oven and microwave drying on the properties of M2H product. In this study, M2H was cooked by electric cooker for 20 min and then dried by combined oven and microwave drying method at various oven temperature (70 & 90 °C) and time (70, 130 and 180 min), and followed by drying in microwave at various power level (450 & 750 W) and time (1, 2, 3, 4 & 5 min). The results showed that the moisture content and rehydration capability of dried M2H increased with the increase of drying conditions of combined oven and microwave drying methods; moisture values reduced up to 5% dry wt. basis and maximum rehydration or water uptake was 56% after 5 min rehydration. In addition, there was gradually colour changes of M2H with the increased of colour difference (ΔE) in the range of 2.6 - 8.6. Combination oven and microwave drying with (90 °C, 130 min, 450 W, 4 min), (90 °C, 180 min, 450 W, 4 min) and (90 °C, 180 min, 750 W, 2 min) produced acceptable final product in term of moisture content, colour and with relatively fast rehydration capability. Each of the selected M2H samples had water activity (w_a) ranged of 0.4-0.5 which was less than the minimum requirement for a good microorganism growth. Proximate compositions of selected M2H were in range of 55.5 - 65.9% for carbohydrate, 6.4 - 9.3% for protein, 65.9 - 17.3% for fat and 3.4 - 3.5 for ash content. In conclusion, based on consumer's perspective by means of sensorial evaluation, dried M2H was found moderately acceptable emergency functional food products.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

A	-	Alpha
$	-	Currency
°C	-	Degree Celsius
G	-	Gram
H	-	Hour
HA	-	Hectare
kcal	-	Kilo calorie
Kg/year	-	Kilogram per year
µg	-	Microgram
mg	-	Milligram
mL	-	Milliliter
mm	-	Millimeter
> or <	-	More than or less than
%	-	Percentage
RM	-	Ringgit Malaysia
S	-	Second
USD	-	United State Dollar
v/v	-	Volume per volume
Wt.	-	Weight
W	-	Watt

LIST OF ABBREVIATIONS

AOAC	-	Association of Analytical Communities
MW	-	Microwave
MWL	-	Microwave power level
MWT	-	Microwave dying time
M2H	-	Meal to heal
RTE	-	Ready-to-eat
Serving/d	-	Serving per day

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The world has witnessed series of natural disasters occurred both naturally and manmade disasters that cause fatalities, huge property damage and social environmental disruption annually. Earthquakes, floods, landslides, volcanic eruption, storms are the most occurrence disasters hit both developed and developing countries including Malaysia. Among the natural disasters, floods are the single most severe of all natural disasters in Malaysia. Recent recorded natural disasters showed that Malaysia has been overwhelmed by the devastated monsoon floods in September and November 2014, and forced about 200,000 individuals are left stranded without supplier of electricity and clean water, 21 deaths and contributed higher damage to infrastructure alone are about US$ 670 million (RM 2.851 billion), making it the country worst flooding after a decade (MERCY, 2014; EM-DAT, 2015).

During the natural disaster, the conditions of affected area are significantly overcrowding and poor sanitation due to disruption of important utilities, which in turn prevent the victims from cooking and get clean water. In addition, the

inadequate food supply with imbalanced nutrition is gradually lowered body immunity and thus increased outbreak of diseases among the affected populations, with severe nutritional consequences. Therefore, ready-to-eat (RTE) foods with well-balanced nutritional content with consideration of other key factors such as light-weight of product design are excellent food choice as functional food for emergency.

Ready-to-eat foods (RTE) categorised as animal or plant derived food that is cooked, frozen and processed to be consumed directly without cooking or requiring minimal preparation such as reheating or boiling prior to consumption. RTE foods are packaged in air tight sealed solutions and manufactured to last fresh for long time in packed lunches, frozen, home meal replacements and ready meals. Typical RTE foods availably at market are frozen or chilled, retort, canned and dried RTE meals, with broad variety of RTE products type, including meat and poultry products, cereal and vegetable based products. RTE foods are also found an ideal use as functional foods for specific-proposed food products, including space, military, elderly, emergency functional foods, immune-compromised patient foods and domestic consumption as well (Uhiara & Onwuka, 2014; Ammasyhuri *et al.*, 2012).

The convenience food stalwart and less time spends in planning and preparing meal make the RTE foods emerged as an excellent food choice globally including Malaysia. According to Malaysian Investment Development Authority (MIDA), the country's food market is projected to grow higher because of increasing demand for functional and healthy minimally processed food from consumers (MIDA, 2015). This market is anticipated to grow on account of increasing working population, rising per capita expenditure on prepared food and affluent of consumers (Malaysian) on food consumption and eating behavior (MATRADE, 2016; Ali *et al.*, 2012). In addition, Malaysia has a large base of young consumers, who form majority of the country's workforce, caused these young consumers hardly find time for traditional cooking due to change of lifestyle which further creates significant potential for RTE food products. Statistical analysis reported that the global RTE

foods are large, expected to be valued US$195.3 by the end 2026, indicating higher demand of RTE food in food industry (FMI, 2016).

Rice is a staple food for most of the Asian region including Malaysian, contributed more than one fifth of the calories. From nutritional standpoints, rice contains high carbohydrate as source of energy, fibre protein, moderate of fat, higher digestibility and universal acceptability and consumption (Idowu *et al.*, 2010; Nakamura *et al.*, 2011). Moreover, rice also contains trace elements such as iron, zinc and others play a crucial role for biological basis of the altered resistance to infection (Mbatchou & Dawda, 2013). Therefore, rice, recognized as a good source of nutritional values especially high in antioxidant properties, that provide and promote human health (Ahmad *et al.*, 2016), make it is potentially choose as functional food for emergency period. Thailand, for instance, a leading country manufactured rice-based RTE foods for domestic consumption (Prasert & Suwannaporn, 2009; Quoc & Jittanit, 2015). Additionally, research on production of rice-based RTE foods recently have gained much popularity due to ease of cooking and fuel economy (Dutta *et al.*, 2016; Idowu *et al.*, 2010).

RTE rice is subjected to various preparation processes such as pretreatment, cooking or parboiling and drying or milling to develop the organoleptic properties of sensory attributes, nutritional characteristics and to ensure good safety practices (Charunuch *et al.*, 2014). Cooking is majorly applied of preparing rice by combining, mixing and heating ingredients. After that, the mixed-rice is preserved by several preservation processes such as drying or milling as the final steps food process. Instead of cooking, parboiling process is employed for RTE rice production. Parboiling, a hydrothermic treatment that is partial boiling of food as the first step in cooking and consist of essentially three steps which include soaking, heating or steaming and drying. Generally, the rice is parboiling to strengthening of kernel integrity, increase of milling recovery and decrease of cooking losses, which affect other processing operations of storage, milling, cooking and eating quality (Bello *et al.*, 2006; Slam *et al.*, 2002).

Moisture content and drying techniques are considered the most important key factor to facilitate rehydration time, sensory attributes and eating qualities of dried RTE rice products. Dehydration or drying process is the final step in RTE rice process and determines, to a large extent, the final quality of the product being manufactures. Conventional drying methods are largely employed for numerous food and non-food products before the emergence of varieties novel food processing such as vacuum or hot air drying, freeze-drying, spray-drying and others. Among the available conventional methods, oven or hot air drying is the oldest method widely used for food preservation because of its uniformity, hygienic characteristic and rapid dried product that can have extended agriculture products shelf life of at least a year (Falade & Solademi, 2010). Nevertheless, the principle of conventional drying is heated by the surrounding air by convection followed by conduction where heat must diffuse in from the surface of the material reported lead to substantial degradation in food quality attributes (Gowen *et al.*, 2008). Although oven drying can reduce moisture content faster at high temperature, but these condition had substantially caused on intense colour changes and structure are getting harder affected by the severity of the heating treatment (Luangmalawat & Prachayawarakorn, 2008; Ramesh, 2003).

Nowadays, food is subjected to wide range of processing treatment and conditions for wider acceptance of dried RTE rice to produce a better quality product with extending shelf life. The quality of final food product has gained the importance because consumers become more health conscious which led to the introduction of varieties thermal and non-thermal processing methods (Chandrasekaran *et al.*, 2013; Doymaz, 2015; Stratakos & Koidis, 2015; Zili, 2013). For example of thermal processing methods are ohmic heating, microwave heating and radio frequency and for non-thermal are high pressure processing, light pressure homogenizations, pulsed electric fields, ultrasound and ionizing irradiation. Additionally, the thermal process methods in combination with conventional process methods are reported as the best alternative to optimize the stability and preserve nutritional and sensory equalities of food products (Gowen *et al.*, 2008; Kerver *et al.*, 2006). Among the thermal methods, microwave technology has gain immerse importance in industrial food applications and widely used in cooking, drying,

pasteurization and preservation of food materials (Lakshmi & Singh, 2007). Unlike convective drying methods, microwave is electromagnetic waves that could interact with matter producing heat in situ, allowing its quick distribution in the matter used in the food industry with allowable frequencies 915 MHz or 2454 MHz.

From engineering point of view, microwave technology method is not only generate shorter drying with low energy consumption for removing moisture content, but it is capable of better in preserving quality and nutritional characteristics (e.g. vitamin retention) compared to foods cooked by conventional methods (Fan *et al.*, 2012; Lakshmi & Singh, 2007). This is due to the fact that energy from microwave power supplies by electromagnetic field directly to the material resulted into rapid heating and capable of penetrating very deeply throughout the material thickness with reduced thermal ingredient and shorter processing time (Prabhanjan *et al.*, 1995). Besides, electromagnetic heat that is generated within the sample creating large vapour pressure difference between the centre and surface of sample, hence resulting in porous structure, deemed good for rehydration capability of dried rice (Quoc & Jittanit, 2015). The high drying efficiency of microwave drying make it suitable to dry heat-sensitive materials such as fruit and vegetables compare to freeze- and spray drying methods (Hazervazifeh *et al.*, 2016; Vadivambal & Jayas, 2010). In addition, microwave treatment on rice starch reported could retain the chemical bonds and chemical groups without destroying the physicochemical structure of the product (Fan *et al.*, 2012). Therefore, combination of oven drying and microwave method is best approach to overcome to disadvantages of oven drying and optimize the stability of the product and as well as preserving nutritional and properties attributes of RTE rice.

1.2 Statement of Problems

During the natural disaster period, especially initial phase of disaster, where the impact occurred from 1-4 days, the conditions at the affected areas are overcrowding, poor sanitation, instability, acute shortage and mass movement of people. In addition, the situation is furthered complicated with disruption of the critical infrastructures and utilities both water supply and electricity, causing the victims unable from cooking and get clean water. The disruption of water purification and sewage system resulted lots of outbreak of diseases due to exposure to pathogens and rotavirus such as acute respiratory tract infections, tetanus, and measles and others in some disaster camp.

Moreover, the inadequate food supply supplemented with imbalanced nutrition is further increased uncontrolled outbreak of diseases majorly to vulnerable groups such as young children, pregnant and lactating women and older groups. The diarrheal illnesses caused by food-born diseases also are found a leading cause of mortality with estimation about 9 percent contributed from children (Bartlett, 2010). Therefore, development of ready-to-eat meal to heal (M2H) supplemented with well-balanced nutrient that can be consumed without cooking or required minimal preparation is best solution to overcome the mortality caused by both nutritional deficiency and contaminated water in affected areas.

The study and development of ready-to-eat foods (RTE) have been existence for a long period of time. However, this RTE foods are reported disadvantages in term of precooking and preparation of food and insufficient nutritional qualities. In order to meet consumers demand on easily prepared RTE foods, the foods are preserved in excessive portion of salt and food additives (e.g. colouring agent and flavour) to make it look and taste palatable as if they are freshly made. The complexity of these composite dishes substantially resulted to less total energy, high in saturated fat and salt and low in sugar that is fail to complement with total energy requirements during emergency. For example, *Maggi* and biscuits are typical RTE

foods are often supplied when disasters occurred in Malaysia, but excessive food additives contained in these foods fail to complement with nutritional and total energy requirement during emergency.

Additionally, minimally foods such as RTE frozen pastries, meat and vegetables-based RTE are prepared by hand found lead to an increased incidence of contamination with potential foodborne pathogens (Kotzekidou, 2013; Murcia *et al.*, 2009; Yang *et al.*, 2016). Moreover, most of the RTE foods available in the market are frozen and refrigerated are generally require microwave or oven reheating prior consumption. Often, these bulky or perishable food products required extra care and cost for storage and transportation. Therefore, typical food products with safe time, light weight and easily to handle and distribute to disaster victim are suitable used as functional food for emergency and to feed victim at the affected area.

1.3 Objectives

The objectives of the study were:

I. To investigate the effect of drying conditions of oven drying (temperature and time) and microwave technology (power level and time) on the properties of ready-to-eat meal to heal (M2H).
II. To evaluate the properties of acceptable final dried M2H in term of moisture content, colour, rehydration capability, texture evaluation, water activity, proximate compositions and sensory evaluation.

1.4 Scope of Study

To achieve the objectives of the study, the following scope of the study:

I. Preparation of M2H meal by cooking of rice, minced chicken and mixed vegetables performed in rice cooker for 20 min.

II. Drying of M2H by using combination of oven drying at different temperature (70 & 90 °C) and drying time (70,130 & 180 min), as first stage drying process, and followed by microwave technology as second stage drying at different power levels (450 & 750 W) and intermittent drying time (1, 2, 3, 4 & 5 min).

III. Analysis of M2H properties was performed by determination of moisture content, food quality attributes including rehydration capability, color changes, food textures, sensory evaluation and nutritional contents covering carbohydrate, protein, fat and mineral content.

1.5 Significance of Study

The study was significant for development of quality ready-to-eat meal to heal (M2H) for natural disaster victim.

REFERENCES

Ahmad, S., John, S., Bosco, D., Ahmad, M. & Maqbool, M. (2016). Effect of Puffing on Physical and Antioxidant Properties of Brown Rice. *Food Chemistry, 191*, 139–146.

Almasyhuri, Nelis, I. & Heru, Y. (2012). Ready-to-Eat Biscuit Bars Formulation for Disaster-Related Emergency Situation. *Penel Gizi Makanan, 35(1)*, 42-48.

Association of Analytical Chemists (AOAC) (2000), Official Methods of Analysis, 17th Edition Horowitz Editorial International, Maryland USA, vol. 1 and 2, 452- 456.

Argyropoulos, D., Heindl, A. & Mu, J. (2011). Original Article Assessment of Convection, Hot-Air Combined with Microwave- Vacuum and Freeze-Drying Methods for Mushrooms with Regard to Product Quality, 333–342.

Ayappa, K. G., Davis, H. T., Davis, E. A. & Gordon, J. (1991). Analysis of Microwave Heating of Materials with Temperature-Dependent Properties. *AIChE Journal, 37(3)*, 313–322.

Barrett, C. B. (2010). Measuring Food Insecurity. *Science (New York, N.Y.), 327*(5967), 825–8.

Basak, S. R., Basak, A. C. & Rahman, M. A. (2015). Impacts of Floods on Forest Trees and Their Coping Strategies in Bangladesh. *Weather and Climate Extremes*, 7, 43–48.

Baynes, E. R. C., Attal, M., Dugmore, A. J., Kirstein, L. A. & Whaler, K. A. (2015). Catastrophic Impact of Extreme Flood Events on the Morphology and Evolution of the Lower Jökulsá á Fjöllum (Northeast Iceland) during the Holocene. *Geomorphology, 250*, 422–436.

Bello, M., Baeza, R. & Tolaba, M. P. (2006). Quality Characteristics of Milled and Cooked Rice Affected by Hydrothermal Treatment, 72, 124–13

Best, R. L. & Appleton, K. M. (2013). The Consumption of Protein-Rich Foods in Older Adults : An Exploratory Focus Group Study. *Journal of Nutrition Education and Behavior*, *45*(6), 751–755.

Bhattacharya, M. & Basak, T. (2006). On the Analysis of Microwave Power and Heating Characteristics for Food Processing : Asymptotes and Resonances, *39*, 1046–1057.

Burger, J. & Gochfeld, M. (2009). Perceptions of the Risks and Benefits of fish Consumption : Individual Choices to Reduce Risk and Increase Health Benefits, *29*, 343–349.

Calderón, L. A., Iglesias, L., Laca, A., Herrero, M. & Diaz, M. (2010). The utility of Life Cycle Assessment in the Ready Meal Food Industry. *Resources, Conservation and Recycling*, *54*(12), 1196–1207.

Caprioli, G., Giusti, F., Ballini, R., Sagratini, G., Vila-donat, P., Vittori, S. & Fiorini, D. (2016). Lipid Nutritional Value of Legumes : Evaluation of Different Extraction Methods and Determination of Fatty Acid Composition. *Food Chemistry*, *192*, 965–971.

Carballo, J., Cofrades, S. & Jime, F. (2001). Healthier Meat and Meat Products : Their Role as Functional Foods, *59*, 5–13.

Carbonaro, M., Maselli, P. & Nucara, A. (2015). Structural Aspects of Legume Proteins and Nutraceutical Properties. *FRIN*, *76*, 19–30.

Cavdur, F., Kose-kucuk, M. & Sebatli, A. (2016). International Journal of Disaster Risk Reduction Allocation of Temporary Disaster Response Facilities under Demand Uncertainty : An Earthquake Case Study. *International Journal of Disaster Risk Reduction*, *19*, 159–166.

Chan, N. W. (2012). Impacts of Disasters and Disasters Risk Management in Malaysia: The Case of Floods. *Economic and Welfare Impacts of Disasters in East Asia and Policy Responses.*, (December), 503–551.

Chandrasekaran, S., Ramanathan, S. & Basak, T. (2013). Microwave food Processing-A Review. *Food Research International*, *52*(1), 243–261.

Chang, S. K. C. (2010). Protein Analysis, 133–146.

Chittapalo, T. & Songsanandr, P. (2014). Product Development of Black Glutanious Rice Cracker with Panang Flavour and its Quality Changes. *International Food Research Journal*, 21(5), 2025-2029

Chua, K. J. & Chou, S. K. (2005). Original Article A Comparative Study between Intermittent Microwave and Infrared Drying of Bioproducts, 23–39.

Cluster, C. D. (2006). Communicable Diseases following Natural Disasters Risk Assessment and Priority Interventions.

Centre for Research on the Epidemiology of Disasters (CRED)(2016). Disaster Data: A Balance Perspective (February).

Centre for Research on the Epidemiology of Disasters (CRED)(2015). Disaster data: A balance perspective (August).

Charunuch, C., Limsangouan, N., Prasert, W. & Womgkrajan, K. (2014). Optimization of Extrusion Conditions for Ready-to-Eat Breakfast Cereal Enhanced with Defatted Rice Bran, *21*(2), 713–722.

Diya, S., Gasim, M., Toriman, M. & Abdullahi, M. (2014). Flood in Malaysia Historical Reviews, Causes, Effects and Mitigations Approach, *2*(4), 59–65.

Darvishi, H., Azadbakht, M., Rezaeiasl, A. & Farhang, A. (2012). Drying Characteristics of Sardine Fish Dried with Microwave Heating. *Journal of the Saudi Society of Agricultural Sciences*, *12*(2), 121–127.

Datar, A., Liu, J., Linnemayr, S. & Stecher, C. (2013). Social Science & Medicine The Impact of Natural Disasters on Child Health and Investments in Rural India. *Social Science & Medicine*, *76*, 83–91.

Datta, A. K. & Rakesh, V. (2013). Principles of Microwave Combination Heating, *12*.

Deen, S. (2015). International Journal of Disaster Risk Reduction Pakistan 2010 fl Oods. Policy Gaps in Disaster Preparedness and Response. *International Journal of Disaster Risk Reduction*, *12*, 341–349.

Dessev, T., Jury, V. & Le-bail, A. (2011). The Effect of Moisture Content on Short Infrared Absorptivity of Bread Dough. *Journal Food Engineering*, *104*(4), 571–576.

Dewan, T. H. (2014). Societal Impacts and Vulnerability to Floods in Bangladesh and Nepal. *Weather and Climate Extremes*, *7*, 36–42.

Dhall, A., Datta, A. K. & Torrance, K. E. (2009). Radiative Heat Exchange Modeling Inside an Oven, *55*(9).

Dipti, S. S., Bergman, C., Indrasari, S. D., Herath, T. & Hall, R. (2012). The Potential of Rice to Offer Solutions for Malnutrition and Chronic Diseases, 1–18.

Doymaz, B. (2015). Infrared Drying Kinetics and Quality Characteristics, *39*, 2738–2745.

Dutta, H., Lata, C., Singh, V., Baruah, B. & Rahman, N. (2016). Physical, Physicochemical and Nutritional Characteristics of Bhoja Chaul, A Traditional Ready to-Eat Dry Heat Parboiled Rice Product Processed by an Improvised Soaking Technique. *Food Chemistry*, *191*, 152–162.

EM-DAT (2015).The International Disaster Database. Centre for Research on the Epidemiology of Disasters—CRED. Retrieved from http://www.emdat.be/

Englyst, K. N., Liu, S. & Englyst, H. N. (2007). Nutritional Characterization and Measurement of Dietary Carbohydrates. *European Journal of Clinical Nutrition*, *61*(Suppl 1), S19–S39.

Fabbri, A. D. T. & Crosby, G. A. (2015). A Review of the Impact of Preparation and Cooking on the Nutritional Quality of Vegetables and Legumes. *International Journal of Gastronomy and Food Science*, 1–10.

Falade, K. O. & Solademi, O. J. (2010). Original Article Modelling of Air Drying of Fresh and Blanched Sweet Potato Slices, 278–288.

Faller, a. L. K. & Fialho, E. (2012). From the Market to the Plate: Fate of Bioactive Compounds during the Production of Feijoada Meal and the Impact on Antioxidant Capacity. *Food Research International*, *49*(1), 508–515.

Fan, D., Ma, W., Wang, L., Huang, J., Zhao, J., Zhang, H. & Chen, W. (2012). Determination of Structural Changes in Microwaved Rice Starch using Fourier Transform Infrared and Raman Spectroscopy, 598–606.

Fleige, L. E., Moore, W. R., Garlick, P. J., Murphy, S. P., Turner, E. H., Dunn, M. L., Schaefer, S. E. (2010). Recommendations for Optimization of Fortified and Blended Food Aid Products from the United States. *Nutrition Reviews*, *68*(5), 290–315.

Fukasawa, T., Deng, Z. & Ando, M. (2001). Pore Structure of Porous Ceramics Synthesized from Water-Based Slurry by Freeze-Dry Process, *6*, 2523–2527.

FMI (Future Market Insight) (2016). Ready-to-Eat Food Market: Meat/poultry Segment to Dominate Market from 2016 to 2026: A Global Industry Analysis and Opportunity Assessment,2016-2026.Retrieved from http://www.futuremarketinsights.com/reports/ready-to-eat-food-market

German, J. B. & Dillard, C. J. (2004). Saturated Fats : What Dietary Intake ? 1 – 3, 550–559.

Gowen, A. A., Abu-ghannam, N., Frias, J. & Oliveira, J. (2008). Modeling Dehydration and Rehydration of Cooked Soybeans Subjected to Combined Microwave – Hot-Air Drying, *9*, 129–137.

Hazervazifeh, A., Moghaddam, P. A. & Nikbakht, A. M. (2016). Microwave Dehydration of Apple Fruit : Investigation of Drying Efficiency and Energy Costs. (May), 1–10.

Hebbar, H. U., Vishwanathan, K. H. & Ramesh, M. N. (2004). Development of Combined Infrared and Hot Air Dryer for Vegetables, *65*, 557–563.

Ibrahim, G. E. & Osman, F. (2012). Effect of Microwave Heating on Flavour Generation and Food Processing. *The Development and Application of Microwave Heating*, 17–44.

Idowu, A. O., Omobuwajo, T. O. & Falade, K. O. (2010). Production proximate Analysis and Shelf Life Studies of Ready-to-Eat Rice and Kilishi, *4*(5), 264–268.

International Federation of Red Cross & Red Crescent Society (2015). Emergency Plan of Action Operation Update Malaysia : Seasonal Floods 2014 A . Situation Analysis. (January).

IOM (Institute of Medicine) (2005). Dietary Reference Intakes: Energy, Carbohydrate, Fibre, Fat, Fatty Acids, Cholestrol, Protein and Amino Acids. The National Academy Press, Washington, DC.

Ismailoglu, S. O. & Basman, A. (2015). Effects of Infrared Heat-Moisture Treatment on Physicochemical Properties of Corn Starch, 528–539.

Israel, D. C. & Briones, R. M. (2013). Impacts of Natural Disasters on Agriculture, Food Security, and Natural Resources and Environment in the Philippines October 2012. *ERIA Discussion Paper Series*, (October), 1–53.

Jiao, A., Xu, X. & Jin, Z. (2014). Modelling of Dehydration-Rehydration of Instant Rice on Combined Microwave-Hot Air Drying. Food & Bioproduct Processing, *92*(3), 259–265.

Karl, J. P. & Saltzman, E. (2012). The Role of Whole Grains in Body Weight Regulation I, 2. *Advances in Nutrition*, *3*, 697–707.

Kerver, J. M., Yang, E. J., Obayashi, S., Bianchi, L. & Song, W. O. (2006). Meal and Snack Patterns are Associated with Dietary Intake of Energy and Nutrients in US adults. *Journal of the American Dietetic Association*, *106*(1), 46–53.

Khalid, M. S. Bin & Shafiai, S. B. (2015). Flood Disaster Management in Malaysia:

An Evaluation of the Effectiveness Flood Delivery System. *International Journal of Social Science and Humanity*, *5*(4), 398–402.

Koletzko, B., Cetin, I., Brenna, J. T., Lipid, P., Working, I., Lopez-soldado, I., Michael-, K. F. (2017). Dietary Fat Intakes for Pregnant and Lactating Women, (2007), 873–877.

Kotzekidou, P. (2013). Microbiological Examination of Ready-to-Eat Foods and Ready-to-Bake Frozen Pastries from University Canteens. *Food Microbiology*, *34*(2), 337–343.

Kouadio, I. K. (2012). Infectious Diseases Following Natural Disasters : Prevention and Control Measures.

Krishnamurthy, K., Khurana, H. K., Jun, S., Irudayaraj, J. & Demirci, A. (2008). in Food Processing : An Overview, *7*.

Kumar, C., Joardder, M., Karim, A., Millar, G. J. & Amin, Z. (2014). Temperature Redistribution Modelling During Intermittent Microwave Convective Heating. *Procedia Engineering*, *90*, 544–549.

Kumar, D., Prasad, S. & Murthy, G. S. (2014). Optimization of Microwave-Assisted Hot Air Drying Conditions of Okra using Response Surface Methodology, *51*(February), 221–232.

OLafiandra, D., Riccardi, G. & Shewry, P. R. (2014). Improving Cereal Grain Carbohydrates for Diet and Health. *Journal of Cereal Science*, *59*(3), 312–326.

Lakshmi, S. & Singh, V. (2007). Energy Consumption in Microwave Cooking of Rice and its Comparison with other Domestic Appliances, *78*, 715–722.

Lands, B. (2014). Historical Perspectives on the Impact of n-3 and n-6 Nutrients on Health. *Progress in Lipid Research*, *55*(1), 17–29.

Lavie, C. J., Milani, R. V, Mehra, M. R. & Ventura, H. O. (2009). Omega-3 Polyunsaturated Fatty Acids and Cardiovascular Diseases. *JAC*, *54*(7), 585–594.

Leelayuthsoontorn, P. & Thipayarat, A. (1995). Textural and Morphological Changes of Jasmine Rice under Various Elevated Cooking Conditions.

Leelayuthsoontorn, P. & Thipayarat, A. (2006). Food Chemistry Textural and Morphological Changes of Jasmine Rice under Various Elevated Cooking Conditions, *96*, 606–613.

Lemonick, D. M. (2011). Epidemics After Natural Disasters, 144–152.

Li, S., Chen, G., Zhang, C., Wu, M., Wu, S. & Liu, Q. (2014). Research Progress of Natural Antioxidants in Foods for the Treatment of Diseases. *Food Science and Human Wellness*, *3*(3-4), 110–116.

Liu, W. & Lanier, T. C. (2016). Rapid (microwave) Heating Rate Effects on Texture, Fat/Water Holding, and Microstructure of Cooked Comminuted Meat Batters. *FRIN*, *81*, 108–113.

Luangmalawat, P. & Prachayawarakorn, S. (2008). Effect of Temperature on Drying Characteristics and Quality of Cooked Rice, *41*, 716–723.

Luo, P., He, B., Takara, K., Xiong, Y. E., Nover, D., Duan, W. & Fukushi, K. (2015). Historical Assessment of Chinese and Japanese flood Management Policies and Implications for Managing Future Floods. *Environmental Science & Policy*, *48*, 265–277.

Madukosiri, C. & Temple, V. (2009). Nutrient Composition of Snacks Consumed by Pregnant and Lactating Women in Bassa Plateau state, Nigeria. *International Journal of Tropical Agriculture and Food Systems*, *2*(12), 1889–1893.

Malaysia External Trade Development (MATRADE)(2016). Summary of Malaysia's Monthly Trade. Retrieved from http://www.matrade.gov.my/en/malaysian-exporters/services-for-exporters/trade-a-market-information/trade-statistics.

Malaysia Investment Development Authority (MIDA) (2015). Food Technology and Development Resources. Retrieved from http://www.mida.gov.my/home/food-Technology-and-Sustainable-Resources/posts/.

Malaysia Dietary Guideline (MDG) (2013). *Malaysian Dietary Guidelines for Children and Adolescents*.

Maskan, M. (2000). Microwave/Air and Microwave ® Nish Drying of Banana, *44*, 71–78.

Maskan, M. (2001). Drying, Shrinkage and Rehydration Characteristics of Kiwifruits During Hot Air and Microwave Drying, *48*, 177–182.

Mbatchou, V. C. & Dawda, S. (2013). The Nutritional Composition of Four Rice Varieties Grown and Used in Different Food Preparations in Kassena-Nankana District, Ghana. *Int. J. Res. Chem. Environ. International Journal of Research in Chemistry and Environment*, *3*(1).

Mccann, D. G. C., Moore, A. & Walker, M. (2011). The Water/Health Nexus in

Disaster Medicine . II : Water Contamination in Disasters. *Current Opinion in Environmental Sustainability*, *3*(6), 486–490.

Mcdonald, C. E. (1977). Methods of Protein Analysis and Variation in Protein Results.

Malaysia Flood Emergency Respond (MERCY) (2014). Malaysia Flood Emergency Response Report 2014.

Meyer, B. J., Mann, N. J., Lewis, J. L., Milligan, G. C., Sinclair, A. J. & Howe, P. R. C. (2003). Dietary Intakes and Food Sources of Omega-6 and Omega-3 Polyunsaturated Fatty Acids, *38*(4).

Milton, P., Ole, P., Oshaug, A., Ribe, L., Rukooko, B., Kikafunda, J. & Anders, B. (2014). Food as a Human Right During Disasters in Uganda, *49*, 312–322.

Mohit, M. A. & Sellu, G. M. (2013). Mitigation of Climate Change Effects through Non-structural Flood Disaster Management in Pekan Town, Malaysia. *Procedia - Social and Behavioral Sciences*, *85*, 564–573.

Murcia, M. A., Jiménez-monreal, A. M., García-diz, L., Carmona, M., Maggi, L. & Martínez-tomé, M. (2009). Antioxidant Activity of Minimally Processed (in Modified Atmospheres), Dehydrated and Ready-to-Eat Vegetables. *Food and Chemical Toxicology*, *47*(8), 2103–2110.

NCCFN (National Coordinating Committee on Food and Nutrition (2005). Recommended Nutrient Intakes for Malaysia (RNI). A Report of the Technical Working Group on Nutritional Guidelines. Ministry of Healt Malaysia, Putrajaya.

Ni, W., Ding, G., Li, Y., Li, H., Liu, Q. & Jiang, B. (2014). Effects of the Floods on Dysentery in North Central Region of Henan Province, China from 2004 to 2009. *The Journal of Infection*, *69*(5), 430–439.

Nijhuis, H. H., Torringa, H. M., Muresan, S., Yuksel, D. & Kloek, W. (1998). Approaches to Improving the Quality of Dried Fruit and Vegetables, *9*, 13–20.

Noor, M. I. (2002). The Nutrition and Health Transition in Malaysia, *5*(Table 1), 191–195.

Norimah, A.K., Safiah, M.Y., Zuhaida, H., Fatimah, S., Rohida, S.H., Siti Haslinda, M. D. & Siti Norazlin, M.N. (2008b). Habitual Food Intake of Adult Aged 18 to 59 Years: Finding of Malaysian Adult Nutrition Survey (MANS). Mal J Nutr 14(1): 25-40

Prachayawarakorn, S. & Mongkut, K. (2011). Effects of Cooking, Drying and Pretreatment Methods on Texture and Starch Digestibility of Instant Rice.

Okarter, N. & Liu, R. H. (2010). Health Benefits of Whole Grain Phytochemicals. *Critical Reviews in Food Science and Nutrition*, *50*(3), 193–208.

Olatunde, G. A., Atungulu, G. G. & Smith, D. L. (2016). One-Pass Drying of Rough Rice with an Industrial 915 MHz Microwave Dryer : Quality and energy use Consideration International Commission on Illumination. *Biosystems Engineering*, *155*, 33–43.

Olmedilla-alonso, B., Jiménez-colmenero, F. & Sánchez-muniz, F. J. (2013). Development and Assessment of Healthy Properties of Meat and Meat Products Designed as Functional Foods. *MESC*, *95*(4), 919–930.

Omwamba, M. & Mahungu, S.M. (2014). Development of a Protein-Rich Ready-to-Eat Extruded Snack from a Composite Blended of Rice, Sorghum and Soybean Flour. *Food & Nutr. Sci.* 5, 1309-1317

Onwude, D. I., Hashim, N. & Chen, G. (2016). Trends in Food Science & Technology Recent Advances of Novel Thermal Combined Hot Air Drying of Agricultural Crops. *Trends in Food Science & Technology*, *57*, 132–145.

Oz, F. & Kotan, G. (2016). Effects of Different Cooking Methods and Fat Levels on the Formation of Heterocyclic Aromatic Amines in Various Fi Shes. *Food Control*, *67*, 216–224.

Pansa-ead, V., Huaisan, K., Yangyeun, S. & Wiriyaumpaiwong, S. (2014). Pre-Processing Glutinous Rice Effects on Textural and Morphological Changes, *12* (October), 115–121.

Pathare, P. B., Opara, U. L. & Al-said, F. A. (2013). Colour Measurement and Analysis in Fresh and Processed Foods : A Review, 36–60.

Pawar, S. B. & Pratape, V. M. (2015). Fundamentals of Infrared Heating and its Application in Drying of Food Materials: A Review, 1–15.

Philstar (2014). Develops Ready-Eat-Rice Porridge for Disaster Victim. Retrieved on Dec 2016 from http://www.philstar.com/headlines/2014/05/28/1328138/dost-develops-ready-eat-rice-porridge-disaster-victims/

Pothiawala, S. (2015). Food and Shelter Standards in Humanitarian Action. *Turkish Journal of Emergency Medicine*, *15* (Suppl 1), 34–39.

Prabhanjan, D. G., Ramaswamyb, H. S. & Raghavan, G. S. V. (1995). Microwave-Assisted Convective Air Drying of Thin Layer Carrots, *25*, 283–293.

Prasert, W. & Suwannaporn, P. (2009). Optimization of Instant Jasmine Rice Process and its Physicochemical Properties. *Journal of Food Engineering*, *95*(1), 54–61.

Puligundla, P., Abdullah, S. A., Choi, W., Jun, S., Oh, S.-E. & Ko, S. (2013). Potentials of Microwave Heating Technology for Select Food Processing Applications - A Brief Overview and Update. *Journal of Food Processing & Technology*, *04*(11), 278.

Quoc, T. & Jittanit, W. (2015). Optimization of Operating Process Parameters for Instant Brown Rice Production with Microwave-Followed by Convective Hot Air Drying. *Journal of Stored Products Research*, *61*, 1–8.

Ramesh, M. N. (2003). Moisture Transfer Properties of Cooked Rice During Drying, *36*(March 2002), 245–255.

Rodríguez, R., Jiménez, A., Fernández-Bolaños, J., Guillén, R. & Heredia, A. (2006). Dietary Fibre from Vegetable Products as Source of Functional Ingredients. *Trends in Food Science & Technology*, *17*(1), 3–15.

Seung, M.K., Myung, H. L., Sun, A. Y., Young, S. C., Sung, A. J., Chang, K. S. & Eun, K. M. (2012). Physichochemical Characteristic and Antioxidant Capacity of Rice Cake (Sulgitteok) Supplemented with Lyophilized *Sedum Sarmentosum* (Dolnamul) Powder. *Prev. Nutr. Food Sci.*, 17, 152-157

Schmidt Rivera, X. C., Espinoza Orias, N. & Azapagic, A. (2014). Life cycle Environmental Impacts of Convenience Food: Comparison of Ready and Home-Made Meals. *Journal of Cleaner Production*, *73*(2014), 294–309.

Shaheen, M. S., El-massry, K. F., El-ghorab, A. H. & Anjum, F. M. (2012). Microwave Applications in Thermal Food Processing. *The Development and Application of Microwave Heating*, 3–16.

Shahar, S. (2009). Atlas of Food Excahnge and Portion Sizes (2nd ed.) MDC Publisher, Kuala Lumpur.

Shaviklo, G. R., Thorkelsson, G., Arason, S., Kristinsson, H. G. & Sveinsdottir, K. (2010). The Influence of Additives and Drying Methods on Quality Attributes of Fish Protein Powder Made from Saithe (Pollachius virens), (May), 2133–2143.

Sidhu, K. S. (2003). Health Benefits and Potential Risks Related to Consumption of Fish or Fish Oil, *38*, 336–344.

Silva, J., Freixo, R., Gibbs, P. & Teixeira, P. (2011). Spray-Drying for the

Production of Dried Cultures, *64*(3), 321–335.

Simopoulos, A. P. (2002). The Importance of the Ratio of Omega-6/Omega-3 Essential Fatty Acids. *56*, 365–379.

Slam, R. I., Oy, P. R., Himizu, N. S. & Imura, T. K. (2002). Effect of Processing Conditions on Physical Properties of Parboiled Rice, *8*(2), 106–112.

Slavin, J. (2004). Whole Grains and Human Health, 1–12.

Souza, R. J. De, Mente, A., Maroleanu, A., Cozma, A. I., Ha, V., Kishibe, T., Anand, S. S. (2015). Intake of Saturated and Trans Unsaturated Fatty Acids and Risk of All Cause Mortality, Cardiovascular Disease, and Type 2 Diabetes : Systematic Review and Meta-Analysis of Observational Studies, 1–16.

Stratakos, A. C. & Koidis, A. (2015). Review Suitability, Efficiency and Microbiological Safety of Novel Physical Technologies for the Processing of Ready-to-Eat Meals, Meats and Pumpable Products, 1283–1302.

Tatar, F., Cengiz, A. & Kahyaoglu, T. (2015). Evaluation of Ultrasonic Nozzle with Spray-Drying as a Novel Method for the Microencapsulation of Blueberry's Bioactive Compounds. *Innovative Food Science and Emerging Technologies*, *32*, 136–145.

Thammarat, N. S., Agricultural, P. & Thammarat, N. S. (2013). Microwave Drying of Cooked Brown Rice and the Effect on the Nutrient Composition and Trace Elements, *20*(1), 351–355.

The Sphere Project (2011). Humanitarian Charter and Minimum Standards in Humanitarian Response. 3rd Edition

Tsuboyama-Kasaoka, N. & Purba, M. B. (2014). Nutrition and Earthquakes: Experience and Recommendations. *Asia Pacific Journal of Clinical Nutrition*, *23*(4), 505–513.

Uhiara, N. S. & Onwuka, G. (2014). Suitability of Protein-Rich Extract from Okra Seed for Formulation of Ready to Use Therapeutic Foods (RUTF). *Nigerian Food Journal*, *32*(1), 105–109.

Vadivambal, R. & Jayas, D. S. (2010). Non-Uniform Temperature Distribution During Microwave Heating of Food Materials-A Review. *Food and Bioprocess Technology*, *3*(2), 161–171.

Wang, H., Rezaee, R. & Saeedi, A. (2015). The Interaction of Reservoir Properties and Microwave Heating – An Experimental and Numerical Modelling Study of Enhanced Gas Recovery (EGR). *Procedia Earth and Planetary Science*,

15, 542–548.

Wang, L.-N., Chen, X.-H., Shao, Q.-X. & Li, Y. (2015). Flood Indicators and Their Clustering Features in Wujiang River, South China. *Ecological Engineering*, *76*, 66–74.

Wanning, S., Süverkrüp, R. & Lamprecht, A. (2015). Pharmaceutical Spray Freeze Drying. *488*, 136–153.

Wehn, U., Rusca, M., Evers, J. & Lanfranchi, V. (2015). Participation in Flood Risk Management and the Potential of Citizen Observatories: A Governance Analysis. *Environmental Science & Policy*, *48*, 225–236.

World Health Organization (WHO) (2000). Nutrition for Health Development: Global Agenda for Combating Malnutrition.

Yan, W., Zhang, M., Huang, L., Tang, J., Mujumdar, A. S. & Sun, J. (2010). Original article Studies on Different Combined Microwave Drying of Carrot Pieces, 2141–2148.

Yang, S., Pei, X., Wang, G., Yan, L., Hu, J., Li, Y., … Yang, D. (2016). Prevalence of Food-Borne Pathogens in Ready-to-Eat Meat Products in Seven Different Chinese regions. *Food Control*, *65*(October 1993), 92–98.

Yrn, S. T. R. B. & Ail, S. T. L. N. (1998). Effects of Freeze-Dry Processing Conditions on the Crystallization of Pentamidine Isethionate, *87*(9), 1155–1160.

Zarein, M., Samadi, S. H. & Ghobadian, B. (2015). Investigation of Microwave Dryer Effect on Energy Efficiency During Drying of Apple Slices. *Journal of the Saudi Society of Agricultural Sciences*, *14*(1), 41–47.

Zili, S. (2013). Effects of Extrusion, Infrared and Microwave Processing on Maillard Reaction Products and Phenolic Compounds in Soybean.