EFFECT OF FOAMING AGENTS ON DRYING CHARACTERISTICS AND PHYSICOCHEMICAL PROPERTIES OF FOAM MAT DRIED JACKFRUIT POWDER

By

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Although jackfruit (*Artocarpus heterophyllus*) is highly nutritious fruit yet it is easily perishable and has limited shelf life in nature. In spite of vast potential and usefulness, jackfruit remain as an underutilized fruit. A gap in the marketing of jackfruits and its processed value-added products can be fully explored in order to gain additional attention from food technology and security. The aims of this study are to determine the effect of different types and concentration of foaming agents on drying characteristics of foam mat drying jackfruit and to evaluate the effect of foam mat drying process variables on the physicochemical properties of foam mat dried jackfruit powder using various foaming agents, namely maltodextrin (5 to 20 %), methylcellulose (5 to 20 %) and gum arabic (0.5 to 2.0 %) at constant temperature (50°C) and thickness (3 mm) were conducted. The results showed that the drying characteristic of foam mat dried jackfruit was best fitted to the Page model as high correlation $R^2 > 0.88$ was obtained. The results showed foaming agents were significantly factor that affect the physical properties, phytochemical content and antioxidant. In general, increased concentration of foaming agents reduced the foam density, moisture content, water activity, water absorption index, but increased color, water solubility index, flowability and bioactive compound. Rapid drying rate was observed when high foam expansion and low foam density was achieved subsequently resulting in reduction of drying time by increasing concentration of foaming agents. Shorter the drying time, higher the retention of bioactive properties in jackfruit powder. The optimum powder was formulated with 15% of gum arabic was recommended to provide superior flowability characteristic and excellent retention of phenolic, flavonoid and carotenoid in production of foam mat dried jackfruit powder. This contribution can be applied in future food product development such as ice cream, functional food and confectionery products.

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sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN AGEN PEMBUIH KE ATAS CIRI PENGERINGAN DAN SIFAT FIZIKOKIMIA SERBUK BUAH NANGKA SECARA PENGERINGAN BUIH

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Walaupun nangka (Artocarpus heterophyllus) adalah buah yang sangat berkhasiat namun ia mudah binasa dan mempunyai jangka hayat yang terhad. Biarpun terdapat banyak potensi dan kegunaan, nangka tetap menjadi buah yang kurang digunakan. Terdapat jurang dalam pemasaran nangka dan produk bernilai tambahnya yang diproses yang boleh dijelajahi sepenuhnya untuk mendapatkan perhatian tambahan dari segi teknologi makanan dan keselamatan. Tujuan kajian ini adalah (i) untuk menentukan kesan pelbagai jenis dan kepekatan agen berbuih terhadap ciri pengeringan Nangka secara pembuihan dan (ii) untuk menilai kesan pemboleh ubah proses pengeringan secara pembuihan terhadap sifat fizikokimia serbuk nangka dengan menggunakan pelbagai agen berbuih, iaitu maltodekstrin (5 hingga 20%), metilselulosa (0.5 hingga 2.0%) dan Gam Arab (5 hingga 20%) pada suhu tetap (50°C) dan ketebalan (3 mm) telah dijalankan. Hasil kajian menunjukkan bahawa ciri pengeringan nangka secara pembuihan ini sesuai dengan model Page kerana korelasi tinggi R^2> 0.88 diperoleh. Serbuk yang dihasilkan diteliti untuk sifat fisiokimia, kandungan fitokimia dan keupayaan antioksidan. Hasil kajian menunjukkan bahawa agen pembuih merupakan faktor yang penting untuk sifat fizikal, kandungan fisiokimia dan keupayaan antioksidan. Secara amnya, peningkatan kepekatan agen berbuih mengurangkan kepadatan buih, kandungan kelembapan, aktiviti air, indeks penyerapan air, tetapi peningkatan warna, indeks kelarutan air, kebolehaliran dan sebatian bioaktif. Kadar pengeringan yang cepat diperhatikan apabila pengembangan buih yang tinggi dan kepadatan buih yang rendah dicapai mengakibatkan pengurangan masa pengeringan dengan meningkatkan kepekatan agen pembuih. Semakin pendek masa pengeringan, semakin tinggi pengekalan sifat bioaktif dalam serbuk nangka. Serbuk optimum diformulasikan dengan 15% gam Arab disyorkan untuk memberikan ciri aliran yang unggul dan pengekalan fenolik, flavonoid dan karotenoid yang sangat baik dalam pengeluaran serbuk nangka secara pengeringan buih. Sumbangan ini dapat diaplikasi

dalam pembangunan produk makanan berasaskan buah durian belanda seperti ais krim, makanan berfungsi dan produk gula-gula.

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LIST OF ABBREVIATIONS

%	Percentage
°C	Degree Celcius
°	Degree
µL	Microlitre
µm	micrometer
a*	Degree of redness or greenness
AOAC	Association of Official Analytical Chemists
A_w	Water activity
b*	Degree of yellowness or blueness
cm	Centimeter
EtOH	Ethanol aqueous
g	Gram
GA	Gum arabic
GAE	Gallic acid equivalent
h	Hour / Hours
kj	Kilojoule
K	Consistency coefficient
L*	Degree of lightness
MD	Maltodextrin
MC	Methylcellulose
mg	Miligram
mL	Mililitre
mm	Milimeter

min	Minute /minutes
QE	Quercetin equivalent
mol	Mole
R^2	Coefficient of determination
Rpm	Revolutions per minutes
TSS	Total soluble solid
TCC	Total carotenoid content
TFC	Total flavonoid content
TPC	Total phenolic content
WAI	Water absorption index
WSI	Water solubility index
w/w	Weight per weight

CHAPTER 1

INTRODUCTION

1.1 Research background

Jackfruit is locally named as 'nangka' and scientifically named as *Artocarpus heterophyllus* Lam. It is a member of Moraceace family (Antherton, 2011; Rosnah, Chia, Chin, Noraziah, & Osman, 2009). Jackfruit has been listed as one of the premium commercial agro-fruits under a project name Entry Point Project 7 (EPP 7) implemented by Government of Malaysia. The National Key Economic Areas (NKEA) revealed that jackfruit has been recognized as an important element in economic activities that directly and potentially contributes toward the Malaysia economic growth that indicated by Malaysia Gross Income (NGI) index (Abidin et al., 2020). Jackfruit is actively cultivated in few districts, such as Temerloh, Lanchang, Raub (Pahang), Kota Tinggi and Segamat (Johor), Kedah and Perak, Malaysia. These interest and attention in jackfruit have allowed it to be one of the popular commercial crops in Malaysia. Therefore, jackfruit is most likely to be consumed in fresh during season, while converted to value-added product in the market during off-season in Malaysia.

Despite of jackfruit is a seasonal fruits but it is plentiful available during season (April to September and November to December) (Gupta, Mann, Sood, & Gupta, 2011). According to Department of Agriculture (DOA) had successfully registered 30 jackfruit clones and more. All clones are mainly grown and supported by local farmers (independent famers and contract farmers). Two cultivars highly recommended by DOA to local farmers which are Tekam Yellow clone and Mastura clone by providing professional replanting assistance by replanting fruit farms with non-productive varieties and non-commercial species trees with high commercial value varieties. Among these varieties, Tekam Yellow or Honey Jackfruit has the most consumer preferences for domestic and export market. However, farmers prefer the new variety with lesser latex clone than big sized fruit clone (Anem, 2010). Those high-quality varieties were given priority and recommended to the current market of Malaysia.

Production of jackfruit in Asia is averagely estimated around 3.7 million tonnes in 2015 to 2017 (Altendorf, 2018). While average output of jackfruit in Bangladesh, India and Indonesia was approximately 1 million tonnes, 1.8 million tonnes and around 7 million tonnes, respectively (Altendorf, 2018). In Malaysia, there is 4,261 ha of plantation area to contribue 23,275 metric tons (worth RM 55,344,266 value) of jackfruit production in year 2011 (Rahman & Rahim, 2017). In the past, jackfruit from Malaysia mainly exported to United Kingdom, Hong Kong, Netherland and Singapore (Baiti, Aziz, Milan, & Razali, 2016). Indicators of self-sufficiency ratio (SSR) revealed that selected agricultural crops are adequate to meet domestic

demands, while import dependency ratio (IDR) indicates the selected agricultural commodities are sufficient to meet the export market requirements. In 2013 and 2014, production of jackfruit recorded more than 100 % of SSR and IDR values in Malaysia. Both indicators are crucial in determining sufficiency of fruit crops in supply chain (Anonymous, 2015).

Overall acceptance of customer towards jackfruits are positive due to its unique taste, pleasant aroma and high nutritional attributes. Jackfruit can be consumed raw as fruits (ripen) or cooked as vegetables (unripen). Nevertheless, fresh jackfruit is highly perishable in nature and susceptible for spoilage by bacteria, molds and yeasts due to the high moisture content. During season, the fruits are harvested abundantly which lead to quality deteriorate such as excessive softening, flavor degradation, color changes and reducing sugar content. Despite of proper postharvest handling and storage technique, jackfruit shelf life still limited up to fortnight (Pua, Hamid, Rusul, & Rahman, 2007).

To overcome these quality degradations, drying is the most suitable method to preserve the fruits by inhibiting the microbial growth and hindering the quality degradation to prolong the shelf life. Several jackfruit value-added products, for instances jack wine, jackfruit candy and jackfruit pickle were famous in Bangladesh, Philippine, Indonesia and Vietnam. However, jackfruit chips and jackfruit jam were available in local market nowadays. In jackfruit industry, storage of jackfruit in whole fruit form was a thorny challenge among fruit farmers and distributors as it was impractical and requires bulk storage spaces. Extensive care is necessary during harvesting techniques and handling processes of fresh fruits to reduce the bruise damage.

Fruit powder consumption is widely diversified in any culinary process, such as snacks, bakery, beverage, pasta, jelly and ice cream. Since powdery products are lower in storage space and longer shelf life, thus there are easier to be transport, package and store. Jackfruit powder was successfully produced using drum drying and spray drying technology (Pua et al., 2007, 2010; Wong, Leow, Lim, & Siew, 2020). However, there were some limitations in these previous studies. Drum-dried jackfruit powder tended to have slightly higher moisture content (5.71 to 8.10%), powder containing both emulsifiers at highest concentration had alter the original fruit flavor and flowability of the powder was not determined. Besides, in order to produce spray-dried jackfruit powder, a high ratio of maltodextrin (DE 10-12) was incorporated to jackfruit puree (1:1). However, maximum limit of food additives to food in food processing was 50% stated by Food Regulations 1985. Flowability of spray-dried jackfruit powder were in fair degrees but reduced to very poor degrees after seven weeks of storage study. β-carotene is a major pigment that manipulating the golden yellowish color in jackfruit and it is extremely sensitive to ambient heat and light (Pua et al., 2010). Thus, selection of thermal treatment towards jackfruit is very challenging as Maillard reaction and caramelization can take place effortlessly during drying process. These research gaps were solved by foam mat drying

technology as it is the most appropriate method for dehydration of any high sugar content, heat labile, sticky and viscous sample products.

1.2 Problem statement

Jackfruit is a high sugar content (glucose, fructose and sucrose) fruit with limited shelf life (Pua et al., 2010). During peak season, jackfruit is harvested in bulk volume. Due to poor transportation network and post-harvest handling skills, the fruits are consequently undergoing rapid quality degradation. Fruits that changing from yellow to brownish yellow (rusting) are inedible and not visually accepted to consumers as such fruits are not marketable (Roseli et al., 2014). The foremost features that affect the fruit appearance are principally size of the fruit while taste is the most crucial aspect of fruit quality (Baiti et al., 2016). To ensure jackfruit is available year-round in Malaysia, fresh jackfruit must be transformed into shelf stable product. while drying is one of the most practical alternatives in post-harvest technology. However, jackfruit is high in moisture content and consists numerous bioactive and volatile compounds which are sensitive to high thermal treatment, such as spraying drying and microwave drying. Gentle temperature and short time were carried out throughout the entire foam mat drying process.

Moreover, choosing the suitable foaming agents are very crucial in to achieve optimum foam mat drying process since it can directly influence the overall quality (physicochemical and phytochemical content) of final products. There are various types of additives applied in food processing industries and markets. However, to the best of our knowledge, no research has yet been reported on effect of different types and concentration of foaming agents on jackfruit powder using foam mat drying method.

1.3 Research objectives

The research aims to produce high quality foam mat dried jackfruit with appropriate types and concentration of foaming agents. To achieve the aim, several objectives were stated as following:

a) To determine the effect of different types and concentration of foaming agents on foam properties and drying characteristics of foam mat drying jackfruit.
b) To evaluate the effect of foam mat drying process variables on the physicochemical properties of foam mat dried jackfruit powder.

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