OPTIMIZATION AND CHARACTERIZATION OF ULTRASONICALLY TREATED JACKFRUIT SEED STARCH

NURULAIN SYUHADA BINTI MOHAMAD YAZID

A thesis submitted in
fulfilment of the requirement for the award of the
Degree of Master of Science

Faculty of Applied Sciences and Technology
Universiti Tun Hussein Onn Malaysia

JANUARY 2022

This Master's Thesis is dedicated to:

My beloved father and mother,
Mohamad Yazid bin Mohamad Salleh and Azian binti Omar,
Thank you, mum and dad,
For your endless support in both moral and financial terms,
For your continuous duas and prayers, eternal love and care,
Because without all of these things,
I will not be able to come this far
My one and only little brother,
Mohamad Safwan bin Mohamad Yazid,
Thank you for taking care of Aleesya when in need
To my husband; Ahmad Azimuddin bin Datuk Hj. Baharudin
And my sweet little daughter; Aleesya
Whom I love so dear
Thank you for being so understanding

ACKNOWLEDGEMENT

All praises to Allah the Almighty for His greatest blessings. Alhamdulillah, Thank you Allah for allowing me to experience such a wonderful journey.

First of all, I would like to express my special indebtedness to my main supervisor as the first reader of this thesis, Ts. Dr. Norazlin Abdullah for being an amazing mentor to me throughout my master's degree study. Your advice in guiding me towards becoming a better person has been ultimately beyond priceless. I would also like to show my sincere appreciation to my co-supervisor as the second reader of this thesis, Dr. Norhayati Muhammad, for her very valuable comments on this thesis.

I would like to be grateful to Post-Graduate Research Grant (GPPS-U813-2017/2018) for providing financial aid support. My greatest thankfulness to all lab technicians from Food Instrumental and Analysis Laboratory, Food Microbiology Laboratory, Food Biochemistry Laboratory, Nano-Technology Laboratory from Physics Lab, respectively at Faculty of Applied Sciences and Technology (FAST), UTH Pagoh Campus. My deepest gratitude for the help of lab technician from Environmental Analysis Laboratory, Faculty of Civil and Environmental Engineering (FKAAS), Materials Science and Material Characterization Laboratory, Faculty of Mechanical and Manufacturing Engineering (FKMP), respectively at UTHM Parit Raja Campus.

I would also like to thank my husband, Ahmad Azimuddin Datuk Haji Baharudin for always lending his ears in listening to all of my research-related problems throughout the entire process. Last but not least, thank you to everyone who has been helping me throughout finishing my master's degree study. It has never been an easy process but these accomplishments shall never be possible without the help from each one of you.

Thank you.

ABSTRACT

Jackfruit seeds contain a high amount of starch but its native is unable to attain required specifications for food industrial applications and researchers are looking for an addition in current available starch products in market. Thus, the aim of this study is to modify jackfruit seed starch (JSS) from a variety of J33 on its physicochemical properties by applying ultrasound treatment. Starch from jackfruit seed was isolated using distilled water and grinded into powder for analysis. The significant effect of factors (starch concentration and ultrasound time) towards responses (paste viscosity, moisture content, and paste clarity) was analysed prior to optimization. Physicochemical properties of the native and ultrasonically treated JSS were then analysed. The results suggested that the paste viscosity of 22.93±13.66cP, moisture content of 10.77±0.07%, and paste clarity of 0.15±0.02% can be achieved at 45% starch concentration and 5 min sonication time. Ultrasound treatment caused the paste viscosity of JSS to be more viscous at 58.14% compared to the untreated JSS. However, in terms of moisture content and paste clarity, the ultrasonically treated JSS exhibited a reduction in value at 17.15% and 37.5% compared to the untreated JSS. In conclusion, JSS can be utilized as an addition to the currently available commercial native and chemically modified starch.

ABSTRAK

Biji nangka mengandungi kandungan kanji yang tinggi, namun dalam keadaan asli, ia tidak dapat memenuhi spesifikasi yang diperlukan untuk kegunaan industri makanan dan para pengkajing sedang mencari kaedah untuk tambahan didalam pasaran kanji sedia ada di pasaraya Maka, tujuan utama kajian ini adalah untuk mengubahsuai kanji biji nangka dari jenis J33 ke atas ciri-ciri fizikokimia dengan menggunakan rawatan ultrabunyi. Kanji dari biji nangka diasingkan menggunakan air suling dan dikisar menjadi serbuk bagi tujuan analisa. Kesan yang penting oleh faktor (kepekatan kanji dan masa rawatan ultrasound) terhadap tindak balas (kelikatan adunan, kandungan kelembapan dan kejelasan adunan) telah dianalisa sebelum proses pengoptimuman. Sifat fizikokimia kanji asli dan kanji yang telah dirawat menggunakan rawatan ultrasound kemudian dianalisa. Hasil dapatan kajian menunjukkan bahawa kelikatan adunan iaitu 22.93±13.66cP, kandungan kelembapan iaitu 10.77±0.07% dan kejelasan adunan iaitu 0.15±0.02% boleh dicapai di bawah keadaan kepekatan kanji 45% dan masa rawatan ultrabunyi 5 minit. Rawatan ultrasound menyebabkan kepekatan kanji biji nangka meningkat sebanyak 58.14% berbanding kanji yang tidak dirawat. Walaubagaimanapun, dari aspek kandungan kelembapan dan kejelasan adunan, kanji biji nangka yang dirawat menggunakan rawatan ultrasound menunjukkan pengurangan pada nilai 17.15% dan 37.5% jika dibandingkan dengan kanji biji nangka yang tidak dirawat. Kesimpulannya, kanji biji nangka boleh digunakan sebagai tambahan kepada kanji yang sedia ada di pasaran komersial secara asli dan telah diubahsuai secara kimia.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Jackfruit (*Artocarpus heterophyllus* Lam.) is a tree native to South-East Asia having multifunctional properties in food supply and industrial applications such as feedstock in the form of dried hay (Van Tri *et al.*, 2015). Malaysia has been amongst the major producers for jackfruit species apart from India, Bangladesh, Nepal, Thailand, Myanmar, Indonesia, and the Philippines (Chhetri *et al.*, 2019). There are five popular jackfruit varieties in Malaysia including J29, NS1 (J31), "*Mantin"* (J32), "*Tekam Yellow*" (J33), and "*Mastura*" (J35) (Department of Agriculture, 2019). Jackfruit can be found in oblong to a cylindrical shape, which grows well under the Malaysian climate and is categorized under non-seasonal crop, thus making it a well-known fruit due to its availability throughout the year (Sy Mohamad *et al.*, 2019). In the food industry, jackfruit has been extensively transformed into numerous food products such as battered fried snacks, dried chips, ice-cream, and paste (Leong *et al.*, 2016; Mamat, 2016). Land used for jackfruit plantation has increased from the year 2008 (1233 ha) to 2015 (3578 ha), followed by a rising in retail price for jackfruit selling from the year of 2015 (RM 4.10/kg) to 2016 (RM 5.40/kg) (AgroFood Statistics, 2016).

Jackfruit has been one of the seven fruits in twelve selected agricultural commodities achieving more than 100% of self-sufficiency ratio (SSR) at 104.3%, which is higher than durian 102.4% and banana 100% (Sahar & Chamhuri, 2016). There has also been a special area for jackfruit trading in Jiaxing, China, and the largest fruit market handling jackfruit comes from Thailand and Vietnam. This is due to great jackfruit sales from the year 2016 at 2,349 tons to 29,300 tons in 2017, which continued to rise in 2018 at 38,200 tons (Jing Zang, 2019). On November 1st, 2018, the Malaysian Agriculture and Agro-Based Industries Minister had suggested exporting several Malaysia's high-value agricultural products to China that included jackfruits, pineapples, and durians (Liu, 2018). A recent study reported that jackfruit from J33 variety, which is in high demand due to its sweet taste and smell, will be exported to United Arab Emirates (UAE) by air shipment (Safari, Razali & Mustaffa, 2019).

The high consumption of jackfruit flesh leads to huge disposal of its by-products such as rinds and seeds. Apparently, little to no data has been recorded on the economic value of these by-products, which is normally addressed as the dumping issue (Lima, Klein & Dotto, 2017). Jackfruit rinds and its cores, which hold the edible jackfruit pods, contribute to about 60% of the whole fruit and have been discarded as waste from the jackfruit-processing industry (Begum *et al.*, 2017). On the other hand, the yield of jackfruit seeds from the total weight of jackfruit is at 8-15%, which contains high carbohydrate and protein (Zhang *et al.*, 2018; Zuwariah *et al.*, 2018). Jackfruit seeds also contain a high amount of starch at 92.8% (Madruga *et al.*, 2014). Lothfy, Haron & Rafaie (2019) proposed that native starch from the seed of jackfruit can be used in the food industry, which requires high thermal properties, and it can also act as a substitute to the existing modified starch in the market. The ability of starch in offering desired texture and stability in food formulations makes it one of the most important polymers in food manufacturing (Silva *et al.*, 2017).

Starch has broad applications in food industries. However, the starch in its native state is unable to attain a specific industrial requirement. Thus, modifications can be made either physically or chemically. Limitations such as a high tendency towards retrogradation, low in thermal and shear resistance lead to chemical modification of starch such as esterification or cross-linking (Singh *et al.*, 2016). On the other hand, starch can also be modified using physical methods. This includes annealing, heat moisture treatment, ultrasound, and microwave treatment (Yazid *et al.*, 2018). Consumers these days are very delicate and care about their health status. Therefore, modifying starch using physical treatment has attained a significant consideration due to the increasing awareness of the side effects caused by chemical treatments (Falsafi *et al.*, 2019). According to Zhu (2015), food properties can be improved by applying ultrasound to starch. The cavitation process will be formed during the ultrasound treatment, which subsequently causes the formation of bubbles inside the system (Muangrat, Pongsirikul & Blanco, 2017). High-intensity ultrasound has also been found to have an ability in changing the functional properties of jackfruit seed protein isolate and, in turn, making it suitable for industrial needs (Resendiz-Vazquez *et al.*, 2017).

In relation to utilizing jackfruit seed starch for this study, modifying its functional properties using ultrasound treatment, a method to optimize the parameters such as starch concentration (%) and ultrasound time (min) is a very crucial step. Response surface methodology (RSM) can help in reducing the number of experimental trials and making reliable relations between several parameters (Said & Amin, 2016). Thus, RSM helps in analysing and optimizing the best two factors to modify three desired responses including paste viscosity, moisture content, and paste clarity. The optimized jackfruit seed starch was validated and compared with its native as well as the commercially available native and chemically modified potato, tapioca, and waxy maize starches. The chosen commercial native and modified starch samples were also limited to only three species, namely potato, tapioca, and waxy maize starches as they are frequently used in food industries. In this study, physicochemical properties analysis measurements were done on native and ultrasonically modified jackfruit seed starch (JSS), which was compared with commercial native and chemically modified potato, tapioca, and waxy maize starches based on their paste viscosity, moisture content, paste clarity, least gelation concentration, swelling power and solubility, thermal properties, crystallinity measurement, morphological characteristics, and chemical structure analysis.

1.2 Problem statement

Fruit can easily deteriorate without proper handling and storage due to its perishability (Mondal *et al.*, 2017). According to Selvaraju and Bakar (2017), the thick solid skin of jackfruit is a waste that is usually formed during fruit processing, thus causing a burden to the local processing industry. Jackfruit is normally harvested in green condition, but it continues to ripen within the storage period and consumption (Singh *et al.*, 2017). Jackfruit, durian, and mangosteen are the fruits with more than 50% of their waste including rind/skin and seed, where these percentages are a definite representative number of wastes (Cheok *et al.*, 2018; Caballero & Soto, 2019). Fruit waste is increasing yearly and the lack of proper handling of fruit wastes can cause a serious issue in terms of pollution towards the air, soil, and water (Sial *et al.*, 2019). However, fruit waste can be reduced by utilizing it into valuable food products such as pectin (Govindaraj *et al.*, 2018). A serious economic, environmental, and nutritional problem has also occurred due to the significant losses and waste caused by fresh and processed fruit industries (Sagar *et al.*, 2018). Starch is one of the functional food products that could be derived from fruit waste, and this study particularly focuses on jackfruit waste.

Starch, over the years, has been modified to improve its properties from its native condition. The currently available commercial starches in the market are known as "modified starch", which has undergone chemical modification. In general, crosslinking, grafting, oxidation, and esterification are examples of chemical modification of starch (Chen *et al.*, 2015). In addition, acetylation is also a common method used to modify starch chemically in which the esterification process occurs inside the hydroxyl functional groups of the starch (Aini & Hariyadi, 2018). Basically, the three main reasons for modifying starch using chemicals are to prolong the stability of the food products, to prevent from overcooking, and to provide tolerance to processing state as well as desirable texture (BeMiller, 2019). However, there has been emerging awareness from consumers regarding health concerns on consuming chemically modified starch-based foods. In consequence, research has grown in number towards an alternative and greener way of modifying starch (Rosu *et al.*, 2017). Generally, physical modification has been a good alternative in modifying starch properties without the usage of chemicals (Zhu, 2015). Physically modified starch is claimed to be safe for human consumption as it does not undergo any chemical treatments (Zhu & Li, 2019). Amongst the lists of currently studied physical modifications for starches include using the sonication method, heat-moisture treatment, and microwave (Zhao *et al.*, 2017; Liu *et al.*, 2019; Yang *et al.*, 2019).

1.3 Significance of the study

This study is very useful as the utilization of jackfruit processing waste is important in maintaining a green environment that promises balanced ecosystems. It is also important to transform jackfruit processing waste into high value-added products using environment-friendly technology (Li *et al.*, 2019). Furthermore, extracting starch from the jackfruit seeds can help in making good use of waste from jackfruit waste such as seed, rind (outer and inner), and rags. A previous study has stated that jackfruit seed properties are similar to grains (Saha *et al.*, 2016). Therefore, it is suggested that instead of throwing seed to landfills, it is better to make use of it.

In addition, this study shall also fit the rising awareness of consumers towards a greener method on starch modification. The currently available starch in the commercial markets or the one used widely by the industry is the one modified using chemicals. The jackfruit seed starch used in this study was extracted using water and modified using ultrasound. A previous study has suggested that the usage of ultrasound is green technology (Zhu, 2015). Besides, extraction using water has also been one of the green extraction methods among six other principles in the extraction process of natural products (Chemat, Vian & Cravotto, 2012). For example, brown rice was found to have an improvement in texture after applying ultrasound treatment (Park & Han, 2016)

1.4 Research objectives

The main aim of this research is to modify the physicochemical properties of jackfruit seed starch from J33 variety using ultrasound. Thus, the specific objectives of this study are as follows:

a) To screen which jackfruit portion (seed, rind, rag and peel) used in the study
b) To determine the optimum starch concentration and ultrasound time in increasing paste viscosity, reducing moisture content, and paste clarity of JSS.
c) To compare the physicochemical properties of untreated and ultrasonically treated JSS with commercial native and chemically modified potato, tapioca and waxy maize starch

1.5 Scope of the study

1. Jackfruit seed from J33 variety was used in this study because its pulp is the most popular variety that is widely consumed by Malaysians.
2. Ultrasound treatment using a water bath (indirect sonication) was applied in modifying jackfruit seed starch characteristics because the main purpose is to analyse the effect of ultrasound treatment in modifying JSS at the mentioned factors (starch concentration and ultrasound time). The limitation is set at a fixed range of starch concentration (5-45%) and sonication time (5-45 min).
3. Jackfruit seed starch was isolated using deionized water in order to make it suitable for human consumption.
4. The commercial modified starch sample chosen was limited to only three species, which are potato, tapioca, and waxy maize starch due to the extensive usage of these three varieties in the food industry.
5. Commercial native potato, tapioca, and waxy maize starches were used for starch properties comparison.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

In general, jackfruit is a tree native to Southeast Asia including Malaysia. Specifically, jackfruit used for this study is from the honey jackfruit variety or also known as clone J33. The main reason for choosing this particular species is due to the high consumption of its pulp owing to its natural sweetness upon ripening. It has crunchy golden yellowish flesh that comes with a pleasant aroma upon reaching its maturity stage. Unripe jackfruit is also popular among consumer to be eaten cooked as a meal because it has a meaty taste which could be a substitute for vegetarian. However, this study is only focusing on matured jackfruit from J33 variety.

Higher demand for jackfruit production and jackfruit pulp consumption has led to an increasing number of jackfruit wastes. These includes peel (green and the most outer part), rind which consists of white and yellow part after the green shell and seed which is white in colour and covered in brown cotyledon. Pulp is the only part that is edible. It has been a great concern on how to utilize part of the waste disposed to the landfill and in this case specifically on seed part to be transformed into something beneficial. Thus, isolation of starch from jackfruit seed has been made using distilled water and analysed for its properties.

Starch, in general, has several applications in the food industry such as stabilizer and thickener. Starch has been modified using several modification methods including chemical and physical. However, this study mainly focused on ultrasound treatment in terms of modifying the properties of jackfruit seed starch. Several sub-topics will discuss the ultrasound treatment and its effect on several physicochemical properties such as paste viscosity, moisture content, paste clarity, thermal properties, morphological characteristics, and a few more properties. In addition to utilizing ultrasound as a method of modifying jackfruit seed starch, response surface methodology (RSM) will be used as a tool to minimize error and the number of experiments needed.

2.2 Jackfruit

Jackfruit is scientifically known as (*Artocarpus heterophyllus* Lam.), which belongs to the family of mulberry (*Moraceae*) (Ravikodi & Raja, 2016). It has a range of names since it can be found in many parts of Southeast Asia. In Malaysia and the Philippines, jackfruit is usually addressed as '*nangka*', '*khnor*' in Cambodia, '*khanun*' in Thailand, and '*mit*' in Vietnam (Foo & Hameed, 2012; Wong & Tan, 2017). However, it can also be found abundantly in India and Bangladesh (Jagadeesh *et al.*, 2007). The tree can produce up to 200-500 fruits yearly, each with 23-40 kg (Moorthy *et al.*, 2017). Jackfruit is the world's largest fruit due to its massive size and shape (Peng *et al.*, 2013). The whole jackfruit can be divided into three parts, which are fruit axis (central part of the fruit), pulp (edible portion), and rinds (horny and inedible areas) (Zhang *et al.*, 2017). Table 2.1 shows the percentage of jackfruit parts. Highest composition of jackfruit was from its pulp at 38.60-47.37% out of it as a whole.

Table 2.1: Percentage of jackfruit parts including pulp, rind, peel, and seed (Ibrahim *et al.*, 2013).

Jackfruit	(%)
Pulp	38.60 - 47.37
Rind (white/yellow part after green shell)	15.67 - 20.00
Peel (Green and most outer part)	14.86 - 23.68
Seed	9.46 - 19.33

Jackfruit is an exotic tropical fruit that has 'meaty' sugary taste coming from the golden yellow flesh (Mustapha *et al.*, 2015). There are varieties of jackfruit species available in Malaysia, including Tekam Yellow (J33) or also known as 'honey jackfruit', Mantin (J32), and Mastura (J35) (Ismail & Kaur, 2013). The wide availability of jackfruit variations reflects good fertilisation practices by seed spreading and cross-pollination (Baliga *et al.*, 2011). In certain areas in Bangladesh, jackfruit is a staple food replacing rice for their people (Ibrahim *et al.*, 2013).

According to Shamsudin (2009), the most frequently used scientific name for jackfruit is *Artocarpus heterophyllus* Lam.

According to Arshad (2017), the demands for local and exotic fruits in Malaysia will continue to rise in 2020. Table 2.2 shows the additional area needed for planting more local fruits in order to promote the exportation and consumption of local fruits in Malaysia. Jackfruit is listed in third place at 4,630 hectares, thus showing a high demand for jackfruit pulp compared to the other popular local fruits such as mangosteen and banana (Husin *et al.*, 2018).

Table 2.2: Land usage for plantation 2011-2020 (Husin *et al.*, 2018).

Type of fruits	Additional plantation area (Ha)
Pineapple	7,120
Rambutan	5,300
Jackfruit/*Chempedak*	4,630
Papaya	1,460
Mangosteen	1,190
Banana	760

There are various types of clones preferred by consumers between 2001 and 2011 (Husin *et al.*, 2018). Back in 2001, the most favourite clones were jackfruit from J29, J31 (NS1), and J3 clones due to its fleshy, smooth and sweet flesh, and not too outsized. However, as new upcoming clones come in the market within 2011, consumers are now looking forward to more ready-to-eat jackfruit from varieties known as Mantin (J32), Tekam Yellow (J33), and Mastura (J35). Table 2.3 shows the characteristics of the above-mentioned jackfruit clones.

The average weight for Mantin (J32), Tekam yellow (J33), and Mastura (J35) is between 15-20 kg for each fruit upon reaching its matured stage. All of the three fruits have yellowish green colour and exhibit the same oblong shape. J33 variety has a thin bulb compared to the other two, while the colour of the bulb for each variety is orange for J32, yellow for J33, and golden yellow for J35. J33 is very prominent among consumers due to its crunchy texture and very sweet taste.

REFERENCES

Abdullah, N., Chin, N. L., Mokhtar, M. N. & Taip, F. S. (2013). Effects of bulking agents, load size or starter cultures in kitchen-waste composting. *International Journal of Recycling of Organic Waste in Agriculture*, *2* (*1*): 3.

Abedi, E., Pourmohammadi, K. & Abbasi, S. (2019). Dual-frequency ultrasound for ultrasonic-assisted esterification. *Food Science & Nutrition*,

Abedi, E., Pourmohammadi, K., Jahromi, M., Niakousari, M. & Torri, L. (2019). The Effect of Ultrasonic Probe Size for Effective Ultrasound-Assisted Pregelatinized Starch. *Food and Bioprocess Technology*, 1-11.

Abegunde, O. K., Mu, T.-H., Chen, J.-W. & Deng, F.-M. (2013). Physicochemical characterization of sweet potato starches popularly used in Chinese starch industry. *Food Hydrocolloids*, *33* (*2*): 169-177.

Abid, M. K., Ibrahim, H. B. & Zulkifli, S. Z. (2019). Synthesis and Characterization of Biochar from Peel and Seed of Jackfruit plant waste for the adsorption of Copper Metal Ion from water. *Research Journal of Pharmacy and Technology*, *12* (*9*): 4182-4188.

Abral, H., Basri, A., Muhammad, F., Fernando, Y., Hafizulhaq, F., Mahardika, M., Sugiarti, E., Sapuan, S., Ilyas, R. & Stephane, I. (2019). A simple method for improving the properties of the sago starch films prepared by using ultrasonication treatment. *Food Hydrocolloids*, *93* 276-283.

Abral, H., Putra, G. J., Asrofi, M., Park, J.-W. & Kim, H.-J. (2018). Effect of vibration duration of high ultrasound applied to bio-composite while gelatinized on its properties. *Ultrasonics sonochemistry*, *40* 697-702.

Agiang, M. A., Dongo, B. S., Williams, I. O. & Utu-Baku, A. B. (2017). Assessment of the haematological indices of albino rats fed diets supplemented with jackfruit bulb, seed or a blend of bulb and seed. *International Journal of Biological and Chemical Sciences*, *11* (*1*): 397-407.

Ahmed, Z., Tetlow, I. J., Falk, D. E., Liu, Q. & Emes, M. J. (2016). Resistant starch content is related to granule size in barley. *Cereal Chemistry*, *93* (*6*): 618-630.

Aini, N. & Hariyadi, P. (2018). Utilization of Modified White Corn Starch in Producing Marshmallow Cream. *IJFAC (Indonesian Journal of Fundamental and Applied Chemistry)*, *3* (*2*): 40-46.

Airlangga, B., Sugianto, A. M., Parahita, G., Puspasari, F., Mayangsari, N. E., Trisanti, P. N., Sutikno, J. P. & Sumarno, S. (2021). Study of cassava starch degradation using sonication process in aqueous sodium chloride. *Journal of the Science of Food and Agriculture*, *101* (*6*): 2406-2413.

Ajala, E., Aberuagba, F., Olaniyan, A. & Onifade, K. (2016). Optimization of solvent extraction of shea butter (Vitellaria paradoxa) using response surface methodology and its characterization. *Journal of food science and technology*, *53* (*1*): 730-738.

Alkiayat, M. (2021). A Practical Guide to Creating a Pareto Chart as a Quality Improvement Tool. *Global Journal on Quality and Safety in Healthcare*, *4* (*2*): 83-84.

Altemimi, A. (2018). Extraction and optimization of potato starch and its application as a stabilizer in yogurt manufacturing. *Foods*, *7* (*2*): 14.

Amadi, J. A., Ihemeje, A. & Afam-Anene, O. (2018). Nutrient and phytochemical composition of jackfruit (Artocarpus heterophyllus) pulp, seeds and leaves. *International Journal of Innovative Food, Nutrition and Sustainable Agriculture*, *6* (*3*): 27-32.

Ambigaipalan, P., Hoover, R., Donner, E., Liu, Q., Jaiswal, S., Chibbar, R., Nantanga, K. & Seetharaman, K. (2011). Structure of faba bean, black bean and pinto bean starches at different levels of granule organization and their physicochemical properties. *Food Research International*, *44* (*9*): 2962-2974.

Amini, A. M., Razavi, S. M. A. & Mortazavi, S. A. (2015). Morphological, physicochemical, and viscoelastic properties of sonicated corn starch. *Carbohydrate polymers*, *122* 282-292.

Arancibia, C., Castro, C., Jublot, L., Costell, E. & Bayarri, S. (2015). Colour, rheology, flavour release and sensory perception of dairy desserts. Influence of thickener and fat content. *LWT-Food Science and Technology*, *62* (*1*): 408-416.

Arshad, F. M. (2017). Food Policy in Malaysia. *Reference Module in Food Sciences*, 1-12.

Babitha, S., Soccol, C. R. & Pandey, A. (2007). Solid-state fermentation for the production of Monascus pigments from jackfruit seed. *Bioresource Technology*, *98* (*8*): 1554-1560.

Bafana, R., Sivanesan, S. & Pandey, R. (2019). Optimization and scale up of itaconic acid production from potato starch waste in stirred tank bioreactor. *Biotechnology progress*,

Bai, W., Hébraud, P., Ashokkumar, M. & Hemar, Y. (2017). Investigation on the pitting of potato starch granules during high frequency ultrasound treatment. *Ultrasonics sonochemistry*, *35* 547-555.

Baliga, M. S., Shivashankara, A. R., Haniadka, R., Dsouza, J. & Bhat, H. P. (2011). Phytochemistry, nutritional and pharmacological properties of Artocarpus heterophyllus Lam (jackfruit): A review. *Food Research International*, *44* (*7*): 1800-1811.

Banura, S., Thirumdas, R., Kaur, A., Deshmukh, R. & Annapure, U. (2018). Modification of starch using low pressure radio frequency air plasma. *LWT*, *89* 719-724.

Barbosa, J. V., Martins, J., Carvalho, L., Bastos, M. M. & Magalhães, F. D. (2019). Effect of peroxide oxidation on the expansion of potato starch foam. *Industrial Crops and Products*, *137* 428-435.

Barros, D. R., Carvalho, A. P. M. G., da Silva, E. O., Sampaio, U. M., de Souza, S. M., Sanches, E. A., de Souza Sant'Ana, A., Clerici, M. T. P. S. & Campelo, P. H. (2021). Aria (Goeppertia allouia) Brazilian Amazon tuber as a non-conventional starch source for foods. *International Journal of Biological Macromolecules*, *168* 187-194.

Begum, R., Yusof, Y. A., Aziz, M. G. & Uddin, M. B. (2017). Structural and functional properties of pectin extracted from jackfruit (Artocarpus heterophyllus) waste: effects of drying. *International Journal of Food Properties*, 1-12.

BeMiller, J. N. (2019). Corn Starch Modification. Corn, Elsevier: 537-549.

Benkeblia, N. (2019). Variation of reducing and total sugars starch, total phenolic contents in unripe and ripe jackfruit (Artocarpus heterophyllus) and West Indian locust (Hymenaea courbaril) fruits.

Bernardo, C. O., Ascheri, J. L. R., Chávez, D. W. H. & Carvalho, C. W. P. (2018). Ultrasound assisted extraction of yam (Dioscorea bulbífera) starch: effect on morphology and functional properties. *Starch‐Stärke*, *70* (*5-6*): 1700185.

Bhattacharjya, B., Dutta, H., Patwari, K. & Mahanta, C. (2015). Properties of annealed jackfruit (Artocarpus heterophyllus Lam.) seed starch. *Acta alimentaria*, *44* (*4*): 501-510.

Bhushan, B., Mani, I., Kar, A. & Datta, A. (2017). Optimization of jackfruit seed starch-soya protein isolate ratio and process variables for flaxseed oil encapsulation.

Bi, X., Hemar, Y., Balaban, M. O. & Liao, X. (2015). The effect of ultrasound on particle size, color, viscosity and polyphenol oxidase activity of diluted avocado puree. *Ultrasonics sonochemistry*, *27* 567-575.

Biduski, B., da Silva, F. T., da Silva, W. M., El Halal, S. L. d. M., Pinto, V. Z., Dias, A. R. G. & da Rosa Zavareze, E. (2017). Impact of acid and oxidative modifications, single or dual, of sorghum starch on biodegradable films. *Food chemistry*, *214* 53-60.

Bisinella, R. Z. B., Beninca, C., Bet, C. D., de Oliveira, C. S., Demiate, I. M. & Schnitzler, E. (2021). Thermal, structural and morphological characterisation of organic rice starch after physical treatment. *Journal of Thermal Analysis and Calorimetry*, 1-9.

Bitik, A., Sumnu, G. & Oztop, M. (2019). Physicochemical and Structural Characterization of Microfluidized and Sonicated Legume Starches. *Food and Bioprocess Technology*, *12* (*7*): 1144-1156.

Bortnowska, G., Krudos, A., Schube, V., Krawczyńska, W., Krzemińska, N. & Mojka, K. (2016). Effects of waxy rice and tapioca starches on the physicochemical and sensory properties of white sauces enriched with functional fibre. *Food chemistry*, *202* 31-39.

Bramantyo, A., Febriyati, P., Gunardi, I. & Trisanti, P. (2019). Ultrasound Pre-treatment for Intensification of Hydrothermal Process in Reducing Sugar Production from Cassava Starch. IOP Conference Series: Materials Science and Engineering, IOP Publishing. 012085.

Braşoveanu, M., Nemţanu, M. R. & Ticoș, D. (2021). Influence of the sample loading on the contribution of competitive effects for granular starch exposed to radio-frequency plasma. *Innovative Food Science & Emerging Technologies*, 102740.

Caballero, E. & Soto, C. (2019). Valorization of Agro-Industrial Waste into Bioactive Compounds: Techno-Economic Considerations. Biorefinery, Springer: 235-252.

Cai, J., Cai, C., Man, J., Zhou, W. & Wei, C. (2014). Structural and functional properties of C-type starches. *Carbohydrate polymers*, *101* 289-300.

Cárcel, J., García-Pérez, J., Riera, E., Rosselló, C. & Mulet, A. (2017). Ultrasonically assisted drying. *Ultrasound in Food Processing*, 371-391.

Carmona-García, R., Bello-Pérez, L., Aguirre-Cruz, A., Aparicio-Saguilán, A., Hernández-Torres, J. & Alvarez-Ramirez, J. (2016). Effect of ultrasonic treatment on the morphological, physicochemical, functional, and rheological properties of starches with different granule size. *Starch-Stärke*, *68* (*9-10*): 972-979.

Castanha, N., Lima, D. C., Junior, M. D. M., Campanella, O. H. & Augusto, P. E. D. (2019). Combining ozone and ultrasound technologies to modify maize starch. *International journal of biological macromolecules*, *139* 63-74.

Chang, R., Tian, Y., Lu, H., Sun, C. & Jin, Z. (2019). Effects of fractionation and heat-moisture treatment on structural changes and digestibility of debranched waxy maize starch. *Food Hydrocolloids*, *101* 1-32.

Charoen, R., Tasana, S., Somprasong, W., Rittisak, S. & Saveboworn, W. (2020). Resistant Starch from Mixed Flours (Banana, Jackfruit Seed and Job's Tear) and The Application in Food Product. E3S Web of Conferences, EDP Sciences. 1-5.

Charoenthai, N., Sanga-ngam, T. & Puttipipatkhachorn, S. (2018). Use of modified tapioca starches as pharmaceutical excipients. *Pharm Sci Asia*, *45* 195-204.

Chemat, F., Vian, M. A. & Cravotto, G. (2012). Green extraction of natural products: concept and principles. *International journal of molecular sciences*, *13* (*7*): 8615-8627.

Chen, J., Liang, Y., Li, X., Chen, L. & Xie, F. (2016). Supramolecular structure of jackfruit seed starch and its relationship with digestibility and physicochemical properties. *Carbohydrate polymers*, *150* 269-277.

Chen, L., Tian, Y., Sun, B., Cai, C., Ma, R. & Jin, Z. (2018). Measurement and characterization of external oil in the fried waxy maize starch granules using ATR-FTIR and XRD. *Food chemistry*, *242* 131-138.

Chen, P., Liu, X., Zhang, X., Sangwan, P. & Yu, L. (2015). Phase transition of waxy and normal wheat starch granules during gelatinization. *International Journal of Polymer Science, 2015*

Chen, Q., Yu, H., Wang, L., ul Abdin, Z., Chen, Y., Wang, J., Zhou, W., Yang, X., Khan, R. U. & Zhang, H. (2015). Recent progress in chemical modification of starch and its applications. *Rsc Advances*, *5* (*83*): 67459-67474.

Chen, Z.-G., Guo, X.-Y. & Wu, T. (2016). A novel dehydration technique for carrot slices implementing ultrasound and vacuum drying methods. *Ultrasonics sonochemistry*, *30* 28-34.

Cheok, C. Y., Mohd Adzahan, N., Abdul Rahman, R., Zainal Abedin, N. H., Hussain, N., Sulaiman, R. & Chong, G. H. (2018). Current trends of tropical fruit waste utilization. *Critical Reviews in Food Science and Nutrition*, *58* (*3*): 335-361.

Chhetri, A., Hazarika, B., Wangchu, L., Singh, S., Alice, A. K. & Singh, M. C. (2019). Appraisement of Variability and Association among the Jackfruit (Artocarpus heterophyllus Lam.) Genotypes Found in North-East India. *Current Journal of Applied Science and Technology*, *33* (*4*): 1-13.

Choi, H.-D., Hong, J. S., min Pyo, S., Ko, E., Shin, H.-Y. & Kim, J.-Y. (2020). Starch nanoparticles produced via acidic dry heat treatment as a stabilizer for a Pickering emulsion: Influence of the physical properties of particles. *Carbohydrate Polymers*, 116241.

Chongkhong, S., Lolharat, B. & Chetpattananondh, P. (2012). Optimization of Ethanol Production from Fresh Jackfruit Seeds Using Response Surface Methodology. *Journal of Sustainable Energy and Environment*, *3* (*3*): 97-101.

Chongkhong, S., Lolharat, B. & Chetpattananondh, P. (2012). Optimization of Ethanol Production from Fresh Jackfruit Seeds Using Response Surface Methodology. *Journal of Sustainable Energy & Environment*, *3* (*3*): 97-101.

Cieśla, K., Sartowska, B. & Królak, E. (2015). SEM studies of the structure of the gels prepared from untreated and radiation modified potato starch. *Radiation Physics and Chemistry*, *106* 289-302.

Cisneros, F. H., Zevillanos, R., Figueroa, M., Gonzalez, G. & Cisneros-Zevallos, L. (2018). Characterization of starch from two Andean potatoes: Ccompis (Solanum tuberosum spp. andigena) and Huayro (Solanum x chaucha). *Starch‐Stärke*, *70* (*3-4*): 1700134.

Colussi, R., Kringel, D., Kaur, L., da Rosa Zavareze, E., Dias, A. R. G. & Singh, J. (2020). Dual modification of potato starch: Effects of heat-moisture and high pressure treatments on starch structure and functionalities. *Food chemistry, 318* 126475.

Costa, L. A. d., Diogenes, I. C. N., Oliveira, M. d. A., Ribeiro, S. F., Furtado, R. F., Bastos, M. d. S. R., Silva, M. A. S. & Benevides, S. D. (2020). Smart film of jackfruit seed starch as a potential indicator of fish freshness. *Food Science and Technology*, (*AHEAD*): 1-8.

Cui, R. & Zhu, F. (2020). Effect of ultrasound on structural and physicochemical properties of sweetpotato and wheat flours. *Ultrasonics sonochemistry*, *66* 105118.

da Silva, E. S., Brandão, S. C. R., da Silva, A. L., da Silva, J. H. F., Coêlho, A. C. D. & Azoubel, P. M. (2019). Ultrasound-assisted vacuum drying of nectarine. *Journal of food engineering*, *246* 119-124.

da Silva Timm, N., Ramos, A. H., Ferreira, C. D., Biduski, B., Eicholz, E. D. & de Oliveira, M. (2020). Effects of drying temperature and genotype on morphology and technological, thermal, and pasting properties of corn starch. *International Journal of Biological Macromolecules*, *165* 354-364.

Dailey, A. & Vuong, Q. V. (2016). Optimum conditions for microwave assisted extraction for recovery of phenolic compounds and antioxidant capacity from Macadamia (Macadamia tetraphylla) skin waste using water. *Processes*, *4* (*1*): 2.

Das, A. & Sit, N. (2021). Modification of Taro Starch and Starch Nanoparticles by Various Physical Methods and their Characterization. *Starch‐Stärke*, *73* (*5-6*): 2000227.

David, J., Parthasarathy, V., Kalaiselvan, S., Hemalatha, S., Swaroop, G. V., Guo, Y., Guo, N., Gao, J., He, Y. & Chellaram, C. (2016). Antioxidant Properties of Fibre Rich Dietetic Chocolate Cake Developed by Jackfruit (Artocarpus heterophyllus L.) Seed Flour. *International Journal of Food Engineering*, *2* (*2*): 132-135.

de Oliveira, C. S., Andrade, M. M. P., Colman, T. A. D., da Costa, F. J. O. G. & Schnitzler, E. (2014). Thermal, structural and rheological behaviour of native and modified waxy corn starch with hydrochloric acid at different temperatures. *Journal of Thermal Analysis and Calorimetry*, *115* (*1*): 13-18.

Dey, B. & Baruah, K. (2019). Morphological Characterization of Jackfruit (Artocarpus heterophyllus Lam.) of Assam, India. *Int. J. Curr. Microbiol. App. Sci*, *8* (*11*): 1005-1016.

Dey, N. N. & Amin, B. K. (2017). Effect of Nutritional, Sensory and Texture Properties of Jackfruit Seed (Artocarpus Heterophyllus Lam.) Flour Burfi. *International Journal of Science and Qualitative Analysis*, *3* (*4*): 42.

Ding, L., Zhang, B., Tan, C. P., Fu, X. & Huang, Q. (2019). Effects of limited moisture content and storing temperature on retrogradation of rice starch. *International journal of biological macromolecules*, *137* 1068-1075.

Ding, Y., Liang, Y., Luo, F., Ouyang, Q. & Lin, Q. (2019). Understanding the mechanism of ultrasonication regulated the digestibility properties of retrograded starch following vacuum freeze drying. *Carbohydrate Polymers*, 115350.

Ding, Y., Luo, F. & Lin, Q. (2019). Insights into the relations between the molecular structures and digestion properties of retrograded starch after ultrasonic treatment. *Food chemistry*, *294* 248-259.

do Nascimento, E. M., Mulet, A., Ascheri, J. L. R., de Carvalho, C. W. P. & Cárcel, J. A. (2016). Effects of high-intensity ultrasound on drying kinetics and antioxidant properties of passion fruit peel. *Journal of Food Engineering*, *170* 108-118.

Dong, C., Chen, J., Guan, R., Li, X. & Xin, Y. (2018). Dual-frequency ultrasound combined with alkali pretreatment of corn stalk for enhanced biogas production. *Renewable Energy*, *127* 444-451.

Ellingham, S. T., Thompson, T. J. & Islam, M. (2018). Scanning Electron Microscopy–Energy-Dispersive X-Ray (SEM/EDX): A Rapid Diagnostic Tool to Aid the Identification of Burnt Bone and Contested Cremains. *Journal of forensic sciences*, *63* (*2*): 504-510.

Falsafi, S. R., Maghsoudlou, Y., Aalami, M., Jafari, S. M. & Raeisi, M. (2019). Physicochemical and morphological properties of resistant starch type 4 prepared under ultrasound and conventional conditions and their in-vitro and in-vivo digestibilities. *Ultrasonics sonochemistry*, *53* 110-119.

Falsafi, S. R., Maghsoudlou, Y., Rostamabadi, H., Rostamabadi, M. M., Hamedi, H. & Hosseini, S. M. H. (2019). Preparation of physically modified oat starch with different sonication treatments. *Food hydrocolloids*, *89* 311-320.

Fan, D., Huang, L., Li, B., Huang, J., Zhao, J., Yan, B., Zhou, W., Zhang, W. & Zhang, H. (2017). Acoustic intensity in ultrasound field and ultrasound-assisted gelling of surimi. *LWT*, *75* 497-504.

Fan, Y. & Picchioni, F. (2020). Modification of starch: A review on the application of "green" solvents and controlled functionalization. *Carbohydrate Polymers*, *241* 116350.

Feili, R., Abdullah, W. N. W. & Yang, T. A. (2013). Physical and sensory analysis of high fiber bread incorporated with jackfruit rind flour. *Food Science and Technology*, *1* (*2*): 30-36.

Flores-Silva, P. C., Roldan-Cruz, C. A., Chavez-Esquivel, G., Vernon-Carter, E. J., Bello-Perez, L. A. & Alvarez-Ramirez, J. (2017). In vitro digestibility of ultrasound-treated corn starch. *Starch-Stärke*, *69* (*9-10*): 1-9.

Foo, K. & Hameed, B. (2012). Potential of jackfruit peel as precursor for activated carbon prepared by microwave induced NaOH activation. *Bioresource Technology*, *112* 143-150.

Girisha, C., Singha, P. & Goyala, A. K. (2017). Removal of Phenol from Wastewater Using tea waste and optimization of conditions using response surface methodology. *International Journal of Applied Engineering Research*, *12* (*13*): 3857-3863.

Gonçalves, P. M., Noreña, C. P. Z., da Silveira, N. P. & Brandelli, A. (2014). Characterization of starch nanoparticles obtained from Araucaria angustifolia seeds by acid hydrolysis and ultrasound. *LWT-Food Science and Technology*, *58* (*1*): 21-27.

González-Soto, R. A., Núñez-Santiago, M. C. & Bello-Pérez, L. A. (2019). Preparation and partial characterization of films made with dual-modified (acetylation and crosslinking) potato starch. *Journal of the Science of Food and Agriculture*, *99* (*6*): 3134-3141.

Govindaraj, D., Rajan, M., Hatamleh, A. A. & Munusamy, M. A. (2018). From waste to high-value product: Jackfruit peel derived pectin/apatite bionanocomposites for bone healing applications. *International journal of biological macromolecules*, *106* 293-301.

Gunaratne, A. (2018). Heat-Moisture Treatment of Starch. Physical Modifications of Starch, Springer: 15-36.

Gunaratne, A., Gan, R., Wu, K., Kong, X., Collado, L., Arachchi, L. V., Kumara, K., Pathirana, S. M. & Corke, H. (2018). Physicochemical properties of mung bean starches isolated from four varieties grown in Sri Lanka. *Starch‐Stärke, 70* (*3-4*): 1700129.

Gunaratne, A., Wu, K., Collado, L., Gan, R. Y., Arachchi, L. V., Kumara, K., Pathirana, S. M. & Corke, H. (2016). Physicochemical and functional properties of Caryota urens flour as compared to wheat flour. *International journal of food science & technology, 51* (*12*): 2647-2653.

Guo, K., Lin, L., Fan, X., Zhang, L. & Wei, C. (2018). Comparison of structural and functional properties of starches from five fruit kernels. *Food chemistry, 257* 75-82.

Haievskyi, V. (2020). Study of Possibilities of Joint Application of Pareto Analysis and Risk Analysis During Corrective Actions. *Technology transfer: fundamental principles and innovative technical solutions,* 22-24.

Halder, D., Bhowmick, S., Biswas, A., Mandal, U., Nriagu, J., Guha Mazumdar, D. N., Chatterjee, D. & Bhattacharya, P. (2012). Consumption of brown rice: a potential pathway for arsenic exposure in rural Bengal. *Environmental science & technology, 46* (*7*): 4142-4148.

Hao, Y., Chen, Y., Li, Q. & Gao, Q. (2018). Preparation of starch nanocrystals through enzymatic pretreatment from waxy potato starch. *Carbohydrate polymers, 184* 171-177.

Hedayati, S., Niakousari, M. & Pour, Z. M. (2019). Production of tapioca starch nanoparticles by nanoprecipitation-sonication treatment. *International Journal of Biological Macromolecules,*

Helle, S., Bray, F., Putaux, J.-L., Verbeke, J., Flament, S., Rolando, C., D'hulst, C. & Szydlowski, N. (2019). Intra-Sample Heterogeneity of Potato Starch Reveals Fluctuation of Starch-Binding Proteins According to Granule Morphology. *Plants, 8* (*9*): 324.

Hettiaratchi, U., Ekanayake, S. & Welihinda, J. (2011). Nutritional assessment of a jackfruit (Artocarpus heterophyllus) meal. *Ceylon Medical Journal, 56* (*2*):

Hsieh, C.-F., Liu, W., Whaley, J. K. & Shi, Y.-C. (2019). Structure and functional properties of waxy starches. *Food Hydrocolloids, 94* 238-254.

Huang, J., Wei, M., Ren, R., Li, H., Liu, S. & Yang, D. (2017). Morphological changes of blocklets during the gelatinization process of tapioca starch. *Carbohydrate polymers*, *163* 324-329.

Husin, N. A., Rahman, S., Karunakaran, R. & Bhore, S. J. (2018). A review on the nutritional, medicinal, molecular and genome attributes of Durian (Durio zibethinus L.), the King of fruits in Malaysia. *Bioinformation*, *14* (*6*): 265.

İbanoğlu, Ş., Özaslan, Z. & İbanoğlu, E. (2018). Combined effect ozonation and ultrasonication on rheological and thermal properties of rice starch in aqueous phase. *Quality Assurance and Safety of Crops & Foods*, *10* (*1*): 69-74.

Ibanoğlu, Ş., Özaslan, Z. T. & Ibanoğlu, E. (2018). Effects of Ultrasonication and Aqueous Ozonation on Gelatinization and Flow Properties of Potato Starch. *Ozone: Science & Engineering*, *40* (*2*): 105-112.

Ibrahim, M., Islam, M., Helali, M., Alam, A. & Shafique, M. (2013). Morphological fruit characters and nutritional food value of different jackfruit (*Artocarpus heterophyllus* Lam.) cultivars in Rajshahi region of Bangladesh. *Bangladesh Journal of Scientific and Industrial Research*, *48* (*4*): 287-292.

Isah, S., Oshodi, A. & Atasie, V. (2017). Physicochemical properties of cross linked acha (digitaria exilis) starch with citric acid. *Chem. Int*, *3* 150-157.

Ismail, N. & Kaur, B. (2013). Consumer Preference for Jackfruit Varieties in Malaysia. *Journal of Agribusiness Marketing*, *6* 37-51.

Ismail, N. M., Osman, H. & Husseinsyah, S. (2014). Tensile Properties of Durian Seed Starch Filled Low Density Polyethylene Composites: Effects of Chemical Surface Modification By Acetic Acid. *Applied Mechanics & Materials*, (*695*):

Jagadeesh, S., Reddy, B., Swamy, G., Gorbal, K., Hegde, L. & Raghavan, G. (2007). Chemical composition of jackfruit (*Artocarpus heterophyllus* Lam.) selections of Western Ghats of India. *Food Chemistry*, *102* (*1*): 361-365.

Jamalabadi, M., Saremnezhad, S., Bahrami, A. & Jafari, S. M. (2019). The influence of bath and probe sonication on the physicochemical and microstructural properties of wheat starch. *Food Science & Nutrition*,

Jan, K. N., Panesar, P. & Singh, S. (2017). Process standardization for isolation of quinoa starch and its characterization in comparison with other starches. *Journal of Food Measurement and Characterization*, 1-9.

Jayus, J., Setiawan, D. & Giyarto, C. (2018). Influence of Lactobacillus plantarum Fermentation on Functional Properties of Flour from Jackfruit (Artocarpus heterophyllus Lamk.) Seeds. *Pertanika Journal of Tropical Agricultural Science*, *41* (*3*):

Ji, Y. (2017). In vitro digestion and physicochemical characteristics of corn starch mixed with amino acid modified by low pressure treatment. *Food Chemistry*,

Jiang, Z., Shi, R., Chen, H. & Wang, Y. (2019). Ultrasonic microwave-assisted extraction coupled with macroporous resin chromatography for the purification of antioxidant phenolics from waste jackfruit (Artocarpus heterophyllus Lam.) peels. *Journal of food science and technology*, *56* (*8*): 3877-3886.

Jiménez-Muñoz, L., Quintanilla, M. & Filomena, A. (2019). Managing the lionfish: influence of high intensity ultrasound and binders on textural and sensory properties of lionfish (Pterois volitans) surimi patties. *Journal of food science and technology*, *56* (*4*): 2167-2174.

Jin, J., Ma, H., Wang, B., Yagoub, A. E.-G. A., Wang, K., He, R. & Zhou, C. (2016). Effects and mechanism of dual-frequency power ultrasound on the molecular weight distribution of corn gluten meal hydrolysates. *Ultrasonics Sonochemistry*, *30* 44-51.

Joharia, A. M., Abd Rahmana, N. A., Baharuddina, A. S., Bashaa, R. K., Mohammeda, M. A. P., Parida, D. M., Razaka, S. Z. A. & Wakisakab, M. (2020). Effects of different low temperature storage conditions on the physico-chemical properties of Mastura (J37) jackfruit bulbs. *Journal of Agricultural and Food Engineering*, *1* 0009.

Juárez-Barrientos, J. M., Hernández-Santos, B., Herman-Lara, E., Martínez-Sánchez, C. E., Torruco-Uco, J. G., de Jesus Ramírez-Rivera, E., Pineda-Pineda, J. M. & Rodríguez-Miranda, J. (2017). Effects of boiling on the functional, thermal and compositional properties of the Mexican jackfruit (Artocarpus heterophyllus) seed Jackfruit seed meal properties. *Emirates Journal of Food and Agriculture*, 1-9.

Juárez-Barrientos, J. M., Hernández-Santos, B., Herman-Lara, E., Martínez-Sánchez, C. E., Torruco-Uco, J. G., de Jesus Ramírez-Rivera, E., Pineda-Pineda, J. M. & Rodríguez-Miranda, J. (2017). Effects of boiling on the functional, thermal and compositional properties of the Mexican jackfruit (Artocarpus heterophyllus) seed Jackfruit seed meal properties. *Emirates Journal of Food and Agriculture*, *29* (*1*): 1-9.

Kahar, A., Lingeswarran, M., Hulwani, M. A. & Ismail, H. (2019). Plasticized jackfruit seed starch: a viable alternative for the partial replacement of petroleum-based polymer blends. *Polymer Bulletin*, *76* (*2*): 747-762.

Kalinina, I., Ruskina, A., Fatkullin, R., Naumenko, N., Potoroko, I., Sonawane, S. & Shaik, S. (2020). The application of ultrasound for the regulation of the starch gel viscosity. *Bulgarian Journal of Agricultural Science*, *26* (*3*): 690-695.

Katherine, R. F., Muthukumaran, C., Sharmila, G., Kumar, N. M., Tamilarasan, K. & Jaiganesh, R. (2017). Xanthan gum production using jackfruit-seed-powder-based medium: optimization and characterization. *3 Biotech*, *7* (*4*): 248.

Kaur, H. & Gill, B. S. (2019). Effect of high-intensity ultrasound treatment on nutritional, rheological and structural properties of starches obtained from different cereals. *International journal of biological macromolecules*, *126* 367-375.

Kaushal, P. & Sharma, H. (2016). Osmo-convective dehydration kinetics of jackfruit (Artocarpus heterophyllus). *Journal of the Saudi Society of Agricultural Sciences*, *15* (*2*): 118-126.

Kaveh, Z., Azadmard-Damirchi, S., Yousefi, G. & Hosseini, S. M. H. (2020). Effect of different alcoholic-alkaline treatments on physical and mucoadhesive properties of tapioca starch. *International journal of biological macromolecules*, *153* 1005-1015.

Ketnawa, S., Kaur, L., Ogawa, Y. & Singh, J. (2019). Sweet potato microstructure, starch digestion, and glycemic index. Sweet Potato, Elsevier: 243-272.

Keyse, R. (2018). Introduction to scanning transmission electron microscopy. London, Routledge.

Khan, S., Saqib, M. & Alim, M. (2016). Evaluation of quality characteristics of composite cake prepared from mixed jackfruit seed flour and wheat flour. *Journal of the Bangladesh Agricultural University*, *14* (*2*): 219-227.

Kim, Y.-J., Kim, K.-b., Park, K.-h. & Choi, S.-k. (2016). Quality characteristics of tomato sauce added with various thickening agent. *Culinary science and hospitality research*, *22* (*7*): 100-111.

Kittipongpatana, O. S. & Kittipongpatana, N. (2011). Preparation and physicochemical properties of modified jackfruit starches. *LWT-Food Science and Technology*, *44* (*8*): 1766-1773.

Klaochanpong, N., Puttanlek, C., Rungsardthong, V., Puncha-arnon, S. & Uttapap, D. (2015). Physicochemical and structural properties of debranched waxy rice, waxy corn and waxy potato starches. *Food Hydrocolloids*, *45* 218-226.

Krishnakumar, T. & Sajeev, M. (2018). Effect of Ultrasound Treatment on Physicochemical and Functional Properties of Cassava Starch. *Int. J. Curr. Microbiol. App. Sci*, *7* (*10*): 3122-3135.

Krishnakumar, T., Sajeev, M., Giri, N. A., Pradeepika, C. & Bansode, V. (2019). Development of Mathematical Model for Cassava Starch Properties Using Response Surface Methodology. *Int. J. Curr. Microbiol. App. Sci*, *8* (*8*): 2631-2646.

Krisnaningsih, A. T. N., Yulianti, D. L., Thohari, I. & Surjowardojo, P. (2017). Optimization of Yogurt Fermented Milk Products with The Addition of Natural Stabilizer Based on Local Potential of Taro Starch (Colocasia esculenta). *UNEJ e-Proceeding*, 77-79.

Kumar, L., Brennan, M., Zheng, H. & Brennan, C. (2018). The effects of dairy ingredients on the pasting, textural, rheological, freeze-thaw properties and swelling behaviour of oat starch. *Food chemistry*, *245* 518-524.

Leach, H. W. (1959). Structure of starch granules. I. Swelling and solubility patterns of various starches. *Cereal Chem.*, *36* 534-544.

Leão, D. P., Botelho, B. G., Oliveira, L. S. & Franca, A. S. (2017). Potential of pequi (Caryocar brasiliense Camb.) peels as sources of highly esterified pectins obtained by microwave assisted extraction. *LWT-Food Science and Technology*,

Lee, R. (2019). Statistical Design of Experiments for Screening and Optimization. *Chemie Ingenieur Technik*, *91* (*3*): 191-200.

Lee, S.-J., Zhang, C., Lim, S.-T. & Park, E. Y. (2021). Effect of combination of dry heating and glucose addition on pasting and gelling behavior of starches. *International Journal of Biological Macromolecules*, *183* 1302-1308.

Lehoczki, G., Kandra, L. & Gyémánt, G. (2018). The use of starch azure for measurement of alpha-amylase activity. *Carbohydrate polymers*, *183* 263-266.

Leong, C., Noranizan, M., Kharidah, M. & Choo, W. (2016). Physicochemical properties of pectin extracted from jackfruit and chempedak fruit rinds using various acids. *International Food Research Journal*, *23* (*3*):

Leong, C. M., Noranizan, M., Kharidah, M. & Choo, W. S. (2016). Physicochemical properties of pectin extracted from jackfruit and chempedak fruit rinds using various acids. *International Food Research Journal*, *23* (*3*): 973-978.

Li, C., Liu, W., Gu, Z., Fang, D., Hong, Y., Cheng, L. & Li, Z. (2017). Ultrasonic pretreatment improves the high-temperature liquefaction of corn starch at high concentrations. *Starch‐Stärke*, *69* (*3-4*): 1600002.

Li, H., Wang, R., Zhang, Q., Li, G., Shan, Y. & Ding, S. (2019). Morphological, structural, and physicochemical properties of starch isolated from different lily cultivars grown in China. *International Journal of Food Properties*, *22* (*1*): 737-757.

Li, J., Shin, G. H., Lee, I. W., Chen, X. & Park, H. J. (2016). Soluble starch formulated nanocomposite increases water solubility and stability of curcumin. *Food Hydrocolloids*, *56* 41-49.

Li, L., Yuan, T. Z., Setia, R., Raja, R. B., Zhang, B. & Ai, Y. (2019). Characteristics of pea, lentil and faba bean starches isolated from air-classified flours in comparison with commercial starches. *Food chemistry*, *276* 599-607.

Li, M., Li, J. & Zhu, C. (2018). Effect of ultrasound pretreatment on enzymolysis and physicochemical properties of corn starch. *International journal of biological macromolecules*, *111* 848-856.

Li, S., Luo, Z., Guan, X., Huang, K., Li, Q., Zhu, F. & Liu, J. (2019). Effect of ultrasonic treatment on the hydration and physicochemical properties of brewing rice. *Journal of Cereal Science*, *87* 78-84.

Li, W. J., Fan, Z. G., Wu, Y. Y., Jiang, Z. G. & Shi, R. C. (2019). Eco‐friendly extraction and physicochemical properties of pectin from jackfruit peel waste by subcritical water. *Journal of the Science of Food and Agriculture*, 1-31.

Li, W. J., Fan, Z. G., Wu, Y. Y., Jiang, Z. G. & Shi, R. C. (2019). Eco‐friendly extraction and physicochemical properties of pectin from jackfruit peel waste by subcritical water. *Journal of the Science of Food and Agriculture*,

Li, Y., Hu, A., Zheng, J. & Wang, X. (2019). Comparative studies on structure and physiochemical changes of millet starch under microwave and ultrasound at the same power. *International journal of biological macromolecules*, *141* 76-84.

Li, Y., Ren, J., Liu, J., Sun, L., Wang, Y., Liu, B., Li, C. & Li, Z. (2018). Modification by α-d-glucan branching enzyme lowers the in vitro digestibility of starch from different sources. *International journal of biological macromolecules*, *107* 1758-1764.

Li, Y., Wu, Z., Wan, N., Wang, X. & Yang, M. (2019). Extraction of high-amylose starch from Radix Puerariae using high-intensity low-frequency ultrasound. *Ultrasonics sonochemistry*, *59* 104710.

Lian, H., Luo, K., Gong, Y., Zhang, S. & Serventi, L. (2020). Okara flours from chickpea and soy are thickeners: increased dough viscosity and moisture content in gluten-free bread. *International Journal of Food Science & Technology*, *55* (*2*): 805-812.

Lima, D. R., Klein, L. & Dotto, G. L. (2017). Application of ultrasound modified corn straw as adsorbent for malachite green removal from synthetic and real effluents. *Environmental Science and Pollution Research*, *24* (*26*): 21484-21495.

Liu, J., Yu, X. & Liu, Y. (2021). Effect of ultrasound on mill starch and protein in ultrasound-assisted laboratory-scale corn wet-milling. *Journal of Cereal Science*, 103264.

Liu, K., Zhang, B., Chen, L., Li, X. & Zheng, B. (2019). Hierarchical structure and physicochemical properties of highland barley starch following heat moisture treatment. *Food chemistry*, *271* 102-108.

Liu, R., Sun, W., Zhang, Y., Huang, Z., Hu, H. & Zhao, M. (2019). Preparation of starch dough using damaged cassava starch induced by mechanical activation to develop staple foods: Application in crackers. *Food chemistry*, *271* 284-290.

Liu, W., Li, Y., Goff, H. D., Nsor-Atindana, J. & Zhong, F. (2018). Distribution of octenylsuccinic groups in modified waxy maize starch: An analysis at granular level. *Food hydrocolloids*, *84* 210-218.

Loksuwan, J. (2007). Characteristics of microencapsulated β-carotene formed by spray drying with modified tapioca starch, native tapioca starch and maltodextrin. *Food hydrocolloids*, *21* (*5-6*): 928-935.

Lothfy, F. A., Haron, M. F. & Rafaie, H. A. (2019). Fabrication and Characterization of Jackfruit Seed Powder Powder and Poly (vinyl alcohol) Blends as Biodegradable Plastic. *Journal of Polymer Science and Technology*, *3* (*2*): 1-5.

Lothfy, F. A., Nor, A. M., Senawi, S. A., Zainuddin, N. S. a., Mohmad, E., Norzeri, N. A. S., Bahri, N. Y. S. S., Azmi, P. E. N. M. & Kamaruzaman, A. N. (2018). MECHANICAL PROPERTIES OF BIOPLASTIC FROM JACKFRUIT SEED

FLOUR AND POLYPROPYLENE. *Malaysian Journal of Analytical Sciences*, *22* (*3*): 429-434.

Lu, X., Su, H., Guo, J., Tu, J., Lei, Y., Zeng, S., Chen, Y., Miao, S. & Zheng, B. (2019). Rheological properties and structural features of coconut milk emulsions stabilized with maize kernels and starch. *Food Hydrocolloids*, *96* 385-395.

Luallen, T. (2018). Utilizing starches in product development. Starch in food, Elsevier: 545-579.

Lubis, M., Gana, A., Maysarah, S., Ginting, M. & Harahap, M. (2018). Production of bioplastic from jackfruit seed starch (Artocarpus heterophyllus) reinforced with microcrystalline cellulose from cocoa pod husk (Theobroma cacao L.) using glycerol as plasticizer. IOP Conference Series: Materials Science and Engineering, IOP Publishing. 012100.

Lubis, M., Harahap, M., Manullang, A., Ginting, M. & Sartika, M. (2017). Utilization starch of jackfruit seed (Artocarpus heterophyllus) as raw material for bioplastics manufacturing using sorbitol as plasticizer and chitosan as filler. Journal of Physics: Conference Series, IOP Publishing. 012014.

Luciano, C. G., Landi Franco, C. M., Ayala Valencia, G., do Amaral Sobral, P. J. & Freitas Moraes, I. C. (2017). Evaluation of extraction method on the structure and physicochemical properties of starch from seeds of two jackfruit varieties. *Starch-Stärke*, *69* (*11-12*): 1700078.

Luo, Z., Fu, X., He, X., Luo, F., Gao, Q. & Yu, S. (2008). Effect of ultrasonic treatment on the physicochemical properties of maize starches differing in amylose content. *Starch-Stärke*, *60* (*11*): 646-653.

Lutfi, Z., Kalim, Q., Shahid, A. & Nawab, A. (2021). Water chestnut, rice, corn starches and sodium alginate. A comparative study on the physicochemical, thermal and morphological characteristics of starches after dry heating. *International Journal of Biological Macromolecules*, *184* 476-482.

Luther, J. L., de Frahan, V. H. & Lieberman, M. (2017). Paper test card for detection of adulterated milk. *Analytical Methods*, *9* (*38*): 5674-5683.

Machado, C. M., Benelli, P. & Tessaro, I. C. (2020). Effect of acetylated starch on the development of peanut skin-cassava starch foams. *International Journal of Biological Macromolecules*, *165* 1706-1716.

Madrigal-Aldana, D. L., Tovar-Gómez, B., de Oca, M. M. M., Sáyago-Ayerdi, S. G., Gutierrez-Meraz, F. & Bello-Pérez, L. A. (2011). Isolation and characterization of Mexican jackfruit (Artocarpus heterophyllus L) seeds starch in two mature stages. *Starch‐Stärke*, *63* (*6*): 364-372.

Madruga, M. S., de Albuquerque, F. S. M., Silva, I. R. A., do Amaral, D. S., Magnani, M. & Neto, V. Q. (2014). Chemical, morphological and functional properties of Brazilian jackfruit (Artocarpus heterophyllus L.) seeds starch. *Food chemistry*, *143* 440-445.

Magalhães, M. L., Cartaxo, S. J., Gallão, M. I., García-Pérez, J. V., Cárcel, J. A., Rodrigues, S. & Fernandes, F. A. (2017). Drying intensification combining ultrasound pre-treatment and ultrasound-assisted air drying. *Journal of Food Engineering*, *215* 72-77.

Mahmood, N. C. & Zaki, Z. M. (2019). The Effectiveness of Raw and Dried Artocarpus Heterophyllus (Jackfruit) Seed as Natural Coagulant in Water Treatment. IOP Conference Series: Materials Science and Engineering, IOP Publishing. 012010.

Malucelli, L. C., Lacerda, L. G., da Carvalho Filho, M. A. S., Fernández, D. E. R., Demiate, I. M., Oliveira, C. S. & Schnitzler, E. (2015). Porous waxy maize starch. *Journal of Thermal Analysis and Calorimetry*, *120* (*1*): 525-532.

Mamat, M. R. (2016). Aiskrim Nangka. *Harian Metro*, https://www.hmetro.com.my/mutakhir/2016/2012/191462/aiskrim-nangka.

Maniglia, B. C., Castanha, N., Le-Bail, P., Le-Bail, A. & Augusto, P. E. (2021). Starch modification through environmentally friendly alternatives: a review. *Critical Reviews in Food Science and Nutrition*, *61* (*15*): 2482-2505.

Maniglia, B. C., Castanha, N., Rojas, M. L. & Augusto, P. E. (2021). Emerging technologies to enhance starch performance. *Current Opinion in Food Science, 37* 26-36.

Manzoor, M. F. & Ahmed, N. (2017). Extraction and utilization of Manihot esculenta crantz and Trapanatans starch as a stabilizer in soy milk based ice cream preparation. *Agricultural Research and Technology*, *8* (*2*): 001-005.

Martinez-Garcia, M., Kormpa, A. & van der Maarel, M. J. (2017). The glycogen of Galdieria sulphuraria as alternative to starch for the production of slowly digestible and resistant glucose polymers. *Carbohydrate polymers*, *169* 75-82.

Martínez, P., Peña, F., Bello-Pérez, L. A., Núñez-Santiago, C., Yee-Madeira, H. & Velezmoro, C. (2019). Physicochemical, functional and morphological characterization of starches isolated from three native potatoes of the Andean region. *Food Chemistry: X*, *2* 100030.

Martins, M. P., Cortés, E. J., Eim, V., Mulet, A. & Cárcel, J. A. (2019). Stabilization of apple peel by drying. Influence of temperature and ultrasound application on drying kinetics and product quality. *Drying Technology*, *37* (*5*): 559-568.

Maurya, P. & Mogra, R. (2016). Assessment of Consumption Practices of Jackfruit (Artocarpus heterophyllus Lam) in the Villages of Jalalpur Block, District Ambedkar Nagar (Uttar Pradesh) India. *Advances in Life Sciences*, *5* (*5*): 1638-1644.

McMaugh, S. J., Thistleton, J. L., Anschaw, E., Luo, J., Konik-Rose, C., Wang, H., Huang, M., Larroque, O., Regina, A. & Jobling, S. A. (2014). Suppression of starch synthase I expression affects the granule morphology and granule size and fine structure of starch in wheat endosperm. *Journal of experimental botany*, *65* (*8*): 2189-2201.

Mehboob, S., Ali, T. M., Sheikh, M. & Hasnain, A. (2020). Effects of cross linking and/or acetylation on sorghum starch and film characteristics. *International journal of biological macromolecules*, *155* 786-794.

Meng, H., Li, D. & Zhu, C. (2018). The effect of ultrasound on the properties and conformation of glucoamylase. *International journal of biological macromolecules*, *113* 411-417.

Miano, A. C., Ibarz, A. & Augusto, P. E. D. (2017). Ultrasound technology enhances the hydration of corn kernels without affecting their starch properties. *Journal of food engineering*, *197* 34-43.

Miao, L., Zhao, S., Zhang, B., Tan, M., Niu, M., Jia, C. & Huang, Q. (2018). Understanding the supramolecular structures and pasting features of adlay seed starches. *Food hydrocolloids*, *83* 411-418.

Miao, M., Li, R., Jiang, B., Cui, S. W., Zhang, T. & Jin, Z. (2014). Structure and physicochemical properties of octenyl succinic esters of sugary maize soluble starch and waxy maize starch. *Food chemistry*, *151* 154-160.

Minakawa, A. F., Faria-Tischer, P. C. & Mali, S. (2019). Simple ultrasound method to obtain starch micro-and nanoparticles from cassava, corn and yam starches. *Food chemistry*, *283* 11-18.

Minh, N. P. (2020). Effectiveness of breadfruit (Artocarpus altilis) starch replacing ratio and incubation temperature in lactic fermentation of formulated yoghurt. *Research on Crops*, *21* (*1*): 198-202.

Mithun, K. & Kaleemullah, S. (2019). Optimization of osmotic dewatering process parameters of jackfruit bulb slices. *Journal of Pharmacognosy and Phytochemistry*, *8* (*2*): 1871-1877.

Mondal, C., Sultana, S., Mannan, M. & Khan, S. (2017). Preparation and Sensorial Evaluation of Pickles, Jam, Jelly and Squash Developed from Jackfruit (Artocarpus heterophyllus). *Journal of Environmental Science and Natural Resources*, *9* (*2*): 35-41.

Monroy, Y., Rivero, S. & García, M. A. (2018). Microstructural and techno-functional properties of cassava starch modified by ultrasound. *Ultrasonics sonochemistry*, *42* 795-804.

Moorthy, I. G., Maran, J. P., Ilakya, S., Anitha, S., Sabarima, S. P. & Priya, B. (2017). Ultrasound assisted extraction of pectin from waste Artocarpus heterophyllus fruit peel. *Ultrasonics Sonochemistry*, *34* 525-530.

Muangrat, R., Pongsirikul, I. & Blanco, P. H. (2017). Ultrasound assisted extraction of anthocyanins and total phenolic compounds from dried cob of purple waxy corn using response surface methodology. *Journal of Food Processing and Preservation*,

Mukprasirt, A. & Sajjaanantakul, K. (2004). Physico-chemical properties of flour and starch from jackfruit seeds (Artocarpus heterophyllus Lam.) compared with modified starches. *International journal of food science & technology*, *39* (*3*): 271-276.

Mukurumbira, A., Mariano, M., Dufresne, A., Mellem, J. J. & Amonsou, E. O. (2017). Microstructure, thermal properties and crystallinity of amadumbe starch nanocrystals. *International journal of biological macromolecules*, *102* 241-247.

Mustapha, N. A., Rahmat, F. F. B., Ibadullah, W. Z. W. & Hussin, A. S. M. (2015). Development of Jackfruit Crackers: Effects of Starch Type and Jackfruit Level. *International Journal on Advanced Science, Engineering and Information Technology*, *5* (*5*): 330-333.

Naeem, M. M., Fairulnizal, M. M., Norhayati, M., Zaiton, A., Norliza, A., Syuriahti, W. W., Azerulazree, J. M., Aswir, A. & Rusidah, S. (2017). The nutritional composition of fruit jams in the Malaysian market. *Journal of the Saudi Society of Agricultural Sciences, 16* (*1*): 89-96.

Naknaen, P., Tobkaew, W. & Chaichaleom, S. (2017). Properties of jackfruit seed starch oxidized with different levels of sodium hypochlorite. *International Journal of Food Properties*, *20* (*5*): 979-996.

Naz, M., Sulaiman, S., Ariwahjoedi, B. & Shaari, K. Z. K. (2014). Characterization of modified tapioca starch solutions and their sprays for high temperature coating applications. *The Scientific World Journal*, *2014*

Nazri, M. S. M., Tawakkal, I. S. M. A., Khairuddin, N., Talib, R. A. & Othman, S. H. (2019). Characterization of Jackfruit Straw-based Films: Effect of Starch and Plasticizer Contents. *Adapting to Challenges*, 1.

Noor, F., Rahman, M. J., Mahomud, M. S., Akter, M. S., Talukder, M. A. I. & Ahmed, M. (2014). Physicochemical properties of flour and extraction of starch from jackfruit seed. *International Journal of Nutrition and Food Sciences*, *4* (*3*): 347-354.

Noorfarahzilah, M., Mansoor, A. & Hasmadi, M. (2017). Proximate composition, mineral content and functional properties of Tarap (Artocarpus odoratissimus) seed flour. *Food Research*, *1* (*3*): 89-96.

O'sullivan, J., Murray, B., Flynn, C. & Norton, I. (2016). The effect of ultrasound treatment on the structural, physical and emulsifying properties of animal and vegetable proteins. *Food hydrocolloids*, *53* 141-154.

Ocloo, F., Bansa, D., Boatin, R., Adom, T. & Agbemavor, W. (2010). Physico-chemical, functional and pasting characteristics of flour produced from Jackfruits (Artocarpus heterophyllus) seeds. *Agriculture and Biology Journal of North America*, *1* (*5*): 903-908.

Ojha, K. S., Kerry, J. P. & Tiwari, B. K. (2017). Investigating the influence of ultrasound pre-treatment on drying kinetics and moisture migration measurement in Lactobacillus sakei cultured and uncultured beef jerky. *LWT-Food Science and Technology*, *81* 42-49.

Önür, İ., Misra, N., Barba, F. J., Putnik, P., Lorenzo, J. M., Gökmen, V. & Alpas, H. (2018). Effects of ultrasound and high pressure on physicochemical properties and HMF formation in Turkish honey types. *Journal of Food Engineering*, *219* 129-136.

Pan, T., Lin, L., Wang, J., Liu, Q. & Wei, C. (2018). Long branch-chains of amylopectin with B-type crystallinity in rice seed with inhibition of starch branching enzyme I and IIb resist in situ degradation and inhibit plant growth during seedling development. *BMC plant biology*, *18* (*1*): 9.

Park, D.-J. & Han, J.-A. (2016). Quality controlling of brown rice by ultrasound treatment and its effect on isolated starch. *Carbohydrate polymers*, *137* 30-38.

Pathak, P. D., Mandavgane, S. A. & Kulkarni, B. D. (2017). Fruit peel waste: Characterization and its potential uses. *Curr. Sci*, *113* 1-11.

Peng, S. D., Lin, L. J., Ouyang, L. J., Zhu, B. Q., Yuan, Y., Jing, W. & Li, J. H. (2013). Comparative analysis of volatile compounds between jackfruit (*Artocarpus heterophyllus* L.) peel and its pulp. *Advanced Materials Research*, *781* 1413-1418.

Peng, W., Ma, Q., Wang, Z. & Xie, Z. (2019). Research Progress On Comprehensive Utilization Of Fruit And Vegetable Waste. E3S Web of Conferences, EDP Sciences. 01106.

Perez Herrera, M., Vasanthan, T. & Hoover, R. (2016). Characterization of maize starch nanoparticles prepared by acid hydrolysis. *Cereal Chemistry*, *93* (*3*): 323-330.

Pfister, B. & Zeeman, S. C. (2016). Formation of starch in plant cells. *Cellular and Molecular Life Sciences*, *73* (*14*): 2781-2807.

Phrukwiwattanakul, P., Wichienchotand, S. & Sirivongpaisal, P. (2014). Comparative studies on physico-chemical properties of starches from jackfruit seed and mung bean. *International journal of food properties*, *17* (*9*): 1965-1976.

Pinto, V. Z., Vanier, N. L., Deon, V. G., Moomand, K., El Halal, S. L. M., da Rosa Zavareze, E., Lim, L.-T. & Dias, A. R. G. (2015). Effects of single and dual physical modifications on pinhão starch. *Food chemistry*, *187* 98-105.

Piyawatakarn, P., Limmatvapirat, C., Sriamornsak, P., Luangtana-Anan, M., Nunthanid, J. & Limmatvapirat, S. (2015). Effect of Glycerol on Properties of Tapioca Starch-based Films. Advanced Materials Research, Trans Tech Publ. 128-132.

Polachini, T. C., Hernando, I., Mulet, A., Telis-Romero, J. & Cárcel, J. A. (2021). Ultrasound-assisted acid hydrolysis of cassava (Manihot esculenta) bagasse: Kinetics, acoustic field and structural effects. *Ultrasonics sonochemistry*, *70* 105318.

Pornsuksomboon, K., Holló, B. B., Szécsényi, K. M. & Kaewtatip, K. (2016). Properties of baked foams from citric acid modified cassava starch and native cassava starch blends. *Carbohydrate polymers*, *136* 107-112.

Pozo, C., Rodríguez-Llamazares, S., Bouza, R., Barral, L., Castaño, J., Müller, N. & Restrepo, I. (2018). Study of the structural order of native starch granules using combined FTIR and XRD analysis. *Journal of Polymer Research*, *25* (*12*): 266.

Praveena, S. M. & Shamsudin, M. I. (2020). Preliminary analysis of selected tropical fruit seed extracts potential as natural coagulant in water. *SN Applied Sciences*, *2* (*7*): 1-11.

Punia Bangar, S., Nehra, M., Siroha, A. K., Petrů, M., Ilyas, R. A., Devi, U. & Devi, P. (2021). Development and characterization of physical modified pearl millet starch-based films. *Foods*, *10* (*7*): 1609.

Punia, S., Sandhu, K. S., Dhull, S. B., Siroha, A. K., Purewal, S. S., Kaur, M. & Kidwai, M. K. (2020). Oat starch: Physico-chemical, morphological, rheological characteristics and its applications-A review. *International journal of biological macromolecules*, *154* 493-498.

Pycia, K., Juszczak, L., Gałkowska, D. & Witczak, M. (2012). Physicochemical properties of starches obtained from Polish potato cultivars. *Starch-Stärke*, *64* (*2*): 105-114.

Qi, Y., Du, F., Jiang, Z., Qiu, B., Guan, Q., Liu, J. & Xu, T. (2018). Optimization of starch isolation from red sorghum using response surface methodology. *LWT*, *91* 242-248.

Raman, R. S. & Basavaraj, Y. (2019). Quality improvement of capacitors through fishbone and pareto techniques. *Int. J. Recent Technol. Eng*, *8* (*2*): 2248-2252.

Ravikodi, K. & Raja, D. H. (2016). An Analysis of Nano Sized Powder of Jackfruit Seed for Bio-Bag Purpose. *International Journal of Emerging Technologies in Engineering Research (IJETER)*, *4* (*12*): 86-91.

Remya, R., Jyothi, A. N. & Sreekumar, J. (2018). Effect of chemical modification with citric acid on the physicochemical properties and resistant starch formation in different starches. *Carbohydrate polymers*, *202* 29-38.

Ren, F. & Wang, S. (2019). Effect of modified tapioca starches on the gelling properties of whey protein isolate. *Food Hydrocolloids*, *93* 87-91.

Resendiz-Vazquez, J., Ulloa, J., Urías-Silvas, J., Bautista-Rosales, P., Ramírez-Ramírez, J., Rosas-Ulloa, P. & González-Torres, L. (2017). Effect of high-intensity ultrasound on the technofunctional properties and structure of jackfruit (Artocarpus heterophyllus) seed protein isolate. *Ultrasonics Sonochemistry*, *37* 436-444.

Rodrigues, A. A. M., Silva, S. d. M., Dantas, A. L., Silva, A. F. d., Santos, L. d. S. & Moreira, D. d. N. (2018). Physiology and postharvest conservation of ‘Paluma’guava under coatings using Jack fruit seed-based starch. *Revista Brasileira de Fruticultura*, *40* (*2*):

Rosu, A. M., Grigoras, C. G., Rafin, C. & Veignie, E. (2017). A Green Chemical Approach of Corn Starch Modification for Innovative Solutions In Adsorption of Polycyclic Aromatic Hydrocarbons. *Scientific Study & Research. Chemistry & Chemical Engineering, Biotechnology, Food Industry*, *18* (*1*): 97.

Russ, N., Zielbauer, B. I., Ghebremedhin, M. & Vilgis, T. A. (2016). Pre-gelatinized tapioca starch and its mixtures with xanthan gum and ι-carrageenan. *Food hydrocolloids*, *56* 180-188.

Safari, S., Razali, N. A. & Mustaffa, R. (2019). DISTRIBUTION CHANNEL ASSESSMENT: A CASE STUDY IN EXPORTING MALAYSIAN JACKFRUIT TO UNITED ARAB EMIRATES (UAE) BY AIR SHIPMENT. *International Journal of Agriculture, Forestry and Plantation*, *8* 75-85.

Sagar, N. A., Pareek, S., Sharma, S., Yahia, E. M. & Lobo, M. G. (2018). Fruit and vegetable waste: Bioactive compounds, their extraction, and possible utilization. *Comprehensive Reviews in Food Science and Food Safety*, *17* (*3*): 512-531.

Saha, P., Das, S., Khanom, S. A., Islam, L., Begum, S. & Parveen, S. (2016). Nutritional & Microbiological quality assessment of dehydrated jackfruit (Artocarpusheterophyllus) seed powder. *Octa Journal of Biosciences*, *4* (*2*):

Sahar, N. & Chamhuri, N. (2016). Agricultural policies effect on livestock industry-Perspectives from Malaysia and New Zealand. *International Journal of Agriculture, Forestry and Plantation*, *2* 77-83.

Said, K. A. M. & Amin, M. A. M. (2016). Overview on the Response Surface Methodology (RSM) in Extraction Processes. *Journal of Applied Science & Process Engineering*, *2* (*1*):

Sameen, A., Khan, M. I., Sattar, M. U., Javid, A. & Ayub, A. (2016). Quality evaluation of yoghurt stabilized with sweet potato (Ipomoea batatas) and taro (Colocassia esculenta) starch. *International Journal of Food and Allied Sciences*, *2* (*1*): 23-29.

Sameen, A., Manzoor, M. F., Huma, N., Sahar, A. & Sattar, U. (2017). Quality evaluation of ice cream prepared with Sagudana (Meteroxylon sagu) and Sweet Potato (Ipomoea batatas) starch as stabilizing agent. *Pak. J. Food Sci*, *27* 1-6.

Santana, R. F., Bonomo, R. C. F., Gandolfi, O. R. R., Rodrigues, L. B., Santos, L. S., dos Santos Pires, A. C., de Oliveira, C. P., Fontan, R. d. C. I. & Veloso, C. M. (2018). Characterization of starch-based bioplastics from jackfruit seed plasticized with glycerol. *Journal of food science and technology*, *55* (*1*): 278-286.

Santhiya, P., Sam, S., Ragunathan, S., Noriman, N. & Voon, C. (2015). The effect of size and content of jackfruit seed flour on the properties of low density polyethylene. AIP Conference Proceedings, AIP Publishing. 070071.

Sarebanha, S. & Farhan, A. (2018). Eco-friendly composite films based on polyvinyl alcohol and jackfruit waste flour. *Journal of Packaging Technology and Research*, *2* (*3*): 181-190.

Sarifuddin, N., Shahrim, N., Rani, N., Zaki, H. & Azhar, A. (2018). Preparation and characterization of jackfruit seed starch/poly (vinyl alcohol)(PVA) blend film. IOP Conference Series: Materials Science and Engineering, IOP Publishing. 012065.

Satibi, Z. (2018). Jualan Terus Dari Ladang (JTDL) Masuk Pasaraya. https://www.hmetro.com.my/agro/2018/2010/387673/jtdl-masuk-pasar-raya.

Satmalawati, E., Pranoto, Y., Marseno, D. & Marsono, Y. (2020). The physicochemical characteristics of cassava starch modified by ultrasonication. IOP Conference Series: Materials Science and Engineering, IOP Publishing. 012030.

Schwall, G. P., Safford, R., Westcott, R. J., Jeffcoat, R., Tayal, A., Shi, Y.-C., Gidley, M. J. & Jobling, S. A. (2000). Production of very-high-amylose potato starch by inhibition of SBE A and B. *Nature biotechnology*, *18* (*5*): 551.

Sehrawat, R., Sehrawat, R., Panesar, P. S., Panesar, P. S., Swer, T. L., Swer, T. L., Kumar, A. & Kumar, A. (2017). Response surface methodology (RSM) mediated interaction of media concentration and process parameters for the pigment production by Monascus purpureus MTCC 369 under solid state fermentation. *Pigment & Resin Technology*, *46* (*1*): 14-20.

Selvaraju, G. & Bakar, N. K. A. (2017). Production of a new industrially viable green-activated carbon from Artocarpus integer fruit processing waste and evaluation of its chemical, morphological and adsorption properties. *Journal of cleaner production*, *141* 989-999.

Sessini, V., Arrieta, M. P., Kenny, J. M. & Peponi, L. (2016). Processing of edible films based on nanoreinforced gelatinized starch. *Polymer degradation and stability*, *132* 157-168.

Setyaningsih, W., Fathimah, R. N. & Cahyanto, M. N. (2021). Process Optimization for Ultrasound-Assisted Starch Production from Cassava (Manihot esculenta Crantz) Using Response Surface Methodology. *Agronomy*, *11* (*1*): 117.

Shabana, S., Prasansha, R., Kalinina, I., Potoroko, I., Bagale, U. & Shirish, S. (2019). Ultrasound assisted acid hydrolyzed structure modification and loading of antioxidants on potato starch nanoparticles. *Ultrasonics sonochemistry*, *51* 444-450.

Shafiq, M., Mehmood, S., Yasmin, A., Khan, S., Khan, N. & Ali, S. (2017). Evaluation of Phytochemical, Nutritional and Antioxidant Activity of Indigenously Grown Jackfruit (Artocarpus heterophyllus Lam). *Journal of Scientific Research*, *9* (*1*): 135-143.

Shamsudin, R., Ling, C. S., Ling, C. N., Muda, N. & Hassan, O. (2009). Chemical Compositions of the Jackfruit Juice (Artocarpus) Cultivar J33 during Storage. J. *Applied Sci*, *9* (*17*): 3202-3204.

Shariffa, Y., Uthumporn, U., Karim, A. & Zaibunnisa, A. (2017). Hydrolysis of native and annealed tapioca and sweet potato starches at sub-gelatinization temperature using a mixture of amylolytic enzymes. *International Food Research Journal*, *24* (*5*):

Shen, Y., Zhang, N., Xu, Y., Huang, J., Yuan, M. a., Wu, D. & Shu, X. (2019). Physicochemical properties of hydroxypropylated and cross-linked rice starches differential in amylose content. *International Journal of Biological Macromolecules*, https://doi.org/10.1016/j.ijbiomac.2019.1001.1194.

Shi, J., Sweedman, M. C. & Shi, Y.-C. (2018). Structural changes and digestibility of waxy maize starch debranched by different levels of pullulanase. *Carbohydrate polymers*, *194* 350-356.

Shrivastava, M., Yadav, R. B., Yadav, B. S. & Dangi, N. (2018). Effect of incorporation of hydrocolloids on the physicochemical, pasting and rheological properties of colocasia starch. *Journal of Food Measurement and Characterization*, *12* (*2*): 1177-1185.

Sial, T. A., Lan, Z., Khan, M. N., Zhao, Y., Kumbhar, F., Liu, J., Zhang, A., Hill, R. L., Lahori, A. H. & Memon, M. (2019). Evaluation of orange peel waste and its biochar on greenhouse gas emissions and soil biochemical properties within a loess soil. *Waste Management*, *87* 125-134.

Silva, I. R. A., Magnani, M., de Albuquerque, F. S. M., Batista, K. S., Aquino, J. d. S. & Queiroga-Neto, V. (2017). Characterization of the chemical and structural properties of native and acetylated starches from avocado (Persea americana Mill.) seeds. *International Journal of Food Properties*, 1-11.

Silva, K. C. G. & Sato, A. C. K. (2019). Sonication technique to produce emulsions: The impact of ultrasonic power and gelatin concentration. *Ultrasonics sonochemistry*, *52* 286-293.

Singh, J., Colussi, R., McCarthy, O. J. & Kaur, L. (2016). Potato starch and its modification. Advances in potato chemistry and technology, Elsevier: 195-247.

Singh, N., Singh, J., Kaur, L., Sodhi, N. S. & Gill, B. S. (2003). Morphological, thermal and rheological properties of starches from different botanical sources. *Food chemistry*, *81* (*2*): 219-231.

Singh, V., Pandey, G., Sarolia, D., Kaushik, R. & Gora, J. (2017). Influence of Pre Harvest Application of Calcium on Shelf Life and Fruit Quality of Mango (Mangifera indica L.) Cultivars. *Int. J. Curr. Microbiol. App. Sci*, *6* (*4*): 1366-1372.

Singla, D., Singh, A., Dhull, S. B., Kumar, P., Malik, T. & Kumar, P. (2020). Taro starch: Isolation, morphology, modification and novel applications concern-A review. *International Journal of Biological Macromolecules*,

Sionkowska, A., Michalska-Sionkowska, M. & Walczak, M. (2020). Preparation and characterization of collagen/hyaluronic acid/chitosan film crosslinked with dialdehyde starch. *International journal of biological macromolecules*, *149* 290-295.

Sirivongpaisal, P. (2018). Functional properties of dual-modified rice starch. *Journal of Food Science and Agricultural Technology (JFAT)*, *4* 93-98.

Siroha, A. K., Punia, S., Kaur, M. & Sandhu, K. S. (2019). A novel starch from Pongamia pinnata seeds: Comparison of its thermal, morphological and rheological behaviour with starches from other botanical sources. *International journal of biological macromolecules*,

Sit, N. (2017). Effect of Ultrasound and Cellulase Pre-Treatment on Extractability and Properties of Taro Starch. *Journal of Root Crops*, *42* (*2*): 128-133.

Soong, Y. Y., Tan, S. P., Leong, L. P. & Henry, J. K. (2014). Total antioxidant capacity and starch digestibility of muffins baked with rice, wheat, oat, corn and barley flour. *Food chemistry*, *164* 462-469.

Spada, F. P., Mandro, G. F., da Matta Junior, M. D. & Canniatti-Brazaca, S. G. (2020). Functional properties and sensory aroma of roasted jackfruit seed flours compared to cocoa and commercial chocolate powder. *Food Bioscience*, 1-37.

Srikaeo, K., Hao, P. T. & Lerdluksamee, C. (2019). Effects of Heating Temperatures and Acid Concentrations on Physicochemical Properties and Starch Digestibility of Citric Acid Esterified Tapioca Starches. *Starch‐Stärke*, *71* (*1-2*): 1800065.

Suh, J. H., Ock, S. Y., Park, G. D., Lee, M. H. & Park, H. J. (2020). Effect of moisture content on the heat-sealing property of starch films from different botanical sources. *Polymer Testing*, *89* 106612.

Sujka, M. & Jamroz, J. (2013). Ultrasound-treated starch: SEM and TEM imaging, and functional behaviour. *Food Hydrocolloids*, *31* (*2*): 413-419.

Sukumar, A. & Athmaselvi, K. (2019). Optimization of process parameters for the development of finger millet based multigrain extruded snack food fortified with banana powder using RSM. *Journal of food science and technology*, *56* (*2*): 705-712.

Sun, J., He, R. M., Gao, F. Y., Kou, Z. L., Lan, L. H., Lan, P. & Liao, A. P. (2019). High‐Efficient Preparation of Cross‐Linked Cassava Starch by Microwave‐Ultrasound‐Assisted and its Physicochemical Properties. *Starch‐Stärke*, *71* (*7-8*): 1800273.

Sun, Q., Li, G., Dai, L., Ji, N. & Xiong, L. (2014). Green preparation and characterisation of waxy maize starch nanoparticles through enzymolysis and recrystallisation. *Food chemistry*, *162* 223-228.

Sun, S., Zhang, G. & Ma, C. (2016). Preparation, physicochemical characterization and application of acetylated lotus rhizome starches. *Carbohydrate polymers*, *135* 10-17.

Sundarraj, A. A. & Ranganathan, T. V. (2018). Extraction and functional properties of cellulose from jackfruit (Artocarpus integer) Waste. *Int J Pharm Sci Res 2018c*, *9* 1000-1008.

Sundarraj, A. A., Vasudevan, R. T. & Sriramulu, G. (2017). Optimized extraction and characterization of pectin from jackfruit (Artocarpus integer) wastes using response surface methodology. *International Journal of Biological Macromolecules*, Sundarraj, A. A., Vasudevan, R. T. & Sriramulu, G. (2018). Optimized extraction and characterization of pectin from jackfruit (Artocarpus integer) wastes using response surface methodology. *International journal of biological macromolecules*, *106* 698-703.

Swami, S. B., Thakor, N., Haldankar, P. & Kalse, S. (2012). Jackfruit and its many functional components as related to human health: a review. *Comprehensive Reviews in Food Science and Food Safety*, *11* (*6*): 565-576.

Sy Mohamad, S. F., Mohd Said, F., Abdul Munaim, M. S., Mohamad, S. W. & Sulaiman, W. M. A. (2019). Proximate composition, minerals contents, functional properties of Mastura variety jackfruit (Artocarpus heterophyllus) seeds and lethal effects of its crude extract on zebrafish (Danio rerio) embryos. *Food Research*, *3* (*5*): 546-555.

Syahariza, Z., Sar, S., Hasjim, J., Tizzotti, M. J. & Gilbert, R. G. (2013). The importance of amylose and amylopectin fine structures for starch digestibility in cooked rice grains. *Food chemistry*, *136* (*2*): 742-749.

Syahariza, Z. & Yong, H. (2017). Evaluation of rheological and textural properties of texture-modified rice porridge using tapioca and sago starch as thickener. *Journal of Food Measurement and Characterization*, *11* (*4*): 1586-1591.

Tao, K., Yu, W., Prakash, S. & Gilbert, R. G. (2019). High-amylose rice: Starch molecular structural features controlling cooked rice texture and preference. *Carbohydrate polymers*, *219* 251-260.

Teixeira, B. S., Garcia, R. H., Takinami, P. Y. & del Mastro, N. L. (2018). Comparison of gamma radiation effects on natural corn and potato starches and modified cassava starch. *Radiation Physics and Chemistry*, *142* 44-49.

Tessema, A. & Admassu, H. (2021). Extraction and characterization of starch from anchote (Coccinia abyssinica): physico-chemical, functional, morphological and crystalline properties. *Journal of Food Measurement and Characterization*, 1-15.

Thaiudom, S. & Pracham, S. (2018). The influence of rice protein content and mixed stabilizers on textural and rheological properties of jasmine rice pudding. *Food hydrocolloids*, *76* 204-215.

Thakur, R., Saberi, B., Pristijono, P., Stathopoulos, C. E., Golding, J. B., Scarlett, C. J., Bowyer, M. & Vuong, Q. V. (2017). Use of response surface methodology (RSM) to optimize pea starch–chitosan novel edible film formulation. *Journal of food science and technology*, *54* (*8*): 2270-2278.

Tongdang, T. (2008). Some properties of starch extracted from three Thai aromatic fruit seeds. *Starch-Stärke*, *60* (*3-4*): 199-207.

Tran, P. L., Nguyen, D. H. D., Do, V. H., Kim, Y.-L., Park, S., Yoo, S.-H., Lee, S. & Kim, Y.-R. (2015). Physicochemical properties of native and partially gelatinized high-amylose jackfruit (Artocarpus heterophyllus Lam.) seed starch. *LWT-Food Science and Technology*, *62* (*2*): 1091-1098.

Tunnarut, D. & Pongsawatmanit, R. (2017). Quality Enhancement of Tapioca Starch Gel using Sucrose and Xanthan Gum. *International journal of food engineering*, *13* (*8*):

Ulbrich, M., Bai, Y. & Flöter, E. (2020). The supporting effect of ultrasound on the acid hydrolysis of granular potato starch. *Carbohydrate polymers*, *230* 115633.

Ulloa, J. A., Villalobos Barbosa, M. C., Resendiz Vazquez, J. A., Rosas Ulloa, P., Ramírez Ramírez, J. C., Silva Carrillo, Y. & González Torres, L. (2017). Production, physico-chemical and functional characterization of a protein isolate from jackfruit (Artocarpus heterophyllus) seeds. *CyTA-Journal of Food*, *15* (*4*): 497-507.

Van Tri, M., Van Hoa, N., Chau, N. M., Pane, A. N., Faedda, R., De Patrizio, A., Schena, L., Olsson, C. H., Wright, S. A. & Ramstedt, M. (2015). Decline of jackfruit (Artocarpus heterophyllus) incited by Phytophthora palmivora in Vietnam. *Phytopathologia Mediterranea*, *54* (*2*): 275.

Vanier, N. L., Vamadevan, V., Bruni, G. P., Ferreira, C. D., Pinto, V. Z., Seetharaman, K., Zavareze, E. d. R., Elias, M. C. & Berrios, J. D. J. (2016). Extrusion of rice, bean and corn starches: Extrudate structure and molecular changes in amylose and amylopectin. *Journal of food science*, *81* (*12*): E2932-E2938.

Waghmare, R., Memon, N., Gat, Y., Gandhi, S., Kumar, V. & Panghal, A. (2019). Jackfruit seed: an accompaniment to functional foods. *Brazilian Journal of Food Technology*, *22*

Wang, H., Wang, Z., Li, X., Chen, L. & Zhang, B. (2017). Multi-scale structure, pasting and digestibility of heat moisture treated red adzuki bean starch. *International journal of biological macromolecules*, *102* 162-169.

Wang, K., Wang, W., Ye, R., Liu, A., Xiao, J., Liu, Y. & Zhao, Y. (2017). Mechanical properties and solubility in water of corn starch-collagen composite films: Effect of starch type and concentrations. *Food chemistry*, *216* 209-216.

Wang, S., Li, C., Copeland, L., Niu, Q. & Wang, S. (2015). Starch retrogradation: A comprehensive review. *Comprehensive Reviews in Food Science and Food Safety*, *14* (*5*): 568-585.

Wang, W., Zhou, H., Yang, H., Zhao, S., Liu, Y. & Liu, R. (2017). Effects of salts on the gelatinization and retrogradation properties of maize starch and waxy maize starch. *Food Chemistry*, *214* 319-327.

Wang, X., Appels, R., Zhang, X., Diepeveen, D., Torok, K., Tomoskozi, S., Bekes, F., Ma, W., Sharp, P. & Islam, S. (2017). Protein interactions during flour mixing using wheat flour with altered starch. *Food chemistry*, *231* 247-257.

Wang, X., Ma, Z., Li, X., Liu, L., Yin, X., Zhang, K., Liu, Y. & Hu, X. (2018). Food additives and technologies used in Chinese traditional staple foods. *Chemical and Biological Technologies in Agriculture*, *5* (*1*): 1.

Warren, F. J., Gidley, M. J. & Flanagan, B. M. (2016). Infrared spectroscopy as a tool to characterise starch ordered structure—a joint FTIR–ATR, NMR, XRD and DSC study. *Carbohydrate polymers*, *139* 35-42.

Waterschoot, J., Gomand, S. V., Willebrords, J. K., Fierens, E. & Delcour, J. A. (2014). Pasting properties of blends of potato, rice and maize starches. *Food hydrocolloids*, *41* 298-308.

Whitney, K., Reuhs, B. L., Martinez, M. O. & Simsek, S. (2016). Analysis of octenylsuccinate rice and tapioca starches: Distribution of octenylsuccinic anhydride groups in starch granules. *Food chemistry*, *211* 608-615.

Wong, C. W. & Tan, H. H. (2017). Production of spray-dried honey jackfruit (Artocarpus heterophyllus) powder from enzymatic liquefied puree. *Journal of Food Science and Technology*, *54* (*2*): 564-571.

Xia, T., Gou, M., Zhang, G., Li, W. & Jiang, H. (2018). Physical and structural properties of potato starch modified by dielectric treatment with different moisture content. *International journal of biological macromolecules*, *118* 1455-1462.

Xian, L., Shariffa, N. & Azwan, M. (2020). Modified tuber starches as potential stabilizer for food-grade Pickering emulsions. *Food Research*, *4* (*3*): 753-763.

Yadav, K., Yadav, B. S., Yadav, R. B. & Dangi, N. (2018). Physicochemical, pasting and rheological properties of colocasia starch as influenced by the addition of guar gum and xanthan gum. *Journal of Food Measurement and Characterization*, *12* (*4*): 2666-2676.

Yadav, S., Mishra, S. & Pradhan, R. C. (2021). Ultrasound-assisted hydration of finger millet (Eleusine Coracana) and its effects on starch isolates and antinutrients. *Ultrasonics Sonochemistry*, *73* 105542.

Yang, Q.-Y., Lu, X.-X., Chen, Y.-Z., Luo, Z.-G. & Xiao, Z.-G. (2019). Fine structure, crystalline and physicochemical properties of waxy corn starch treated by ultrasound irradiation. *Ultrasonics sonochemistry*, *51* 350-358.

Yang, W., Kong, X., Zheng, Y., Sun, W., Chen, S., Liu, D., Zhang, H., Fang, H., Tian, J. & Ye, X. (2019). Controlled ultrasound treatments modify the morphology and physical properties of rice starch rather than the fine structure. *Ultrasonics sonochemistry*, *59* 104709.

Yazid, N.-S. M., Zulkifli, M. F., Ismail, W. I. W. & Siva, R. (2019). Chlorogenic acid from banana and papaya peels inhibit lipid accumulation in 3T3-L1 cells. *Malaysian Journal of Fundamental and Applied Sciences*, *15* (*4*): 561-565.

Yazid, N. S. M., Abdullah, N., Muhammad, N. & Matias-Peralta, H. M. (2018). Application of Starch and Starch-Based Products in Food Industry. *Journal of Science and Technology*, *10* (*2*): 144-174.

Yin, H., Zheng, P., Zhang, E., Rao, J., Lin, Q., Fan, M., Zhu, Z., Zeng, Q. & Chen, N. (2020). Improved wet shear strength in eco-friendly starch-cellulosic adhesives for woody composites. *Carbohydrate Polymers*, *250* 116884.

You, Q., Zhang, X., Fang, X., Yin, X., Luo, C. & Wan, M. (2019). Ultrasonic-Assisted Preparation and Characterization of RS3 from Pea Starch. *Food and Bioprocess Technology*, 1-6.

Yu, S., Zhang, Y., Ge, Y., Zhang, Y., Sun, T., Jiao, Y. & Zheng, X. Q. (2013). Effects of ultrasound processing on the thermal and retrogradation properties of nonwaxy rice starch. *Journal of Food Process Engineering*, *36* (*6*): 793-802.

Yu, W., Tan, X., Zou, W., Hu, Z., Fox, G. P., Gidley, M. J. & Gilbert, R. G. (2017). Relationships between protein content, starch molecular structure and grain size in barley. *Carbohydrate polymers*, *155* 271-279.

Yu, Z., Wang, Y.-S., Chen, H.-H., Li, Q.-Q. & Wang, Q. (2018). The gelatinization and retrogradation properties of wheat starch with the addition of stearic acid and sodium alginate. *Food Hydrocolloids*, *81* 77-86.

Zailani, M. A., Kamilah, H., Husaini, A. & Sarbini, S. R. (2021). Physicochemical properties of microwave heated sago (Metroxylon sagu) starch. *CyTA-Journal of Food*, *19* (*1*): 596-605.

Zambelli, R. A., Galvão, A. M. M. T., de Mendonça, L. G., de Souza Leão, M. V., Carneiro, S. V., Lima, A. C. S. & Melo, C. A. L. (2018). Effect of Different Levels of Acetic, Citric and Lactic Acid in the Cassava Starch Modification on Physical, Rheological, Thermal and Microstructural Properties. *Food Science and Technology Research*, *24* (*4*): 747-754.

Zarski, A., Ptak, S., Siemion, P. & Kapusniak, J. (2016). Esterification of potato starch by a biocatalysed reaction in an ionic liquid. *Carbohydrate polymers*, *137* 657-663.

Zhang, C., Lim, S.-T. & Chung, H.-J. (2019). Physical modification of potato starch using mild heating and freezing with minor addition of gums. *Food Hydrocolloids*, *94* 294-303.

Zhang, H., Li, M., Li, K. & Zhu, C. (2018). Effect of ultrasound pretreatment on physicochemical properties of corn starch. 2018 8th International Conference on Manufacturing Science and Engineering (ICMSE 2018), Atlantis Press.

Zhang, Y., Hu, M., Zhu, K., Wu, G. & Tan, L. (2018). Functional properties and utilization of Artocarpus heterophyllus Lam seed starch from new species in China. *International journal of biological macromolecules*, *107* 1395-1405.

Zhang, Y., Zhang, Y., Li, B., Wang, X., Xu, F., Zhu, K., Tan, L., Dong, W., Chu, Z. & Li, S. (2019). In vitro hydrolysis and estimated glycemic index of jackfruit seed starch prepared by improved extrusion cooking technology. *International journal of biological macromolecules*, *121* 1109-1117.

Zhang, Y., Zhang, Y., Xu, F., Li, S. & Tan, L. (2018). Structural characterization of starches from Chinese jackfruit seeds (Artocarpus heterophyllus Lam). *Food hydrocolloids*, *80* 141-148.

Zhang, Y., Zhang, Y., Xu, F., Wu, G. & Tan, L. (2017). Molecular structure of starch isolated from jackfruit and its relationship with physicochemical properties. *Scientific reports*, *7* (*1*): 13423.

Zhang, Y., Zhang, Y., Xu, F., Wu, G. & Tan, L. (2017). Molecular structure of starch isolated from jackfruit and its relationship with physicochemical properties. *Scientific Reports, 7* (*1*): 1-12.

Zhao, B., Sun, S., Lin, H., Chen, L., Qin, S., Wu, W., Zheng, B. & Guo, Z. (2019). Physicochemical properties and digestion of the lotus seed starch-green tea polyphenol complex under ultrasound-microwave synergistic interaction. *Ultrasonics sonochemistry*, *52* 50-61.

Zhao, Y., Jiang, Y., Zheng, B., Zhuang, W., Zheng, Y. & Tian, Y. (2017). Influence of microwave vacuum drying on glass transition temperature, gelatinization temperature, physical and chemical qualities of lotus seeds. *Food chemistry*, *228* 167-176.

Zhu, F. (2015). Impact of ultrasound on structure, physicochemical properties, modifications, and applications of starch. *Trends in Food Science & Technology*, *43* (*1*): 1-17.

Zhu, F. & Li, H. (2019). Modification of quinoa flour functionality using ultrasound. *Ultrasonics sonochemistry*, *52* 305-310.

Zou, Y. & Jiang, A. (2016). Effect of ultrasound treatment on quality and microbial load of carrot juice. *Food Science and Technology*, *36* (*1*): 111-115.

Zuo, Y. Y. J., Hébraud, P., Hemar, Y. & Ashokkumar, M. (2012). Quantification of high-power ultrasound induced damage on potato starch granules using light microscopy. *Ultrasonics Sonochemistry*, *19* (*3*): 421-426.

Zuwariah, I., Fadilah, N., Hadijah, H. & Rodhiah, R. (2018). Comparison of amino acid and chemical composition of jackfruit seed flour treatment. *Food Research*, *2* (*6*): 539-545.

Zuwariah, I., Noor, F., Hadijah, M. & Rodhiah, R. (2018). Comparison of amino acid and chemical composition of jackfruit seed flour treatment. *Food Research*, *2* (*6*): 539-545.

VITA

The author was born on March 30, 1993, in Muar, Johor, Malaysia. She received her first formal education at a primary school known as Sekolah Kebangsaan Bandar Maharani, Muar and followed by het secondary education at Sekolah Menengah Kebangsaan Agama Maahad Muar, Johor. She then went for Foundation in Science at Centre of Foundation Studies (UiTM) Puncak Alam, Selangor and later pursued her first degree in Food Science and Technology at UiTM Shah Alam, Selangor. She previously had undergone her practical training at Mae Fah Luang University, Chiang Rai Province in Thailand. She graduated with first-class honours from Universiti Teknologi Mara (UiTM) Shah Alam and is currently pursuing a Master of Science (MSc.) at Faculty of Applied Sciences and Technology (FAST), Universiti Tun Hussein Onn (UTHM) Pagoh Campus, Muar, Johor under the supervision of Ts. Dr. Norazlin Abdullah. She had orally presented her research at three different conferences, starting with the International Food Research Conference (IFRC 2017) during her first semester of postgraduate study. The second seminar attended and orally presented was during Sciemathic 2017 at Shared Facilities of Pagoh Education Hub in Pagoh, Johor. Her review paper presented during Sciemathic 2017 was selected for publication under the Journal of Science and Technology, UTHM. Her third paper was presented during the International Conference on Biodiversity (ICB 2018) at Shared Facilities of Pagoh Education Hub in Pagoh, Johor. She has authored one scientific review paper and two conference proceedings in the area of starch. She has also joined MIFT 11th National Food Science and Technology Competition under the category of Postgraduate Research Paper - Oral Competition on April 6th - 7th, 2019 at Universiti Tunku Abdul Rahman (UTAR), Kampar, Perak.