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EFFECTIVELY EXPLOIT SPECIALTIES OF THE CENTRAL HIGHLANDS REGION OF VIETNAM AND POTENTIAL UTILIZE BY-PRODUCTS TO CREATE VALUE-ADDED PRODUCTS

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ABSTRACT

The Central Highlands is a key agricultural production region of Vietnam with many high-value export agricultural products such as coffee, pepper, rubber, and valuable fruits such as avocado, durian, and passion fruit, and some other agricultural products. However, the commercial value of edible agricultural products for human consumption is limited due to lack of attention to storage and processing conditions. Therefore, applying and investing in advanced preservation and processing techniques suitable for available raw materials in the Central Highlands is a highly feasible activity. Recent studies from international and domestic researchers showed various application could apply, which were presented in this paper including irradiation technology, steam/hot water treatment technology, zeolite technology, cold/cold storage technology combined with controlled atmosphere storage. When these activities are successful, it would reduce post-harvest loss of agricultural products, meeting the demand for food for the whole country and for export. For high nutritional value raw materials, it is necessary to invest more in potential preservation, processing, and utilization of waste by-products to increase diversity, improve quality, and ensure food hygiene and safety value-added products. The utilization of waste from agricultural product also was well-known that suitable for Sustainable Development Goals of United Nations. The quality of input materials and output products must be strictly controlled when applying advanced technology. This activity was controlled, that would ensure the safety of processed products, creating good conditions for the national and global agricultural value chain. Thanks to that, effectively taking advantage of the region's specialties and food processing is no longer a weakness of Central Highlands agricultural products in Vietnam, making an important contribution to the socio-economic development and stability of the region and the whole country.

Keywords: Agricultural products, Central Highlands, Food Preservation, Food processing; Diversification

INTRODUCTION

The Central Highlands includes 5 provinces: Dak Lak, Gia Lai, Kon Tum, Dak Nong and Lam Dong, with 2 million hectares of agricultural land, of which over 850,000 hectares are planted with annual crops and more than 1.15 million hectares are planted with perennial crops. The area of regional basalt accounts for 74.25% of the country's area. This type of soil is suitable for many industrial crops such as coffee, rubber, cashew, pepper, bamboo shoot, banana, and "Sim" fruit (*Rhodomyrtus tomentosa*). Of which, the total coffee growing area reaches about 639,000 hectares (accounting for 92% of the country's area), productivity reaches 28.5 tons/ha (1.1 times higher than the whole country), output is about 1,669,000 tons, accounting for 95% of the country's area **(Le Nguyen et al., 2024)**.

Some types of agricultural specialties in the Central Highlands are presented in Figure 1. The Central Highlands has become a major agricultural production center in Vietnam, producing many products in high demand and bringing in billions of dollars in export revenue. According to the Ministry of Agriculture and Rural Development, the Central Highlands has a favorable climate for the development of fruit trees, industrial trees, forestry trees, and high-quality medicinal trees with large yields and competitiveness, next to the coffee tree, such as pepper, avocado, durian, rubber, cassava, wood, "Ngoc Linh" ginseng, etc.

In the period 2016-2020, although the pepper growing area decreased, the annual harvest output increased. In 2016, the pepper output of the Central Highlands reached 120,357 tons (accounting for 55.62% of the country's pepper output) and by 2020 it increased to 165,677 tons (accounting for 61.32% of the country's pepper output). Of which, Dak Lak province has a pepper growing area of 41.46% and an output of 44.46% of the whole region, the locality with the highest area and output in the Central Highlands **(Huyền, 2021)**. Dak Lak is the province with the second largest avocado growing area in the country (after Lam Dong province); the output ranks first (nearly 90,000 tons), accounting for 40.6% of the country's avocado output. In the years 2018 - 2021, the province's avocado acreage increased rapidly (in 2021 it reached 9,146 hectares, an increase of 3,540 hectares compared to 2018). However, recently, due to falling avocado prices, the acreage has gradually decreased to 7,200 hectares **(Thuận, 2023)**.

According to the Department of Crop Production (Ministry of Agriculture and Rural Development), the durian growing area in the Central Highlands provinces is currently expanding, with the largest area being Dak Lak province. According to the 2023 Official Report of the Dak Lak Provincial Statistics Office, the total durian growing area is 32,785 hectares, accounting for 50.27% of the fruit growing area, an increase of 10,326.4 hectares compared to 2022, with an estimated output of 281,350 tons, an increase of 93,364 tons compared to 2022. It is forecasted that in the coming time, the durian growing area and output will continue to increase as durian prices are expected to remain high **(Đức, 2024)**.

Vietnam is an Asian country that produces and exports high-quality fermented cocoa beans to chocolate manufacturers. This is an opportunity for Vietnam in general and for the people of Dak Lak (one of the provinces in the Central Highlands) in particular. According to the Department of Industry and Trade of Dak Lak province, the whole province currently has over 2,000 hectares of cocoa growing area, with an average yield of 10 quintals/ha and an annual output of 2,000 tons. Growing and producing commercial cocoa in Dak Lak province has been a bright spot in recent years **(An, 2022)**.

Currently, the Central Highlands is the main passion fruit growing area of the country with about 8.2 thousand hectares, accounting for more than 86% of the country's area. Of which, Gia Lai province is the locality with the largest passion fruit growing area with more than 4,263 hectares, with an output of more than 134 thousand tons. This is also the locality that attracts and concentrates businesses to invest in seed production, processing and consumption of the largest passion fruit in the country **(Dương, 2023)**.

With full information on planting area and output announced, it has shown that the Central Highlands leads the country in coffee, pepper, avocado, passion fruit output. Compared to the national output, Central Highlands coffee accounts for 94.8%, pepper accounts for 68.6%. Some fruit trees grow quickly, durian accounts for 43.1% of the area and 36.3% of output; avocado accounts for 78.1% of area and 81.9% of output, passion fruit accounts for over 70% of area. "Farmers in the Central Highlands develop agriculture haphazardly and often break planning. Whenever the selling price of a certain product such as coffee, pepper, or cashew goes down, farmers are ready to cut down trees to switch to growing other crops, even though they know that new crops take 3-5 years to harvest, leading to unstable output" said the Deputy Minister of Agriculture and Rural Development in Vietnam.

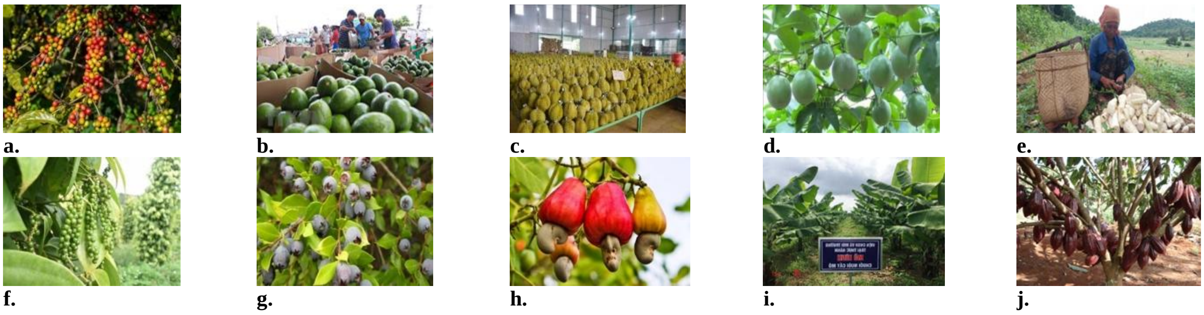

Figure 1. Agricultural specialties of the Central Highlands (a. Coffee, b. Avocado, c. Durian, d. Passion fruit, e. Bamboo shoot, f. Black pepper, g. "Sim" fruit, h. Cashew apple, i. Banana, j. Cocoa)

The development of the entire region's agriculture is not commensurate with its potential and advantages. The situation of good harvest prices losing, good prices losing crops still happens, sometimes agricultural products "block" output, pushing farmers into a vicious cycle of growing and destroying. In addition, the ability to access, receive and apply farming technology of farmers in the Central Highlands region is quite slow. Because of arbitrariness, many farmers in the Central Highlands are willing to break contracts when private traders pay higher prices. Most farmers in this area still lack connectivity in the production and processing chain. The relationship between entities participating in the agricultural value chain has not been established sustainably based on harmonious handling and balancing of benefits. Therefore, there is a lack of connection with processing, consumption, and export, leading to passive export and not being able to find stable markets.
The development status of production and export of key products in recent years in the Central Highlands region has shown great dependence on natural conditions. This makes exports unstable. The chorus of good harvests losing prices or good prices then losing crops keeps repeating. The quality of key agricultural products is uneven, so there are many technical trade barriers. Key products of the Central Highlands such as coffee, rubber, pepper, cashew, sweet potatoes, etc., although they are at the top or in the top product group in the world, are still dependent on fluctuations in prices on the world market. However, agricultural development in the entire region in general has not yet met the region's potential.
The major agricultural products of the Central Highlands participate in the global value chain mostly in the form of fresh ingredients or semi-finished products with low levels of preliminary processing, leading to low added value and income for local farmers. In addition, planning of growing areas and agricultural production areas needs to be linked to farmer organizations and markets, connected to modern technology in production, preservation, and processing, creating organic agriculture for the Central Highlands. The added value of agricultural products in the Central Highlands is also still low due to weak processing. Along with the general development of the world, increasing requirements for agricultural product quality, food hygiene and safety, especially export markets, are increasingly challenging. Therefore, it is necessary to invest in new processing facilities, paying attention to technology and equipment innovation issues to improve quality and ensure food safety and hygiene. Besides, under climate change conditions, drought has greatly affected agricultural production **(Bharambe et al., 2023)**, therefore, along with the strict requirements of the consumer market, the development of high-tech agriculture is an inevitable trend for agriculture in the Central Highlands.
Many physical and chemical methods can be applied to treat fresh agricultural products after harvest to maintain fresh quality with original nutritional value, meeting safety standards of fresh products. In addition, assessing the current status of agricultural production activities, applying post-harvest treatment measures along with applying new/advanced technologies is the best way to reduce waste of fresh products after harvest. It is also necessary to promote the exploitation and post-harvest processing of these valuable plant resources, creating new food products with high nutritional value, ensuring food safety and meeting consumer requirements. These works would be meaningful scientific and practical work, capable of supporting and improving community health in residential areas and the whole country.

POTENTIAL APPLICATION OF INNOVATION TECHNOLOGY IN PRESERVATION OF AGRICULTURAL PRODUCTS IN CENTRAL HIGHLANDS OF VIETNAM

The biggest problem in applying high technology to agriculture in the Central Highlands provinces is capital, human resources for research and transferable technologies. The innovative technologies applied will maintain the quality of raw materials during storage and support high quality raw materials for processing. At the same time, to meet consumer needs, processed products must be "healthy, nutritious and still natural". Technologies that can be applied in preserving agricultural products in the Central Highlands may include:

Irradiation technology

Implementing innovative food technologies is an effective strategy to prevent global foodborne epidemics, which have significantly impacted public health and economic structures. The primary factors contributing to these foodborne illnesses are post-harvest losses and microbial contamination. Processors face challenges in extending the shelf life of food and ensuring their availability during the off-season for future consumption **(Wakholi et al., 2015)**. According to the World Health Organization, over 600 million individuals worldwide are projected to become sick due to food consumption, resulting in an annual mortality toll of around 42,000 **(WHO, 2015)**. Furthermore, nearly a quarter of food losses occur due to post-harvest spoiling. In order to address these challenges, several approaches have been utilized and extensively studied for the purpose of food preservation. Both thermal and non-thermal procedures have been employed and thoroughly investigated to ensure the maintenance of food quality and safety.
Irradiation occurs after food is produced and packaged. Food enters a chamber where it is exposed to a specific amount of radiation. Radiation penetrates food and kills germs or stops them from multiplying and does not survive in the food. This technology is well applied to fresh vegetables, tubers, and fruits (export) to reduce or eliminate the risk of food-borne diseases. Some foods are irradiated with sufficient and appropriate doses to ensure that they are sterilized and do not have any spoilage or pathogenic microorganisms in the final product **(Thuy et al., 2013)**. Irradiation is also used to reduce post-harvest losses. Besides reducing pathogens, irradiation also affects cells, slowing down the rate of action of enzymes that are produced during natural processes, and thus slowing down the deterioration process, ripening or sprouting of foods **(Loaharanu, 1990)**. There are three different technologies used to irradiate food: gamma rays (using radioactive cobalt or cesium salts), electron beams, and X-rays. Gamma rays can penetrate food to a depth of several meters; Electron beams penetrate up to 3 cm and X-rays penetrate up to several feet. Approved irradiation doses range from 0.05 kGy to inhibit germination in white potatoes to 30 kGy for sterilization of herbs and spices. Fresh fruits and vegetables are treated with maximum irradiation at a dose of 1 kGy to sterilize insects and slow down the ripening process (which is the FDA-approved radiation level for food products). Higher irradiation doses (maximum 4.5 kGy) can be applied to red, uncooked and frozen meat **(Wanamaker & Grimm, 2004)**. As mentioned, food irradiation is a non-thermal method that involves exposing food or agricultural products to a controlled amount of non-ionizing radiation, such as UV, visible light, infrared, radio waves, or ionizing radiation like gamma-rays, X-rays, and accelerated electron beams. Multiple research studies have demonstrated that ultraviolet lights enhance the quality of many fruits and vegetables post-harvest such as mangoes **(Ruan et al., 2015)**, pineapples and grapes **(Zhang & Jiang, 2019)**, broccoli **(Formica-Oliveira et al., 2017)**, and strawberries **(Ortiz-Araque et al., 2022)**. These processes effectively eliminate microorganisms like viruses and bacteria present in the food or agricultural commodities. Furthermore, irradiation contributes to the improvement of cleanliness and safety, as well as the enhancement of storage and distribution in the aforementioned commodities **(Nair & Sharma, 2016; Pathak et al., 2018)**.
According to **Kalaiselvan et al. (2018)**, it has a little impact on the flavor, color, taste, nutritional content, and other attributes of food. Fruits and vegetables serve as abundant reservoirs of vital nutrients that play a crucial role in maintaining human well-being. Therefore, a substantial intake of fruits and vegetables reduces the likelihood of developing chronic and deficiency diseases such as obesity and diabetes **(Mozaffarian, 2016)**. According to **Maraei and Elsawy (2017)**, research has shown that gamma radiation can effectively be utilized as an alternative therapy to kill microbes and increase the shelf life of products. UV-C and UV-B, known for their lethal germicidal properties, are well recognized in the food sector as excellent means for disinfecting the surface of

food products. Additionally, they are used in post-harvest treatment to prevent fungal development and prolong shelf life **(Sheng et al., 2018)**.

In Vietnam, 14,200 tons of frozen seafood (mainly shrimp) were irradiated at the Ho Chi Minh City Irradiation Center under the Vietnam Atomic Energy Commission and Son Son Electron Beam Irradiation Company **(Kume et al., 2009)**. Food irradiation in Vietnam has developed rapidly and the construction of new irradiation facilities is being planned. Many products of the Central Highlands region also can be effectively applied this technique for preservation or export. **Gautam and Tripathi (2016)** reported that food products were divided into 8 class for treating by radiation including: bulbs, stem and root tubers, and rhizomes (class 1), fresh fruits and vegetables other than class 1 (class 2), Cereals and their milled products, pulses and their milled products, nuts, oil seeds, dried fruits and their products (class 3), Fish, aquaculture, seafood and their products (fresh and frozen) and crustaceans (class 4), Meat and meat products including poultry (class 5), dry vegetables, seasonings, spices, condiments, dry herbs and their products, tea, coffee, cocoa and plant products (class 6), dried foods of animal origin and their products (class 7), ethnic foods, military rations, space foods, ready-to-eat, ready-to-cook/minimally processed foods (class 8). However, depending on the purposes of process, the dose limit (Kilo-gray) could be varied **(Gautam & Tripathi, 2016)**. For instance, 0.02-0.2 Kilogray (kGy) treatment for inhibit sprouting of class 1 products was used. However, the range limit of insect desinfactation for class 2, 3, 7 were different, which were from 0.2-1.0, 0.25-1.0, 0.3-1.0 kGy, respectively. Moreover, it also found that the level of treatment for reduction microbial load and decontamination from microbial was 1.5-5.0 kGy for class 3, 1.0-7.0 kGy for class 4, 5, 6, and 2.0-10.0 kGy for class 7. However, for sterilization process of class 8, the required radition process need the higher dose (5-25 kGy). However, the investment cost could be the disadvantage for this application.

Steam/hot water treatment technology

Heat treatment can be applied as an alternative to chemical treatments for fresh fruits after harvest. The beneficial effects of these heat treatments are related to changes in physiological processes such as reduced chilling injury and delayed ripening by thermal inactivation of enzymes, killing insects and controls fungal infections. This heat treatment method can be applied to all types of potatoes and fruits. Hot water treatment (HWT) also helps fruit retain quality during cold storage and extends shelf life, reduces the development of rot and ensures quarantine safety against invasive pests **(D'Aquino et al., 2014; Mahajan et al., 2014)**. The possibility of HWT to improve the quality of 'Hass' avocado fruit after cold disinfestation against fruit flies was studied by **Hofman et al. (2002)**. The results showed the commercial potential of HWTs at a temperature of about 41°C for 25–30 minutes or 42°C for 25 minutes improved the external and internal quality of avocado after cold disinfestation.

The combination of hot water treatment at 47°C (4 or 5 minutes) and the application of K or Zn phosphites significantly reduced the severity of the disease on passion fruit **(Dutra et al., 2018)**. Treatment with 1-MCP at a concentration of 200 nL/L/24 hours reduced the severity of anthracnose disease in passion fruit.

Application of HWT at 50°C for 20 minutes reduced the severity of stem rot caused by *Colletotrichum musae* on bananas by 50% after 7 days and 33% after 14 days. Complete control of *C. gloeosporioid*es on papaya cultivars is achieved by treating the fruit for 20 min at 50°C **(Martins et al., 2004)**. **Hu et al. (2011)** also reported that HWT at 50°C for 30 min significantly inhibited the germination and decay of sweet potatoes during storage.

The lemons were treated with hot water at 50°C for 3 and 5 min and then kept at 25°C in the dark; the results shown that heat treatment extended the shelf life by 5 and 10 days for fruits treated for 3 and 5 minutes, respectively **(Kaewsuksaeng et al., 2015)**. It is also possible to use hot water at a temperature of 37 to 55°C for 30 seconds to 3 minutes which can improve the post-harvest quality of common fruits **(Fallik, 2004; Glowacz et al., 2013; Hong et al., 2014)**. Although, steam/hot water treatment technology could bring some benefits as rapid heating, high efficiency and heat capacity, low toxicity and transportability,… But the potential of nutrient loss during heating process also need to further consideration.

Zeolite technology

Zeolites are microporous crystalline aluminosilicates made up of tetrahedral units of AlO_4 and SiO_4 **(Huwei et al., 2021)**. Zeolite has proven to be a convenient and versatile material to ensure food safety from many different aspects. In the food technology industry, zeolites have also helped ensure food safety in the food safety and quality management approach, as these materials can act as active ingredient stabilizers and remove pathogens. Zeolite has high antibacterial properties with the ability to fight some pathogenic bacteria **(Villa et al., 2020)**. In particular, Ag+-doped zeolite systems are of great interest, as they have broad-spectrum antibacterial activity against both Gram-negative bacteria (such as *Campylobacter*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Salmonella Typhimurium*), Gram-positive bacteria (*Clostridium perfringens*, *Lactobacillus casei*, *Listeria monocytogenes*, *Staphylococcus aureus*, and *Streptococcus mutans*) and fungi (*e.g.*, *Candida albicans*) **(Belaabed et al., 2016; Janićijević et al., 2020; Prabhu & Devaraju, 2018)**.

Pd/zeolite can slow down the ripening process of bananas and significantly improve the hardness and color of banana peels. The findings indicate that the prepared Pd/zeolite is an effective adsorbent/catalyst with high potential for practical application in ethylene removal, especially in the post-harvest stage **(Tzeng et al., 2019)**. The ethylene-inhibiting activity of climacteric fruits such as avocado, banana, durian, *etc*. has been developed in recent studies as palladium-promoted zeolite materials, which can be considered as palladium-promoted zeolite materials effective ethylene adsorbent to extend the shelf life of fresh products **(Smith et al., 2009; Terry et al., 2007)**. This method has the potential to be commercialized, as an alternative and/or supplement to the previously performed 1-methylcyclopropene (1-MCP) treatment of avocados.

In addition, the use of natural zeolite helped increase lycopene synthesis significantly higher than tomatoes stored in the presence of modified zeolite. Natural zeolite doped with copper and zinc cations helps remove ethylene and slows down the ripening process of tomatoes. Incorporation of copper and zinc cations into zeolite supports is an emerging new post-harvest technology to slow fruit ripening, which could create new commercial opportunities for fresh tomatoes in the market **(Melin et al., 2019)**.

Cold/cold storage technology combined with controlled atmosphere storage

Post-harvest durian should be cooled and stored in a cooling room regulating the temperature and humidity at 15ºC and 85-90% to slow ripen, reduce fungal growth and dehydration. In addition, fruit is not stored in the condition in which atmospheric humidity below 80%, oxygen concentration less than 10% and carbon dioxide higher than 5% **(Thuy et al., 2013; Thuy & Tuyen, 2017)**.

Pretreatment of durian before storage and transportation are also taken to extend the shelf life of the fruit and to prevent cracking. The common treatment methods of 1-MCP (1-methylcyclopropene) is a safe treatment for consumer health and is accepted worldwide. **Amornputti et al. (2014)** concluded that durian treatment with 1-MCP before storage at 15°C extended storage life from 18 to 30 days.

Controlled atmospheric conditions of 4 kPa O_2 and 6 kPa CO_2 at 5ºC controlled black spot disorder on avocado skin for up to 40 days. This condition also maintains the total phenolic content of the avocado peel well. The results obtained have practical applications for the Hass avocado supply chain and contribute to reducing post-harvest avocado loss. The purple passion fruit was well preserved at a temperature of 10±2ºC and a relative humidity of 75%, the fruit did not suffer from cold injury and maintained good quality for 33 days **(Díaz et al., 2012)**. High in initially cost is one of the disvantage of this method. Moreover, the consideration of complexity and maintenance also need further determination.

POTENTIAL TECHNOLOGIES IN PROCESSING SPECIFIC AGRICULTURAL PRODUCTS OF THE CENTRAL HIGHLANDS REGION

Besides preservation methods, new technologies can be applied in processing a variety of agricultural products (plants and animals). This activity is carried out to take full advantage of agricultural resources in the next ripening stage, reducing post-harvest losses. Reality also shows that products harvested from agriculture often have low value when using raw materials, the added value of agricultural products is only achieved once they are converted into processed products with high quality and long-term preservation. High-tech agricultural products could be produced from different production scales, starting with small production scales, then building larger production models and investments to create higher-quality products, especially the highland part of central of Vietnam. The products have superior quality, features, high added value, are environmentally friendly and can gradually replace imported products **(Van Tai et al., 2023)**. In addition, a typical processing center or facility also needs to always have four or five types of fruits harvested at different times of the year and two or three types of vegetables. This equipment system also needs to be able to process dried products, juices, pickles, juices, sauces, jams, and semi-finished fruit products.

Avocado processing

Avocados contain about 73% water, 12.5% fat, 10% carbohydrates and 2% protein. The vitamin content in avocado is quite high, including vitamin A, vitamin C, vitamin E, vitamin K, vitamin B1, B2, B3, B5, B6. Fairly high amounts of folate (about 20%) are found in the fruit. Compared to other fruits, avocados contain very little sugar, only about 1% in the form of glucose and fructose. Avocados also contain minerals such as magnesium, iron, copper, zinc, phosphorus, manganese... 100 g of avocado provides about 160 kcal. Fiber in avocados also has many health benefits, can regulate appetite, reduce bacteria in the intestines and reduce the risk of disease **(Burton-Freeman, 2000)**. Avocado is also a rich source of unsaturated fatty acids, mainly oleic acid, which is an ingredient that reduces inflammation and has beneficial effects for cancer

patients. Avocado oil is a source of healthy fats, and animal studies show protective effects against inflammation, heart disease and diabetes. Some studies have shown that consuming avocados can improve cholesterol levels in some people. Specifically, research shows that people who eat avocados have higher HDL cholesterol levels **(Fulgoni et al., 2013)**. Higher HDL cholesterol levels are associated with a lower risk of cardiovascular disease **(Ali et al., 2012)**. A healthy diet that includes foods like avocados can help improve heart health.
As it is known that avocados are one of the few fruits in the human diet that are high in water-soluble vitamins, minerals and fat-soluble compounds that are linked to health. Avocados provide significant amounts of monounsaturated fatty acids. The main protective effects of avocados include preventing cardiovascular diseases, diabetes and some forms of cancer, improving digestion, reducing the risk of depression and preventing bone loss, etc... **(Ramos-Aguilar et al., 2019)**. These are also diseases that many countries consider a public health problem. Avocado is one of the tropical fruits that is in higher demand worldwide as it is the source of many commercially valuable food products. So incorporating them into a healthy, varied diet may offer a number of benefits. Processing avocados is also a good way to reduce post-harvest losses and enhance their value with a variety of high quality and safe processed products. Avocado sauce is also a potential product made from avocado which are commonly used in many countries, can be eaten with fish foods, grilled meat or rice paper... Avocados can also be frozen in many ways for a longer storage time. Intense pulsed light treatment is recognized as a rapid, heat-free technology that can neutralize microorganisms and enzymes that cause spoilage of fresh products. High-intensity pulsed light was applied to prolong the shelf life of fresh-cut avocados in terms of quality and increase the phytochemical content of this food product **(Ramos-Aguilar et al., 2019)**. The scientific contribution of this text also can be exploited to commercialize fresh-cut avocado products with higher nutritional and health-related properties.

Passion fruit processing

Passion fruit is also known as a fruit with high nutritional content, especially fiber, vitamin C and vitamin A. Passion fruit contains about 72% water, 23% carbohydrates, 2% protein and about 0.8% fat, rich in bioactive active compounds such as carotenoids and polyphenols. Passion fruit is a highly acidic food (pH ~ 3.2) with citric acid and malic acid predominating. This fruit is also rich in minerals. The nutritional and biological compounds in this fruit have good effects on health, protect against degenerative and chronic diseases, and prevent cancer. Passion fruit has high amounts of antioxidants and flavonoids, and has anti-inflammatory, anti-bacterial, anti-fungal and anti-aging properties **(Biswas et al., 2021)**.
Passion fruits were used in the processing of value-added products such as juice, jam, jelly, ice cream and wine. Passion fruit powder can be included in cookie, muffin, and candy recipes. In addition, after extracting the juice, passion fruit pulp can be used in combination with baking powder to give bread products better functionality thanks to the balanced ratio of soluble/insoluble fiber. Besides, the passion fruit processing process creates a large amount of by-products (about 72 to 76% - of which the peel accounts for about 88 to 90%). These ingredients may have their own functional properties. Passion fruit seed oil is rich in linoleic acid (65%), the peel can be used to produce pectin, one of the main additives in the confectionery industry. The addition of passion fruit peel powder to cookie recipes was studied by **(Weng et al., 2020)**. The final product was rich in fiber, had good textural properties and good organoleptic quality.

Safe handling and processing technology of bamboo shoots

Bamboo shoots are low in fat, high in fiber and rich in mineral content, making them an ideal vegetable that has been used traditionally. Besides nutrients, bamboo shoots also contain lethal concentrations of antinutrients (cyanogen glycosides) that need to be minimized and eliminated before human consumption. Therefore, the best treatment method is needed to remove cyanogen. Fresh bamboo shoots can be treated by boiling in water with 5 to 10% NaCl concentration for 25 to 30 minutes to maximize cyanogen removal with minimal nutrient loss **(Shinde et al., 2019; Thuy et al., 2013)**. High hydrostatic pressure can be considered effective in maintaining the quality of bamboo shoots during storage at room temperature. The activities of two enzymes polyphenol oxidase and peroxidase of bamboo shoots were effectively inhibited when the sample was treated at 400 MPa for 15 minutes, and the microbial content was also lowest **(Li et al., 2021)**.

Applying combined technologies (heat treatment and enzymes) in white pepper processing

The advantage of this technique is that it avoids excessive heat treatment, which improves the color of the finished product such as white pepper, a multi-enzyme preparation containing cellulase, hemicellulase, pectinase, arabinase, β-glucanase and xylanase is used. Activities may be included as soaking black pepper pods in water (overnight) and then continue treatment in enzyme mixture (0.04% w/w) at room temperature. The raw materials were washed after treatment in a water solution containing chlorine or citric acid; dried, winnowing and sieved to obtain white pepper. It can also be processed by soaking black pepper for 4 days and boiling for 15 minutes, which will produce a grade I quality white pepper product **(Hidayat & Sukasih, 2023)**.

"Sim" fruit processing

"Sim" fruit, also known as rose myrtle (*Rhodomyrtus tomentosa*) is a flowering plant belonging to the *Myrtaceae* family. Sim is eaten fresh (ripe fruit is very delicious and nutritious) and is also exploited to make specialties such as "Sim" syrup or wine **(Thuy & Tuyen, 2016)**. Sim fruit contains a little protein, fat, starch, sugar, red anthocyanin, flavone-glucosides, malvidin-3 glucoside, phenolic compounds, amino acids, and organic acids. Anthocyanin in "Sim" fruit is a natural organic color compound, belonging to the red flavonoid group, giving beautiful colors, being safe, having good biological activities for humans, and being able to help the body fight cancer, antioxidant, anti-ultraviolet, anti-inflammatory, anti-aging.
"Sim" fruit has a sweet, astringent taste, and has the effect of improving blood circulation, strengthening blood, nourishing blood, and promoting joy. Often used in cases of physical weakness, anemia due to blood loss, anemia due to pregnancy, weakness and fatigue after illness, neurasthenia, tinnitus, spermatorrhea. Medicine has also proven that the purple pigment of the fruit, anthocyanin, has very good antioxidant and anti-aging effects for humans. Research into processing a variety of products from wild myrtle fruits, including: wine, jelly, juice, concentrate, syrup, marshmallows... are also highly feasible from this precious material available in the Central Highlands **(Thuy et al., 2011; Thuy & Tuyen, 2016)**.

Durian

Durian (*Durio zibethinus* Murr.) grows seasonally in Southeast Asia. Vietnam has more than 110,000 hectares of durian with a yearly output of nearly 850,000 tones. In the Central Highlands of Vietnam, durian was previously produced in Dak Lak province (including today's Dak Nong province). After that, the production area was expanded to include Gia Lai and Kon Tum provinces at altitudes from 500 to 800 meters above sea level and Bao Loc and Di Linh districts in Lam Dong province at altitudes from 700 to 800 meters above sea level. meters above sea level. level. The Central Highlands is the fastest expanding durian production region (2.5 times more) nationwide in the past three years. The durian production area in the Central Highlands has surpassed the Mekong Delta to become the largest durian production area in Vietnam. Newly established durian production areas in the Central Highlands are mainly specialized farms, in contrast to the traditional method of intercropping durian and coffee. Due to falling coffee prices and rising durian prices, durian growers have received widespread investment and are given priority to generate higher income. However, the agricultural sector and localities need to find timely solutions for sustainable development in durian growing and consumption. If the durian industry wants to develop sustainably, it must reorganize its structure from production to consumption. Besides fresh durian products, the industry needs to develop processed products, and at the same time have a specific plan to develop durian growing areas nationwide. To achieve sustainable development of the durian industry, several key bottlenecks need to be addressed, including processing infrastructure, quality management, and establishing connections between farmers, traders, and exporters; and create standard processes. Local businesses focus on frozen durian products for export due to the potential of this product. Another huge challenge in the durian industry is the lack of synchronization in the link between production and consumption.
Therefore, choosing suitable raw materials and applying each separate technology to process durian into attractive products is meaningful and interesting work for the production area. Products made from durian can be durian chips, spray-dried durian powder, freeze-dried durian, candy, frozen form, ice cream and yogurt, durian powder... **(Van Hau et al., 2023)**. By freezing at -20ºC in the form of paste and pulp, durian can be preserved for a long time and can be eaten directly as a dessert or used as a filling in folk cakes, moon cakes or candies. Durian can be processed into powder from a freeze-drying process, then ground into powder with particles ranging in size from 40 mesh to 60 mesh with a maximum moisture content of 5%. At a temperature of 5ºC, this product can be preserved for more than 2 years **(Thuy & Tuyen, 2016)**. Durian powder can be used as a flavoring or mixed with all the products mentioned above.

UTILIZE WASTE FROM THE PRODUCTION PROCESS TO CREATE VALUE-ADDED PRODUCTS

Food waste/waste comes from the processes of producing food for human consumption. These parts may degrade after discharge or cause environmental pollution **(Van Tai et al., 2023)**. The problem of food waste is currently on the rise, involving all areas of waste management from collection to disposal. Identifying and selecting scalable sustainable solutions can effectively contribute to the food supply chain, agricultural and industrial sectors, retail operations and end consumers. Food waste is also used in industrial processes to produce biofuels or biopolymers, composting, etc. **(Van Tai et al., 2023)**.

The causes of food loss and waste in low-income countries are mainly related to financial, management and technical limitations in harvesting, storage and cooling techniques under climatic conditions, infrastructure, packaging system and marketing are difficult **(López-Sánchez et al., 2021)**. The food supply chain in Central Highlands also needs to be strengthened, necessary activities to be promoted are investment in infrastructure, transportation, food industry and packaging industry. Furthermore, waste reuse is a point of concern in Vietnam, contributing to the development of a circular economy - a sustainable development direction for domestic businesses.

With ideal soil characteristics for coffee cultivation, the Central Highlands is considered the coffee "capital" of the country. Specialty coffee processing methods and processes have reached a high level of maturity and farmers here are producing towards building sustainable coffee landscape clusters. Coffee waste generated during the production of instant coffee contains approximately 6% and 4% of total polyphenols and tannins, respectively **(Pujol et al., 2013)**. Total phenolic content equivalent to 17.75 mg gallic acid/g was extracted from waste coffee grounds **(Zuorro & Lavecchia, 2012)**. **Pambudi et al. (2023)** also reported that it is a potential source of eco-friendly biochar. Moreover, the study of **Reichembach et al. (2024)** presented that the coffee waste in Brazil contained 49% uronic acid, which is a promising source for producing the pectin. The extract of β-mannanase, inulinase, and oligosaccharides from coffee wastes also was becoming the trend in development of nutraceutical foods around the world **(Basmak & Turhan, 2024)**.

Potato peel, a by-product of potato processing, contains a lot of biologically active substances, mainly including chlorogenic, cryptochlorogenic, caffeic, ferulic, gallic and p-coumaric acids, flavonoids such as flavanols, flavanol, anthocyanin and some other additives. amount of syringic, vanillic, sinapic and salicylic acids. Among these, caffeic acid, chlorogenic acid and quercetin have mild inhibitory effects on parasites **(Akyol et al., 2016; Friedman et al., 2018)**. Recently, the potato waste was consider as the source for producing biofuels, which is contributed into the sustainable goals **(Rodríguez-Martínez et al., 2023)**. The sources of nano-fibrillated cellulose from potato peel waste also successfully extracted by microwave and ultrasound application **(Sadeghi-Shapourabadi et al., 2023)**. Due to containing various source of nutrients, potato peel waste is the good sources for various biotechnology process as polymers of hydroxy alkanoates by *Bacillus circulans* **(Kag et al., 2023)** and fungi production by hydrolyzed potato peel **(Almuhayawi et al., 2023)**.

Banana peels are discarded during the processing of banana products, accounting for about 18-30% of the whole fruit **(Van Tai et al., 2023)**. The rich composition of minerals, a variety of amino acids, antioxidant compounds, carbs, proteins and fibers can potentially be a good foundation for the development of value-added goods **(Van Tai et al., 2021)**. **Tai et al. (2021)** used traditional drying techniques to create powders. In addition, the extraction of phenolic and flavonoid compounds from Siamese banana peel also yielded significant amounts of these compounds, 62.41 mgGAE/g and 6.98 mgQE/g, respectively. Banana pulp peel has also been used in noodle production, opening up a promising direction to improve income for local farmers **(Tai et al., 2021)**.

Avocado production generated about 30% waste, including defatted seeds, peels and pulp that have been released from avocado production. Among the sources of nutrients, edible proteins in avocado byproducts have good water absorption, oil absorption and free radical scavenging capabilities. In addition, the ability to stabilize emulsions (oil in water) of protein in avocado by-products has also shown superior results compared to soy protein, so it can be considered a source with good potential applications for processing dairy products, functional food products **(Wang et al., 2019)**. Avocado seeds are also an ideal source of starch with freezing temperature of 56–74ºC, water absorption of 22–24 g of water/g of starch, solubility of 19–20%, swelling ability of 28–30 g of water/g starch and maximum viscosity is 380–390 BU. Therefore, they have potential for use as thickeners and gelators, carriers for pharmaceuticals or components of biodegradable food packaging materials **(Chel-Guerrero et al., 2016; Salazar-López et al., 2020)**.

During durian processing, only 1/3 of the durian fruit is edible, while the durian seeds and peel often have to be thrown away. According to previous studies, durian seeds contain many nutrients and high fiber content. Durian seeds can be processed into powder, widely used in products: cakes, candies, soups or as a substitute for flour or coagulant **(Amiza et al., 2019)**. When cutting, durian seeds contain a lot of viscosity, so they have the ability to thicken the product due to the presence of hydrocolloids and starch **(Amin et al., 2007)**. Natural hydrocolloids can be used as dietary fiber, structural support agent, gelling agent, thickener, stabilizer, emulsifier, film coating agent **(Tan et al., 2023)**. Recent review of **Gamay et al. (2024)** reported that durian waste could be potential into two main sectors, including application in food products as source of pectin, antioxidants, functional flour, film production, nutrient for bacteria, and non-food application as biochar, absorbent, hydrogen bandages, paper industry, liquid smoke, bio-ethanol feedstock,…

The ultrasound-assisted extraction of pectin from cocoa pod husks and other cocoa by-products has demonstrated encouraging outcomes. This approach enhances the yield and quality of pectin, applicable in the food business **(Mounya & Chowdary, 2024)**. Cocoa waste, when mixed with other agricultural wastes, can be utilized for biogas production via anaerobic digestion. This not only offers a sustainable energy source but also facilitates effective trash management **(Uyen et al., 2007)**.

The skin of purple passion fruit, often discarded, possesses substantial quantities of pectin. Pectin serves as a significant gelling agent and stabilizer within the food sector. Studies indicate that the ideal parameters for obtaining high-quality pectin from passion fruit peel include the application of HCl at 96°C and a pH of 1.96 for a duration of 83.5 minutes. The extracted pectin demonstrates excellent gel-forming capabilities, elevated stability, and viscosity, rendering it superior to commercial pectin **(Dam & Nguyen, 2013)**. Employing passion fruit trash lowers environmental damage and fosters a circular economy by transforming garbage into profitable products. This methodology is consistent with sustainable practices and bolsters the food processing industry in Vietnam **(Dieu, 2006)**.

CONCLUSION

Considering the above factors, growing and processing key agricultural products in the Central Highlands region is technically feasible and can be expanded in the region. The first and most important step to take is to raise public interest and provide widespread public information through various channels, followed by developing coordinated initiatives among all stakeholders' potential stakeholders, such as farmer and government agencies, research organizations and others. Strategies such as proper post-harvest management, building appropriate storage facilities, improving packaging and transportation facilities, establishing new processing facilities with advanced techniques, etc. need to be developed. Applying new/advanced techniques in the production process will increase the value of agricultural products, ensure the perfection of a closed production model and develop product processing processes from many unique raw materials. products in the Central Highlands, aiming to provide enough products. If this activity is carried out well, it will meet high product quality standards and serve consumer needs, both domestically and internationally. At the same time, it also helps local branded products to be developed and can be compared with existing products in the domestic market and other countries with similar raw material sources. In addition, when new technologies are applied and replicated in the area, collective production organizations will be formed, using local idle human resources, and implementing safe production methods. The goal is to improve the quality of life, increase income for local people, and help them have a stable and sustainable life.

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REFERENCES

Akyol, H., Riciputi, Y., Capanoglu, E., Caboni, M. F., & Verardo, V. (2016). Phenolic Compounds in the Potato and Its Byproducts: An Overview. *International Journal of Molecular Sciences*, *17*(6). https://doi.org/10.3390/ijms17060835

Ali, K. M., Wonnerth, A., Huber, K., & Wojta, J. (2012). Cardiovascular disease risk reduction by raising HDL cholesterol–current therapies and future opportunities. *British journal of pharmacology*, *167*(6), 1177-1194. https://doi.org/10.1111/j.1476-5381.2012.02081.x

Almuhayawi, M. S., Hassan, E. A., Alkuwaity, K. K., Abujamel, T. S., Mokhtar, J. A., Niyazi, H. A., Almasaudi, S. B., Alamri, T. A., Najjar, A. A., & Zabermawi, N. M. (2023). Enzymatic-based hydrolysis of digested potato peel wastes by amylase producing fungi to improve biogas generation. *Catalysts*, *13*(5), 913. https://doi.org/10.3390/catal13050913

Amin, A. M., Ahmad, A. S., Yin, Y. Y., Yahya, N., & Ibrahim, N. (2007). Extraction, purification and characterization of durian (Durio zibethinus) seed gum. *Food Hydrocolloids*, *21*(2), 273-279. https://doi.org/10.1016/j.foodhyd.2006.04.004

Amiza, M. A., Aziz, Y., Ong, B. C., Wong, V. L., & Pang, A. M. (2019). Cheap high fibre flour from local fruit seed. *Expo Science,Technology and Innovation*, *13*(3), 114-119.

Amornputti, S., Ketsa, S., & van Doorn, W. G. (2014). Effect of 1-methylcyclopropene (1-MCP) on storage life of durian fruit. *Postharvest Biology and Technology*, *97*, 111-114. https://doi.org/10.1016/j.postharvbio.2014.06.011
An, A. (2022). *Phát triển các sản phẩm có nguồn gốc từ ca cao trên địa bàn tỉnh Đắk Lắk*. Retrieved October 9th, 2024 from https://moit.gov.vn/tu-hao-hang-viet-nam/phat-trien-cac-san-pham-co-nguon-goc-tu-ca-cao-tren-dia-ban-tinh-dak-lak.html
Basmak, S., & Turhan, I. (2024). Production of β-mannanase, inulinase, and oligosaccharides from coffee wastes and extracts. *International Journal of Biological Macromolecules*, *261*, 129798. https://doi.org/10.1016/j.ijbiomac.2024.129798
Belaabed, R., Elabed, S., Addaou, A., Laajab, A., Rodríguez, M. A., & Lahsini, A. (2016). Synthesis of LTA zeolite for bacterial adhesion. *boletín de la sociedad española de cerámica y vidrio*, *55*(4), 152-158. https://doi.org/10.1016/j.bsecv.2016.05.001
Bharambe, K. P., Shimizu, Y., Kantoush, S. A., Sumi, T., & Saber, M. (2023). Impacts of climate change on drought and its consequences on the agricultural crop under worst-case scenario over the Godavari River Basin, India. *Climate Services*, *32*, 100415. https://doi.org/10.1016/j.cliser.2023.100415
Biswas, S., Mishra, R., & Bist, A. S. (2021). Passion to profession: A review of passion fruit processing. *Aptisi Transactions on Technopreneurship (ATT) Journal*, *3*(1), 48-57. https://doi.org/10.34306/att.v3i1.143
Burton-Freeman, B. (2000). Dietary fiber and energy regulation. *The Journal of nutrition*, *130*(2), 272S-275S. https://doi.org/10.1093/jn/130.2.272S
Chel-Guerrero, L., Barbosa-Martín, E., Martínez-Antonio, A., González-Mondragón, E., & Betancur-Ancona, D. (2016). Some physicochemical and rheological properties of starch isolated from avocado seeds. *International Journal of Biological Macromolecules*, *86*, 302-308. https://doi.org/10.1016/j.ijbiomac.2016.01.052
D'Aquino, S., Chessa, I., & Schirra, M. (2014). Heat Treatment at 38 °C and 75–80 % Relative Humidity Ameliorates Storability of Cactus Pear Fruit (Opuntia ficus-indica cv "Gialla"). *Food and Bioprocess Technology*, *7*(4), 1066-1077. https://doi.org/10.1007/s11947-013-1111-y
Dam, S. M., & Nguyen, D. V. (2013). Optimization of pectin extraction from fruit peel of purple passion fruit (Passiflora edulis Sims) in Vietnam. *Acta Horticulturae*, *989*, 279-284. http://doi.org/10.17660/ActaHortic.2013.989.36
Díaz, R. O., Moreno, L., Pinilla, R., Carrillo, W., Melgarejo, L. M., Martínez, O., Fernández-Trujillo, J. P., & Hernández, M. S. (2012). Postharvest behavior of purple passion fruit in Xtend® bags during low temperature storage. *Acta Horticulturae*, *934*, 727-731. https://doi.org/10.17660/ActaHortic.2012.934.95
Dieu, T. T. M. (2006). Greening food processing industries in Vietnam: Opportunities and constraints [Review]. *Environment, Development and Sustainability*, *8*(2), 229-249. http://doi.org/10.1007/s10668-005-9016-1
Đức, A. (2024). *Nguy cơ và thách thức đối với ngành sầu riêng tỉnh Đắk Lắk* Retrieved October 9th, 2024 from https://congan.daklak.gov.vn/-/nguy-co-va-thach-thuc-oi-voi-nganh-sau-rieng-tinh-ak-lak
Dương, H. (2023). *Phát triển cây chanh leo bền vững, mang lại thu nhập ổn định cho nông dân*. Retrieved October 9th, 2024 from https://nhandan.vn/phat-trien-cay-chanh-leo-ben-vung-post767581.html
Dutra, J. B., Blum, L. E. B., Lopes, L. F., Cruz, A. F., & Uesugi, C. H. (2018). Use of hot water, combination of hot water and phosphite, and 1-MCP as post-harvest treatments for passion fruit (Passiflora edulis f. flavicarpa) reduces anthracnose and does not alter fruit quality. *Horticulture, Environment, and Biotechnology*, *59*, 847-856. https://doi.org/10.1007/s13580-018-0092-1
Fallik, E. (2004). Prestorage hot water treatments (immersion, rinsing and brushing). *Postharvest Biology and Technology*, *32*(2), 125-134. https://doi.org/10.1016/j.postharvbio.2003.10.005
Formica-Oliveira, A. C., Martínez-Hernández, G. B., Díaz-López, V., Artés, F., & Artés-Hernández, F. (2017). Use of postharvest UV-B and UV-C radiation treatments to revalorize broccoli byproducts and edible florets. *Innovative Food Science & Emerging Technologies*, *43*, 77-83. https://doi.org/10.1016/j.ifset.2017.07.036
Friedman, M., Huang, V., Quiambao, Q., Noritake, S., Liu, J., Kwon, O., Chintalapati, S., Young, J., Levin, C. E., Tam, C., Cheng, L. W., & Land, K. M. (2018). Potato Peels and Their Bioactive Glycoalkaloids and Phenolic Compounds Inhibit the Growth of Pathogenic Trichomonads. *Journal of Agricultural and Food Chemistry*, *66*(30), 7942-7947. https://doi.org/10.1021/acs.jafc.8b01726
Fulgoni, V. L., Dreher, M., & Davenport, A. J. (2013). Avocado consumption is associated with better diet quality and nutrient intake, and lower metabolic syndrome risk in US adults: results from the National Health and Nutrition Examination Survey (NHANES) 2001–2008. *Nutrition journal*, *12*(1), 1-6. https://doi.org/10.1186/1475-2891-12-1
Gamay, R. A. J., Botecario, P. M. N., Sanchez, P. D. C., & Alvarado, M. C. (2024). Durian (Durio zibenthinus) waste: a promising resource for food and diverse applications—a comprehensive review. *Food Production, Processing and Nutrition*, *6*(1), 27. http://doi.org/10.1186/s43014-023-00206-4
Gautam, S., & Tripathi, J. (2016). Food processing by irradiation——an effective technology for food safety and security. *Indian Journal of Experimental Biology*, *54*(6), 700-707.
Glowacz, M., Mogren, L. M., Reade, J. P. H., Cobb, A. H., & Monaghan, J. M. (2013). Can hot water treatments enhance or maintain postharvest quality of spinach leaves? *Postharvest Biology and Technology*, *81*, 23-28. https://doi.org/10.1016/j.postharvbio.2013.02.004
Hidayat, T., & Sukasih, E. (2023). Processing of White Pepper Through the Combination of Soaking and Boiling Time Towards the Quality. *International Journal of Technology*, *14*(5), 1147-1156. https://doi.org/10.14716/ijtech.v14i5.4169
Hofman, P. J., Stubbings, B. A., Adkins, M. F., Meiburg, G. F., & Woolf, A. B. (2002). Hot water treatments improve 'Hass' avocado fruit quality after cold disinfestation. *Postharvest Biology and Technology*, *24*(2), 183-192. https://doi.org/10.1016/S0925-5214(01)00131-4
Hong, P., Hao, W., Luo, J., Chen, S., Hu, M., & Zhong, G. (2014). Combination of hot water, Bacillus amyloliquefaciens HF-01 and sodium bicarbonate treatments to control postharvest decay of mandarin fruit. *Postharvest Biology and Technology*, *88*, 96-102. https://doi.org/10.1016/j.postharvbio.2013.10.004
Hu, W., Jiang, A., Jin, L., Liu, C., Tian, M., & Wang, Y. (2011). Effect of heat treatment on quality, thermal and pasting properties of sweet potato starch during yearlong storage. *Journal of the Science of Food and Agriculture*, *91*(8), 1499-1504. https://doi.org/10.1002/jsfa.4340
Huwei, S., Asghari, M., Zahedipour-Sheshglani, P., & Alizadeh, M. (2021). Modeling and optimizing the changes in physical and biochemical properties of table grapes in response to natural zeolite treatment. *LWT-Food Science and Technology*, *141*, 110854. https://doi.org/10.1016/j.lwt.2021.110854
Huyền, L. T. T. (2021). *Phát triển hồ tiêu xuất khẩu ở các tỉnh Tây Nguyên theo hướng bền vững*. Retrieved October 9th, 2024 from https://kinhtevadubao.vn/phat-trien-ho-tieu-xuat-khau-o-cac-tinh-tay-nguyen-theo-huong-ben-vung-22144.html
Janićijević, D., Uskoković-Marković, S., Ranković, D., Milenković, M., Jevremović, A., Vasiljević, B. N., Milojević-Rakić, M., & Bajuk-Bogdanović, D. (2020). Double active BEA zeolite/silver tungstophosphates–Antimicrobial effects and pesticide removal. *Science of the Total Environment*, *735*, 139530. https://doi.org/10.1016/j.scitotenv.2020.139530
Kaewsuksaeng, S., Tatmala, N., Srilaong, V., & Pongprasert, N. (2015). Postharvest heat treatment delays chlorophyll degradation and maintains quality in Thai lime (Citrus aurantifolia Swingle cv. Paan) fruit. *Postharvest Biology and Technology*, *100*, 1-7. https://doi.org/10.1016/j.postharvbio.2014.09.020
Kag, S., Kumar, P., & Kataria, R. (2023). Potato Peel Waste as an Economic Feedstock for PHA Production by Bacillus circulans. *Applied Biochemistry and Biotechnology*, 1-15. https://doi.org/10.1007/s12010-023-04741-1
Kalaiselvan, R. R., Sugumar, A., & Radhakrishnan, M. (2018). Chapter 21 - Gamma Irradiation Usage in Fruit Juice Extraction. In G. Rajauria & B. K. Tiwari (Eds.), *Fruit Juices* (pp. 423-435). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-802230-6.00021-7
Kume, T., Furuta, M., Todoriki, S., Uenoyama, N., & Kobayashi, Y. (2009). Status of food irradiation in the world. *Radiation Physics and Chemistry*, *78*(3), 222-226. https://doi.org/10.1016/j.radphyschem.2008.09.009
Le Nguyen, T., Do, P. B. N., Nguyen, L. H., & Bui, T. H. (2024). Assessing the Current Status of Vietnam's Coffee Exports in the Period 2014-2023 in the Global Coffee Value Chain. *Journal of Multidisciplinary Science: MIKAILALSYS*, *2*(2), 240-252. https://doi.org/10.58578/mikailalsys.v2i2.3261
Li, X., Xing, Y., Shui, Y., Cao, X., Xu, R., Xu, Q., Bi, X., & Liu, X. (2021). Quality of bamboo shoots during storage as affected by high hydrostatic pressure processing. *International Journal of Food Properties*, *24*(1), 656-676. https://doi.org/10.1080/10942912.2021.1914084
Loaharanu, P. (1990). Food irradiation: Facts or fiction? *IAEA Bulletin*, *32*(2), 44-48.
López-Sánchez, A., Luque-Badillo, A. C., Orozco-Nunnelly, D., Alencastro-Larios, N. S., Ruiz-Gómez, J. A., García-Cayuela, T., & Gradilla-Hernández, M. S. (2021). Food loss in the agricultural sector of a developing country: Transitioning to a more sustainable approach. The case of Jalisco, Mexico. *Environmental Challenges*, *5*, 100327. https://doi.org/10.1016/j.envc.2021.100327
Mahajan, P. V., Caleb, O. J., Singh, Z., Watkins, C. B., & Geyer, M. (2014). Postharvest treatments of fresh produce. *Philosophical Transactions of the Royal Society A 372*(2017), 20130309. https://doi.org/10.1098/rsta.2013.0309
Maraei, R. W., & Elsawy, K. M. (2017). Chemical quality and nutrient composition of strawberry fruits treated by γ-irradiation. *Journal of Radiation Research and Applied Sciences*, *10*(1), 80-87. https://doi.org/10.1016/j.jrras.2016.12.004
Martins, D. M. S., Blum, L. E. B., Sena, M. C., Dutra, J. B., Freitas, L. F., Lopes, L. F., Yamanishi, O. K., & Dianese, A. C. (2004). Effect of hot water treatment on the control of papaya (Carica papaya L.) post harvest diseases. III International Symposium on Tropical and Subtropical Fruits 864,
Melin, P., Gomez, A., Loyola, C., De Bruijn, J., Valdes, H., & Solar, V. (2019). Effect of doping natural zeolite with copper and zinc cations on ethylene removal and postharvest tomato fruit quality. *Chemical Engineering Transactions*, *75*, 265-270. https://doi.org/10.3303/CET1975045
Mounya, K. S., & Chowdary, A. R. (2024). Optimization of ultrasound-assisted pectin recovery from cocoa by-products using response surface methodology

[Article]. *Journal of the Science of Food and Agriculture*, *104*(11), 6714-6723. http://doi.org/10.1002/jsfa.13498
Mozaffarian, D. (2016). Dietary and policy priorities for cardiovascular disease, diabetes, and obesity: a comprehensive review. *Circulation*, *133*(2), 187-225. https://doi.org/10.1161/CIRCULATIONAHA.115.018585
Nair, P. M., & Sharma, A. (2016). 2.02 - Food Irradiation. In K. Knoerzer & K. Muthukumarappan (Eds.), *Innovative Food Processing Technologies* (pp. 19-29). Elsevier. https://doi.org/https://doi.org/10.1016/B978-0-12-815781-7.02950-4
Ortiz-Araque, L. C., Darré, M., Civello, P. M., & Vicente, A. (2022). Short UV-C Treatments to Extend the Shelf-Life of Fresh-Cut Strawberries (Fragaria x ananassa Duch cv. Camarosa). *Ingeniería e Investigación*, *42*(3), e88627. https://doi.org/10.15446/ing.investig.88627
Pambudi, S., Saechua, W., & Jongyingcharoen, J. S. (2023). A thermogravimetric assessment of eco-friendly biochar from oxidative torrefaction of spent coffee grounds: combustion behavior, kinetic parameters, and potential emissions. *Environmental Technology & Innovation*, 103472. https://doi.org/10.1016/j.eti.2023.103472
Pathak, B., Omre, P., Bisht, B., & Saini, D. (2018). Effect of thermal and non-thermal processing methods on food allergens. *Progressive Research An International Journal*, *13*, 314-319.
Prabhu, R., & Devaraju, A. (2018). Developing an antimicrobial packaging to improve the shelf life of meat using silver zeolite coating on BOPP film. *Materials Today: Proceedings*, *5*(6), 14553-14559. https://doi.org/10.1016/j.matpr.2018.03.045
Pujol, D., Liu, C., Gominho, J., Olivella, M., Fiol, N., Villaescusa, I., & Pereira, H. (2013). The chemical composition of exhausted coffee waste. *Industrial Crops and Products*, *50*, 423-429. https://doi.org/10.1016/j.indcrop.2013.07.056
Ramos-Aguilar, A. L., Ornelas-Paz, J., Tapia-Vargas, L. M., Ruiz-Cruz, S., Gardea-Béjar, A. A., Yahia, E. M., de Jesús Ornelas-Paz, J., Pérez-Martínez, J. D., Rios-Velasco, C., & Ibarra-Junquera, V. (2019). The importance of the bioactive compounds of avocado fruit (Persea americana Mill) on human health. *Biotecnia*, *21*(3), 154-162. https://doi.org/10.18633/biotecnia.v21i3.1047
Reichembach, L. H., Guerrero, P., de Oliveira Petkowicz, C. L., & de la Caba, K. (2024). Valorization of pectins from coffee wastes for the development of pectin-chitosan films. *Carbohydrate Polymers*, *334*, 122057. https://doi.org/10.1016/j.carbpol.2024.122057
Rodríguez-Martínez, B., Coelho, E., Gullón, B., Yáñez, R., & Domingues, L. (2023). Potato peels waste as a sustainable source for biotechnological production of biofuels: Process optimization. *Waste Management*, *155*, 320-328. https://doi.org/10.1016/j.wasman.2022.11.007
Ruan, J., Li, M., Jin, H., Sun, L., Zhu, Y., Xu, M., & Dong, J. (2015). UV-B irradiation alleviates the deterioration of cold-stored mangoes by enhancing endogenous nitric oxide levels. *Food Chemistry*, *169*, 417-423. https://doi.org/10.1016/j.foodchem.2014.08.014
Sadeghi-Shapourabadi, M., Elkoun, S., & Robert, M. (2023). Microwave-Assisted Chemical Purification and Ultrasonication for Extraction of Nano-Fibrillated Cellulose from Potato Peel Waste. *Macromol*, *3*(4), 766-781. https://doi.org/10.3390/macromol3040044
Salazar-López, N. J., Domínguez-Avila, J. A., Yahia, E. M., Belmonte-Herrera, B. H., Wall-Medrano, A., Montalvo-González, E., & González-Aguilar, G. A. (2020). Avocado fruit and by-products as potential sources of bioactive compounds. *Food Research International*, *138*, 109774. https://doi.org/10.1016/j.foodres.2020.109774
Sheng, K., Zheng, H., Shui, S., Yan, L., Liu, C., & Zheng, L. (2018). Comparison of postharvest UV-B and UV-C treatments on table grape: Changes in phenolic compounds and their transcription of biosynthetic genes during storage. *Postharvest Biology and Technology*, *138*, 74-81. https://doi.org/10.1016/j.postharvbio.2018.01.002
Shinde, S., Sawate, A., Kshirsagar, R., & Patangare, S. (2019). Effect of pre-treatment on quality attributes of fresh bamboo shoot pickle. *Journal of Pharmaceutical Innovation*, *8*(3), 257-260.
Smith, A. W., Poulston, S., Rowsell, L., Terry, L. A., & Anderson, J. A. (2009). A new palladium-based ethylene scavenger to control ethylene-induced ripening of climacteric fruit. *Platinum Metals Review*, *53*(3), 112-122. https://doi.org/10.1595/147106709X462742
Tai, N. V., Linh, M. N., & Thuy, N. M. (2021). Modeling of thin layer drying characteristics of "Xiem" banana peel cultivated at U Minh district, Ca Mau province, Vietnam. *Food Research*, *5*(5), 244-249. https://doi.org/10.26656/fr.2017.5(5).180
Tan, C.-H., Ishak, W. R. W., Easa, A. M., Hii, C.-L., Meng-Jun Chuo, K., How, Y.-H., & Pui, L.-P. (2023). From waste to wealth: a review on valorisation of durian waste as functional food ingredient. *Journal of Food Measurement and Characterization*, *17*(6), 6222-6235. https://doi.org/10.1007/s11694-023-02087-0
Terry, L. A., Ilkenhans, T., Poulston, S., Rowsell, L., & Smith, A. W. J. (2007). Development of new palladium-promoted ethylene scavenger. *Postharvest Biology and Technology*, *45*(2), 214-220. https://doi.org/10.1016/j.postharvbio.2006.11.020
Thuận, M. (2023). *Cách nào lấy lại vị thế cho trái bơ Tây Nguyên?* Retrieved October 9th, 2024 from https://baodaklak.vn/kinh-te/202309/cach-nao-lay-lai-vi-the-cho-trai-bo-tay-nguyen-2c21fda/
Thuy, N. M., Dung, N. C., Cuong, N. P., Tuyen, N. T. M., & Thanh, D. K. (2011). Influence of raw material and tannin addition to "sim" (Hill Gooseberry) wine quality. *Can Tho University Journal of Science*, *18B*, 228-237.
Thuy, N. M., Lien, D. T. P., Tri, N. M., & Linh, N. C. (2013). *Giáo trình Kỹ thuật sau thu hoạch nông sản*. Nhà xuất bản Đại học Cần Thơ.
Thuy, N. M., & Tuyen, N. T. M. (2016). *Kỹ thuật sau thu hoạch (Bảo quản và Chế biến) một số loại nông sản ở đồng bằng sông Cửu Long*. Can Tho Publishing House.
Thuy, N. M., & Tuyen, N. T. M. (2017). *Kỹ thuật Chế biến Rau Quả. Nhà xuất bản Đại học Cần Thơ*. Can Tho University Publishing House.
Tzeng, J.-H., Weng, C.-H., Huang, J.-W., Shiesh, C.-C., Lin, Y.-H., & Lin, Y.-T. (2019). Application of palladium-modified zeolite for prolonging post-harvest shelf life of banana. *Journal of the Science of Food and Agriculture*, *99*(7), 3467-3474. https://doi.org/10.1002/jsfa.9565
Uyen, N. N., Berghold, H., & Schnitzer, H. (2007). Utilization of agro-based industrial by-products for biogas production in Vietnam. Proceedings of the 3rd IASTED Asian Conference on Power and Energy Systems, AsiaPES 2007,
Van Hau, T., Tien, D. H., Thuy, N. M., Ky, H., Yen, T. T. O., Van Tri, M., Van Hoa, N., & Hieu, T. S. (2023). Durian. In *Tropical and Subtropical Fruit Crops* (pp. 161-200). Apple Academic Press. https://doi.org/https://doi.org/10.1201/9781003305033-3
Van Tai, N., Linh, M. N., & Thuy, N. M. (2021). Optimization of extraction conditions of phytochemical compounds in "Xiem" banana peel powder using response surface methodology. *Journal of Applied Biology and Biotechnology*, *9*(6), 56-62. https://doi.org/10.7324/JABB.2021.9607
Van Tai, N., Minh, V. Q., & Thuy, N. M. (2023). Food processing waste in vietnam: Utilization and prospects in food industry for sustainability development. *Journal of microbiology, biotechnology and food sciences*, *13*(1), e9926. https://doi.org/10.55251/jmbfs.9926
Villa, C. C., Galus, S., Nowacka, M., Magri, A., Petriccione, M., & Gutiérrez, T. J. (2020). Molecular sieves for food applications: A review. *Trends in Food Science & Technology*, *102*, 102-122.
Wakholi, C., Cho, B.-K., Mo, C., & Kim, M. S. (2015). Current state of postharvest fruit and vegetable management in East Africa. *Biosystems Engineering*, *40*(3), 238-249. https://doi.org/10.5307/JBE.2015.40.3.238
Wanamaker, R., & Grimm, I. (2004). Encyclopedia of gastroenterology. *Gastroenterology*, *127*(4), 1274-1275. https://doi.org/10.1053/j.gastro.2004.08.036
Wang, J.-S., Wang, A.-B., Zang, X.-P., Tan, L., Xu, B.-Y., Chen, H.-H., Jin, Z.-Q., & Ma, W.-H. (2019). Physicochemical, functional and emulsion properties of edible protein from avocado (Persea americana Mill.) oil processing by-products. *Food Chemistry*, *288*, 146-153. https://doi.org/10.1016/j.foodchem.2019.02.098
Weng, M., Li, Y., Wu, L., Zheng, H., Lai, P., Tang, B., & Luo, X. (2020). Effects of passion fruit peel flour as a dietary fibre resource on biscuit quality. *Journal of Food Science and Technology*, *41*, 65-73. https://doi.org/10.1590/fst.33419
WHO. (2015). *WHO estimates of the global burden of foodborne diseases: foodborne disease burden epidemiology reference group 2007-2015*. World Health Organization.
Zhang, W., & Jiang, W. (2019). UV treatment improved the quality of postharvest fruits and vegetables by inducing resistance. *Trends in Food Science & Technology*, *92*, 71-80. https://doi.org/10.1016/j.tifs.2019.08.012
Zuorro, A., & Lavecchia, R. (2012). Spent coffee grounds as a valuable source of phenolic compounds and bioenergy. *Journal of Cleaner Production*, *34*, 49-56. https://doi.org/10.1016/j.jclepro.2011.12.003