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# Storage stability of jackfruit (*Artocarpus heterophyllus*) powder packaged in aluminium laminated polyethylene and metallized co-extruded biaxially oriented polypropylene during storage

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ABSTRACT

Total colour difference ($\Delta E$), rates of adsorbed moisture and sensory attributes of drum-dried jackfruit powder packaged in aluminium laminated polyethylene (ALP) and metallized co-extruded biaxially oriented polypropylene (BOPP/MCPP) pouches stored at accelerated storage (38 °C, with 50%, 75% and 90% relative humidity (RH)) were determined over 12 weeks period. The changes in total colour followed zero order reaction kinetics. Packaging materials, storage temperature and RH values significantly ($p < 0.05$) influenced the rates of adsorbed moisture of jackfruit powder. There was a significant ($p < 0.05$) decrease in the intensities of the fruity odour, taste and increase in the lumpiness of the jackfruit powder stored at 38 °C with 90% RH. The shelf life of jackfruit powder stored at 38 °C and 90% RH was limited by overall acceptability and the intensity of fruity odour, taste and lumpiness at week 8 of storage. Jackfruit powder stored at 28 °C remained stable and acceptable throughout the storage period for all RH values. The powder packaged in ALP significantly ($p < 0.05$) reduced total colour change, rates of adsorbed moisture, lumpiness intensity of jackfruit powder and was rated higher in terms of overall acceptability over BOPP/MCPP. Results of this study suggested that ALP packaging with storage conditions of 28 °C and RH less than 75% was better suited for keeping jackfruit powder.



## 1. Introduction

The genus *Artocarpus* comprises about 50 species of evergreen and deciduous trees belonging to the Moraceae family. The jackfruit (*Artocarpus heterophyllus*) is indigenous to the rain forests of the Western Ghats of India. It then spread on to other parts of India, Southeast Asia, the East Indies and ultimately the Philippines. It is often planted in central and eastern Africa and is fairly popular in Brazil and Surinam. Jackfruit is also called jak, jaca, and, in Malaysia and the Philippines, *nangka*; in Thailand, *khanun*; in Cambodia, *khnor*; in Laos, *mak mi* or *may mi*; in Vietnam, *mit*. The jackfruit can be eaten raw, salted as a pickle, cooked or as a sweet (Morton, 1987; Vaughan and Geissler, 1997).

Dehydrated fruits and vegetables are used either as food products or as industrial ingredients in the processing of various foods, such as bakery products, soups, instant fruit powders, etc. According to Jaya and Das (2005), powdered dehydrated products require protection against ingress of moisture, oxygen and the loss of volatile flavourings and colour. During storage and distribution, foods are exposed to a wide range of environmental conditions such as temperature, humidity, oxygen, and light that can trigger several reaction mechanisms leading to food degradation. As a consequence, foods may be altered to such an extent that they are either rejected by the consumer or they may become harmful to the person consuming them.

According to Brown and Williams (2003), shelf life testing is carried out by holding representative samples of the final product under conditions likely to mimic those that the product will encounter from manufacturer to consumption. It is a complex concept that is dependent on the nature of food product under consideration, the preservation technologies applied, and the environmental conditions to which the food product is exposed. Potter (1978) reported that accelerated storage involving high humidity and temperature such as 90% relative humidity (RH) and 38 ± 2 °C can be used for developing moisture ingress and storage time relationships quickly.

Storage studies on mango powder have been reported extensively by some researchers. Kumar and Mishra (2004) investigated the stability of mango soy fortified yoghurt powder in aluminium laminated polyethylene (ALP) and high-density polypropylene

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(HDPP) pouches under accelerated storage conditions (38 ± 1 °C, 90% RH). Hymavathi and Khader (2005) reported on the nutrient and physicochemical changes of mango powders kept in metallized polyester/polyethylene and polyester poly pouches. Jaya and Das (2005) predicted the shelf life of mango powder packaged in aluminium foil-laminated pouches stored under an accelerated storage environment (38 ± 2 °C and 90% RH).

In this study, jackfruit powder was produced by adding soy lecithin and gum arabic to the fruit pulp followed by drying of the mixture in a double drum dryer. The present study was carried out to study the stability of jackfruit powder produced packaged with aluminium laminated polyethylene (ALP) and metallized co-extruded biaxially oriented polypropylene (BOPP/MCPP) pouches, during storage (38 °C with 50%, 75% and 90% RH) over a 12 week period.

## 2. Materials and methods

### 2.1. Preparation of jackfruit powder

The jackfruit powder was prepared according to the method of Pua et al. (2007). A blend of jackfruit pulp, soy lecithin, gum arabic and 40% w/v filtered water was formulated. Soy lecithin (Centrol 3F-UB standard grade lecithin) and gum arabic (instant gum AS IRX 40830, CNI) were incorporated at 2.65% and 10.28%, respectively. Then the mixture was blended using a 4L Waring blender for 30 s low speed and 60 s at high speed.

The jackfruit powder was prepared using a double drum dryer (R. Simon (Dryers) Ltd. Nottingham England, Universal Test Machine 304.8 mm × 203.2 mm). The jackfruit puree was drum-dried under the drying conditions of 336 kPa steam pressure, 1.2 rpm rotation speed of drum, 0.25 mm drum clearance and 100 mm pool level. The jackfruit flake obtained was then ground in a heavy-duty analytical mill (IKA M20, Germany) for 20 s and the jackfruit powder was then stored in either ALP or BOPP/MCPP pouches.

### 2.2. Packaging materials

Two flexible packaging materials: (I) aluminium laminated polyethylene (ALP) made from 12 μm polyethylene terephthalate (PET) and 70 μm linear low density polyethylene (LLDPE) laminated with 7 μm aluminium purchased from Infra Plastics Sdn. Bhd. (Selangor, Malaysia); and (II) Metallized co-extruded biaxially oriented polypropylene (BOPP/MCPP) made from 20 μm biaxially oriented polypropylene laminated with 35 μm metallized cast polypropylene film (MCPP) obtained from Packaging Research Centre Sdn. Bhd. (Selangor, Malaysia) were selected. Unit pouches of the packaging material measuring 10 cm × 15 cm were made for holding 80 g of the jackfruit powder.

### 2.3. Assessment of stability of jackfruit powder

The jackfruit powder (80 g) packed in ALP and BOPP/MCPP pouches were heat sealed using a pulse sealer with minimum possible air space remaining in the leak-proof packets. Twelve desiccators (30 cm) with three different relative humidity (RH) levels (50 ± 2%, 75 ± 2%, and 90 ± 2% RH) were prepared using saturated salt solutions of magnesium nitrate ($Mg(NO_3)_2$), sodium chloride (NaCl), and potassium nitrate ($KNO_3$). Eight pouches from each packaging material were stored in each desiccator. The desiccators were placed in two incubators maintained thermostatically at 28 ± 2 and 38 ± 2 °C under dark conditions. Each incubator contained two desiccators from each RH level. Evaluation of moisture content and Hunter *L, a, b* values were carried out at 0, 1, 2, 3, 4, 6, 8, and 12 weeks intervals. Each determination was replicated.

### 2.4. Colour measurement

The colour of dried jackfruit powder was measured using a spectrocolorimeter (HunterLab UltraScan Sphere Spectrocolorimeter version 1.4, HunterLab 11491 Sunset Hills Road, Reston, VA 22090). A sample was homogenized and placed in a polypropylene (PP) bag for colour measurement. The *L, a, b* values of the jackfruit powder were measured. Total colour difference ($\Delta E$) of jackfruit powder between initial and during storage was calculated using the following equation:

$$\Delta E = \sqrt{(L_i - L_r)^2 + (a_i - a_r)^2 + (b_i - b_r)^2} \quad (1)$$

where $L_i$, $a_i$, and $b_i$ are the initial *L, a,* and *b* values for the jackfruit powder and $L_r$, $a_r$, and $b_r$ are the corresponding values for stored jackfruit powder.

### 2.5. Kinetics of total colour change during storage

According to Singh (2000), most reactions that showed loss in food quality may be described by zero or first order. In order to determine the reaction order of a quality attribute, the experimental data obtained was fitted to a linear equation. The concentration of a quality attribute [*Q*] measured at different times of storage versus time was plotted and data obtained was made to fit a linear equation. If the [*Q*] versus time data showed a good fit to a linear equation, then the data indicated a zero order reaction. On the other hand, if the ln[*Q*] versus time fits a linear equation, then the reaction is considered to be of first order. Changes in total colour difference value of jackfruit powder as a result of storage conditions was investigated using either zero or first order kinetics as shown in Eqs. (2) and (3), respectively,

$$C = C_0 \pm k_0 t \quad (2)$$

$$\ln C = \ln C_0 \pm k_1 t \quad (3)$$

where *C* is the measured total colour difference value, $C_0$ is the initial *C*, *t* is the storage time, $k_0$ is the reaction rate constant for the zero order model and $k_1$ is the reaction rate constant for the first order model. The symbols, (+) and (−) indicated formation and degradation of quality parameters, respectively.

### 2.6. Moisture content

The moisture content of jackfruit powder was determined by using the volumetric Karl Fischer titration method. A Karl Fisher titrator (701 KF Titrino, Metrohm Ltd, CH-9101 Herisau, Switzerland) together with Hydranal®-Composite 5 as the titrant was used. A mixture of dried methanol and formamide at a ratio of 1:1 was used as solvent/working medium. During titration, a jacketed vessel circulated with warm water was maintained at 50 °C in order to promote the solubility of jackfruit powder in the working medium. Approximately 500 mg of jackfruit powder was weighed and introduced into the jacketed vessel. Sample was stirred using a magnetic stirrer (703 Ti Stand, Metrohm Ltd, CH-9101 Herisau, Switzerland) at speed 4 for 8 min before the titration.

### 2.7. Sensory evaluation

Eight panellists were selected and trained based on ISO: 8586-2 (1994) procedures. Jackfruit powder was analyzed for sensory qualities during storage by eight trained panellists for fruity odour, fruity taste, and lumpiness using descriptive quantitative analysis (QDA). Approximately 4 g of sample was served in plastic cups, coded with three digits chosen at random. Panellists were required to rate on a 10-point intensity scale anchored at the two ends of the scale. For fruity odour and taste intensities, the anchor words