CHAPTER 1

INTRODUCTION

1.1 Research background

Agriculture solid waste has become a concern nowadays due to its growing amount resulting from the increased agricultural production, arising from the need to feed the ever-expanding human population. Unfortunately, waste is poorly managed in many developing countries as little is known about its potential benefits and possibilities if properly managed. In Malaysia, there are around 2,776 hectares of sweet potato (*Ipomoea batatas* L.) plantation area in 2022 (Department of Agriculture Malaysia, 2023). A cycle of sweet potato plantation is repeated 3 times a year on the same piece of land. Figure 1.1 below shows the haulm of sweet potato plant.

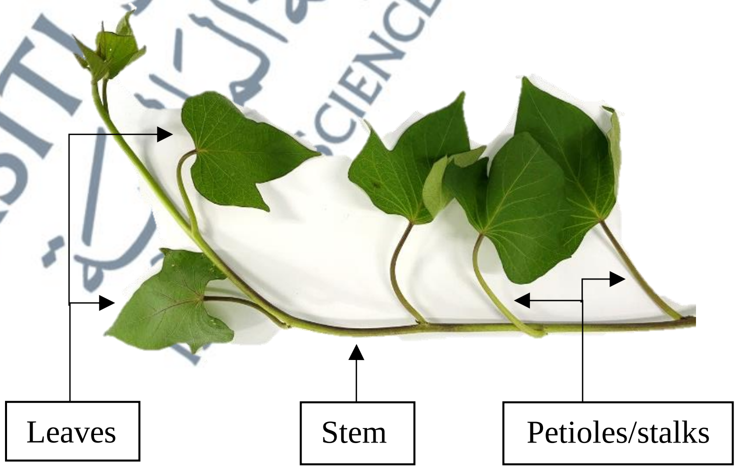

Figure 1.1: Sweet potato haulm

The sweet potato haulms (SPH) contain stalks and leaves with a high content of protein, phenolic compounds, antioxidant activity, ascorbic acid, and tocopherol (Suárez et al., 2020; Zhang et al., 2019). Despite its plenty amount, SPH is only used to feed livestock, returned directly to the soil, mulched, or burnt (Zhang et al., 2019). This agricultural solid waste can be utilised as an alternate source for the production of different products in various research and industry.

Chloroplasts are organelles in the leaves of plants where most of the valuable nutrients, vitamins, pigments, fatty acids, and amino acids are synthesised. Isolating the organelles as a chloroplast-rich fraction (CRF) is potentially rich in essential micronutrients for human or animal consumption. Chloroplast liberated from its cell wall is expected to increase the accessibility and availability of lipophilic nutrients from plant (Gedi et al., 2019; Syamila, 2019). SPH could be a great source to start this study in Malaysia, due to its availability, high moisture content that helps efficient juicing and can be grown throughout the year. Presently, very limited scientific projects examine CRF's nutritional and antinutritional properties of green biomass. To date, no CRF derived from SPH has been studied.

Vitamins A, D, E, and K as well as carotenoids found in chloroplasts are lipophilic nutrients. Limited bioaccessibility of lipophilic nutrients for body uptake was reported in unheat-treated CRF derived from spinach compared to blanched CRF (Syamila, 2019; Wattanakul et al., 2019). Hence, downstream processing involving heat treatments is proposed to remove or weaken the envelope of chloroplast. The removal of the cell wall is expected to increase its nutrient bioaccessibility. There is no data available on the bioaccessibility of CRF’s nutrients derived from SPH. It is expected that the CRF derived from SPH could be an innovative ingredient that will enable research scientists and product developers to introduce a variety of plant-based products, following the current trend to go green, healthy eating and only consume plant-based products. This year-round source of green biomass should not be neglected and must be valued as an ample source of essential nutrients.

Partial replacement of fish meal with a CRF from spinach shows positive growth in Zebrafish (Gedi et al., 2019). There are suggestions to enrich the food with chloroplast as it contains bioactive compounds like pro-vitamin A (β-carotene) and vitamin E (α- tocopherol), and its thylakoid is found to have a health-promoting effect. Furthermore, there is interest in the impact of thylakoid membranes on the digestive process. Thylakoid membrane possesses a satiety-promoting effect by inducing cholecystokinin, leptin, and enterostatin while reducing the hunger peptide, ghrelin (Montelius et al., 2014; Rayner et al., 2011). The research on the CRF of pea vine haulm and spinach has shown that the galactolipids in the CRF are well digested by the pancreatic enzymes (Wattanakul et al., 2019), which indicates promising bioaccessibility of nutrients from CRF compared to eating fresh green vegetables.

The utilisation of sweet potato green waste as a sustainable source of nutrients can benefit Malaysia in various ways. The CRF from SPH could produce new ingredient innovations that will also benefit humans and animals. In addition, by-products from green waste could contain an appreciable amount of nutrients that may be innovated into food and non-food applications. The focus on post-harvest physiology and technology will contribute to the National Priority Areas (NPA) on food security and benefit the well-being of the bottom 40 % (B40) Malaysians.

Moreover, this initiative supports the 17 Sustainable Development Goals (SDGs) envisioned in Malaysia via the 2030 Agenda, which aims to develop a path that balances economic growth with social inclusion and environmental sustainability (United Nations, 2023). This is also in line with the Integration of Naqli and Aqli Knowledge (INAQ) concept, introduced by Universiti Sains Islam Malaysia (USIM), in which the dimension of knowledge and science potentially provides a formula for solving current issues (Jailani, 2019). Therefore, upcycling agricultural waste such as sweet potato haulm can minimise environmental degradation, promote a healthy environment for all forms of life, and support renewable resources of materials.

1.2 Problem statement

Based on the remarkable quantity of agricultural biomass from sweet potato plantations produced per year, it is unavailing to use the wastes just to feed livestock, return directly to the soil, be burnt, or left to degrade. The abundance of nutrients found in the sweet potato haulm can be extracted and converted into some beneficial inventions. The nutrients found could give some added value towards the food security chain in Malaysia by acting as a sustainable source of nutrients. On top of that, optimisation of the green biomass can be upcycled back to the economy in a long-term perspective.

The liberation of chloroplast from its cell wall would promote the release of essential nutrients. Thus, slow juicing of sweet potato haulm is proposed in this study. The recovery of chloroplasts is performed by centrifugation technique to obtain a nutrient-rich layer called chloroplast-rich fraction (CRF). The nutritional compositions of sweet potato leaves were influenced by harvesting periods. However, no data was recorded on the physicochemical variation of the plants harvested from different crop borders. Hence, sweet potato haulms are scheduled to be collected from three different crop borders within the same plantation area to prevent variation in environmental conditions (soil, fertiliser, climate, or even availability of water) and their physicochemical properties were investigated.

The nutrient composition sourced from a green plant can greatly fluctuate in response to agricultural and post-harvest factors. To overcome this, the implementation of pre-treatment such as thermal processing is suggested to avoid physicochemical quality degradation due to the indigenous enzymatic activity that will cause degradation in the quality of CRFs from sweet potato haulm. Therefore, heat treatments involving conventional pasteurisation, steam pasteurisation, and water blanching are proposed in this study.

The bioaccessibility of carotenoids from green plants is reported to be relatively low. This has been attributed to several reasons, including a limited release of nutrients from the plant cellular environment and low micellarisation of lipophilic nutrients during gastrointestinal tract digestion. Thus, the influence of heat treatments on the bioaccessibility of lipophilic nutrients from the liberated CRFs is investigated in this study. An *in-vitro* digestion model is used as preliminary evaluation before executing *in-vivo* animal or human studies.

1.3 Objectives

This research notably focuses on the chloroplast-rich fraction (CRF) from sweet potato haulm. To exploit nutrients from the green biomass proposed in this work, three (3) objectives were computed:

1. To investigate the effect of different crop borders on the physicochemical variation of chloroplast-rich fractions (CRFs) from sweet potato haulm.

2. To investigate the effect of heat treatments on the physicochemical variation of chloroplast-rich fractions (CRFs) from sweet potato haulm.

3. To investigate the digestive stability and bioaccessibility of β-carotene and lutein of chloroplast-rich fractions (CRFs) from sweet potato haulm.

1.4 Scope of study

This study mainly focuses on the physicochemical properties of chloroplast-rich fraction (CRF) from sweet potato haulm (SPH). The SPH used in this study was obtained from the purple-skin yellow-fleshed sweet potato plant. The purple-skin yellow-fleshed sweet potato (Figure 1.2, Table 2.1e) is popular in Malaysia and known as the Japanese Yellow sweet potato.

Figure 1.2: Purple-skin yellow-fleshed sweet potato

The haulm was collected at the same time from three different crop borders of sweet potato plants as illustrated in Figure 1.3. Three different heat treatments were proposed in the study: conventional pasteurisation (CP), steam pasteurisation (SP), and water blanching (WB). The digestibility of lipophilic nutrients (β-carotene and lutein) of CRF from SPH was determined using the static *in-vitro* digestion model by Minekus et al. (2014). The *in-vitro* digestion model simulates the physiological and crucial conditions of the *in-vivo* digestion process (oral, gastric, and intestinal phases) that occur during human gastrointestinal digestion. The *in-vitro* digestion also offers a better understanding of nutrients' bioaccessibility besides being rapid, inexpensive, less laborious, and has no ethical restrictions process.

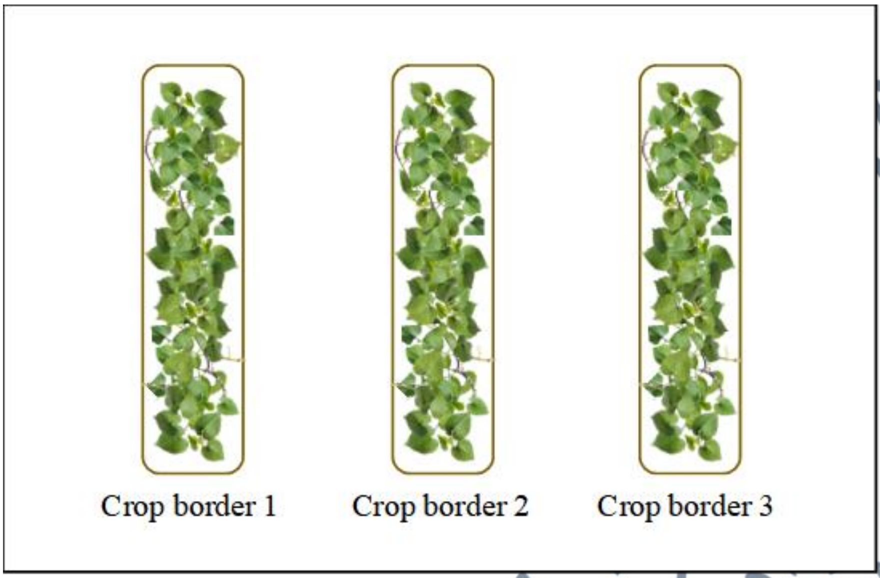

Figure 1.3: Illustration for crop borders of sweet potato plantation within the same farm

1.5 Chapter summary

This study suggested that the green waste of sweet potato plants contains a high amount of protein, phenolic compounds, antioxidant activity, and potential lipophilic nutrients such as carotenoids. Sweet potato haulm (SPH) collected from three different crop borders was used to study the physicochemical variation between the crop borders. Conversely, different heat treatments were performed to prevent physicochemical quality degradation of chloroplast-rich fraction (CRF) from SPH in response to agricultural and post-harvest factors. In addition, heat treatments could have a positive impact on the bioaccessibility of lipophilic nutrients from the liberated CRF. A static *in-vitro* digestion system is applied as a preliminary evaluation before *in-vivo* study.