EXPERIMENTAL INVESTIGATION ON LASER DRYING OF SARAWAK BLACK PEPPER BERRIES

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PRESENTATION OVERVIEW

INTRODUCTION

LITERATURE REVIEW

PROBLEM STATEMENT

RESEARCH QUESTIONS

OBJECTIVES

METHODOLOGY

REFERENCES

THE USES OF BLACK PEPPER (PIPER NIGRUM L.)

FLAVOURING

SEASONING

TRADITIONAL MEDICINE

INTRODUCTION

- During the production and storage of black pepper, moisture content is a crucial quality factor that must be constantly monitored.
- To guarantee that the black peppers are safe for storing and transportation, they must undergo an intense dehydration process.

INTRODUCTION

- Drying is one of the effective methods in food storage with the primary focus of extending product shelf life by reducing the water activity.
- It prevents enzymatic and microbial activity, hence, increasing the product shelf life.

IMPORTANCE OF DRYING IN FOOD INDUSTRY

- Most prevalent fruits are seasonal, and thus may not be obtainable in fresh forms throughout the year (Donno et al., 2019).
- Drying is one of the most effective methods for preserving agricultural commodities and prolonging the shelf life of fruits (Turan, 2018; Zhang et al., 2018).

IMPORTANCE OF DRYING IN FOOD INDUSTRY

- Changes in consumer behaviors, as well as a lack of time to cook a decent meal at home, force consumers to dine out of the house, frequently opting for snacks (Tylewicz et al., 2020).
- As a result, the food sector is concentrating its efforts on producing healthy fruit snacks that may supply consumers with nutrient-dense energy snacks (Tylewicz et al., 2020).
- Healthy snacks have useful elements that benefit human health and are typically well-balanced in nutrients (Tylewicz et al., 2020).

IMPORTANCE OF DRYING IN FOOD INDUSTRY

- Dried fruits are convenient to store and distribute throughout the year, and they might be regarded as healthier alternatives to traditional snacks (Tylewicz et al., 2020).
- According to (Donno et al., 2019), dried fruits are high in important health-promoting substances and nutrients, and their intake is linked to the quality of diet.
- Among the health benefits of dried fruit snacks are protection against obesity, type II diabetes, osteoporosis, cardiovascular disease, and cancer (Donno et al., 2019).

METHODS OF DRYING

SPRAY DRYING

FREEZE DRYING

MICROWAVE DRYING

LASER DRYING

METHODS OF DRYING

SPRAY DRYING

Raw materials for ceramic tiles, whiteware clays, detergents, and milk powder can be done with spray drying (Golman & Yermukhambetova, 2019).

FREEZE DRYING

Encapsulation of sensitive bioactive compounds (Pudziuvelyte et al., 2020) and pharmaceutical dry powders (Wang et al., 2021) are typically prepared by freeze drying.

METHODS OF DRYING

MICROWAVE DRYING

It has been applied in drying red bell peppers (Zahoor & Khan, 2021), powder synthesis, and enhancing the chemical and physical characteristics of a variety of products (Ouertani et al., 2018).

LASER DRYING

Laser drying has been utilized in inkjet printing (Sakamoto et al., 2015) and production of trehalose amorphous solids (M. Young et al., 2018).

DRYING OF BLACK PEPPER

SUN DRYING

- Peppercorn is often dried in the sun (Zainal Abidin et al., 2020).
- The sun drying of peppercorn takes roughly 4 to 7 days, depending on the intensity of the sun and the length of hours of sunshine acquired, and the time can be prolonged on wet days (Zainal Abidin et al., 2020).

SPOUTED BED DRYING

- The drying of black pepper has been studied in a conventional spouted bed dryer (Jayatunga & Amarasinghe, 2019).
- An air blower, air heater, a spouted bed contactor, and a cyclone separator for fine particle retention comprise the drying unit. The blower is powered by a 2.2 kW motor, while the air heater has a 12 kW capacity.
- The black pepper samples were dried in a spouted bed dryer at four different temperatures: 45 °C, 55 °C, 65 °C, and 75 °C, while all other parameters remained constant.

DRYING OF BLACK PEPPER

ROTARY DRUM DRYING

- A control system for black pepper rotary drum dryer has been developed by (Zainal Abidin et al., 2020).
- The designed system employed Arduino Mega 2560 REV board as a microcontroller.
- A type K thermocouple with MAX6675 thermocouple amplifier and S-type load cells (TAS501) with HX711 load cell amplifier were employed as input sensor to microcontroller.
- The dryer has reduced the drying time from 4 to 7 days to 3 to 5 hours.

PROBLEM STATEMENT

- Sun drying technique has some disadvantages, including non-uniform daytime sun light (Jayatunga & Amarasinghe, 2019) and issues in the wet seasons (Deng et al., 2017).
- Hot air drying with the advantages of reducing the volume and weight of the product, improving the transportation process and making it possible to store the product in ambient temperature (Abbaspour-Gilandeh et al., 2019) however, use comparatively high temperatures for prolonged periods of time, thus lowering the final product quality (Shende & Datta, 2020; Zainal Abidin et al., 2020).

PROBLEM STATEMENT

- Microwave drying which is the alternative approach over hot air-drying technique (Horuz et al., 2017) due to its high drying rate, high energy efficiency, higher quality for the product, and efficient use of space (Abbaspour-Gilandeh et al., 2019) also comes with some disadvantages such as possible textural damage, limited penetration of the microwaves through the samples (Horuz et al., 2017), non-uniform heating and surface overheating results (Zeng et al, 2019).
- Freeze-dried foods retain a lot of their original flavor and phytochemical properties while also being exceptionally light and crispy (Ahmed et al., 2022; Donno et al., 2019). However, freeze drying has a scarcity of expensive equipment investment, consumes a lot of energy, and takes a long time to dry (Zeng et al., 2019).

PROBLEM STATEMENT

- An appropriate drying system and the development of different drying methods are needed to reduce the moisture content of black pepper and shorten the drying process.
- The literature lacks a detailed description of the laser-based drying process and its effect on black pepper quality.

RESEARCH QUESTIONS

1. What are the optimum laser parameters for drying black pepper berry to achieve the best drying characteristics?
2. What are the parameters that may cause ablation and burning of black pepper berry?
3. How to design an effective set of experiments and optimize the laser drying parameters with respect to drying characteristics?

OBJECTIVES

1. To experimentally investigate the optimum laser processing parameters in drying black pepper.

2. To assess the effects on morphological, structural, and thermal properties of laser processed berries by different analytical techniques.

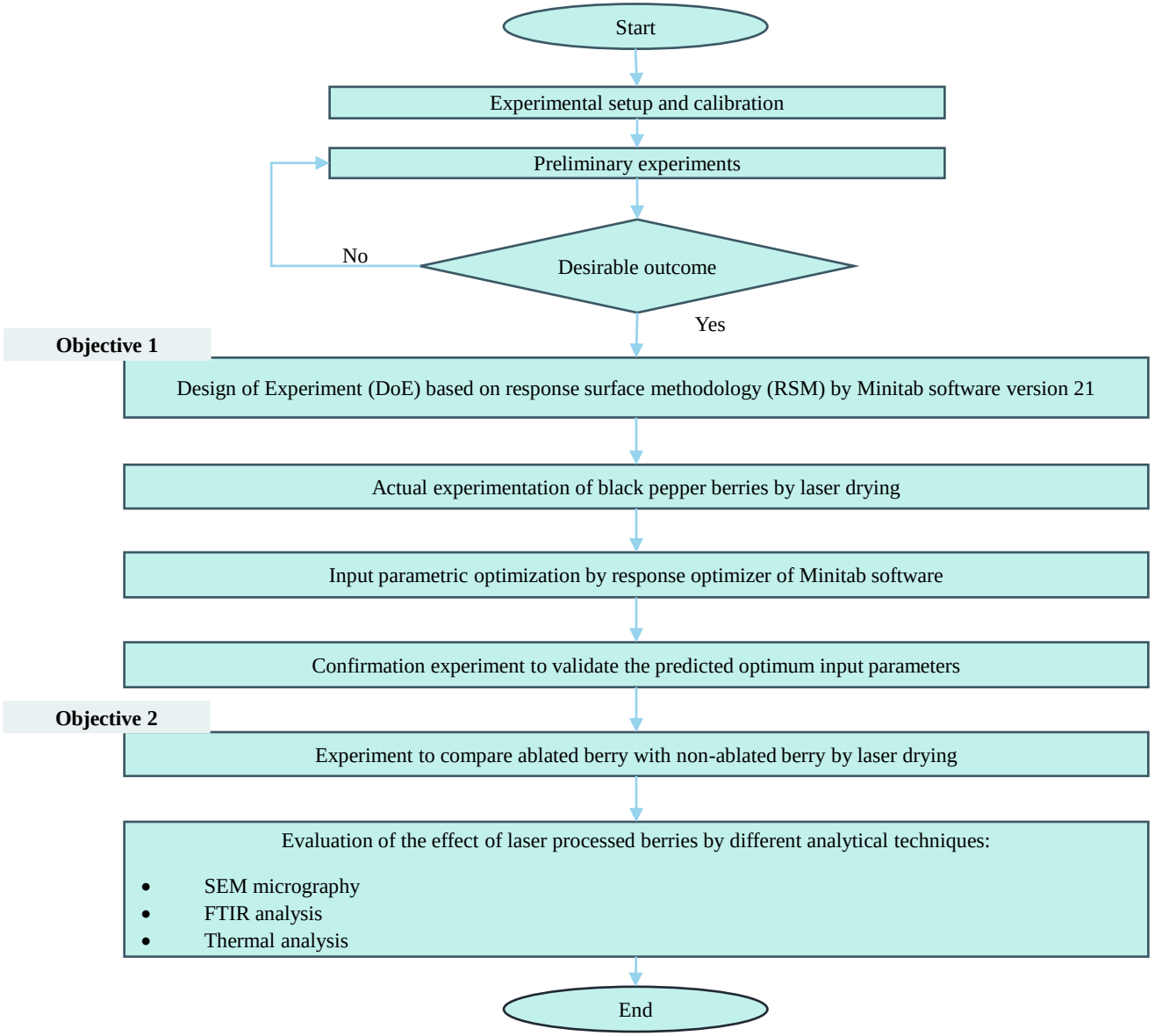

Figure 1: Flowchart of research methodology

MATERIALS

The materials used for this study are black pepper (Piper nigrum L.) seeds (green colour), which are purchased from Sunday Market located in Kuching Division, Sarawak, Malaysia

Figure 2: Sarawak black pepper

LASER EQUIPMENT

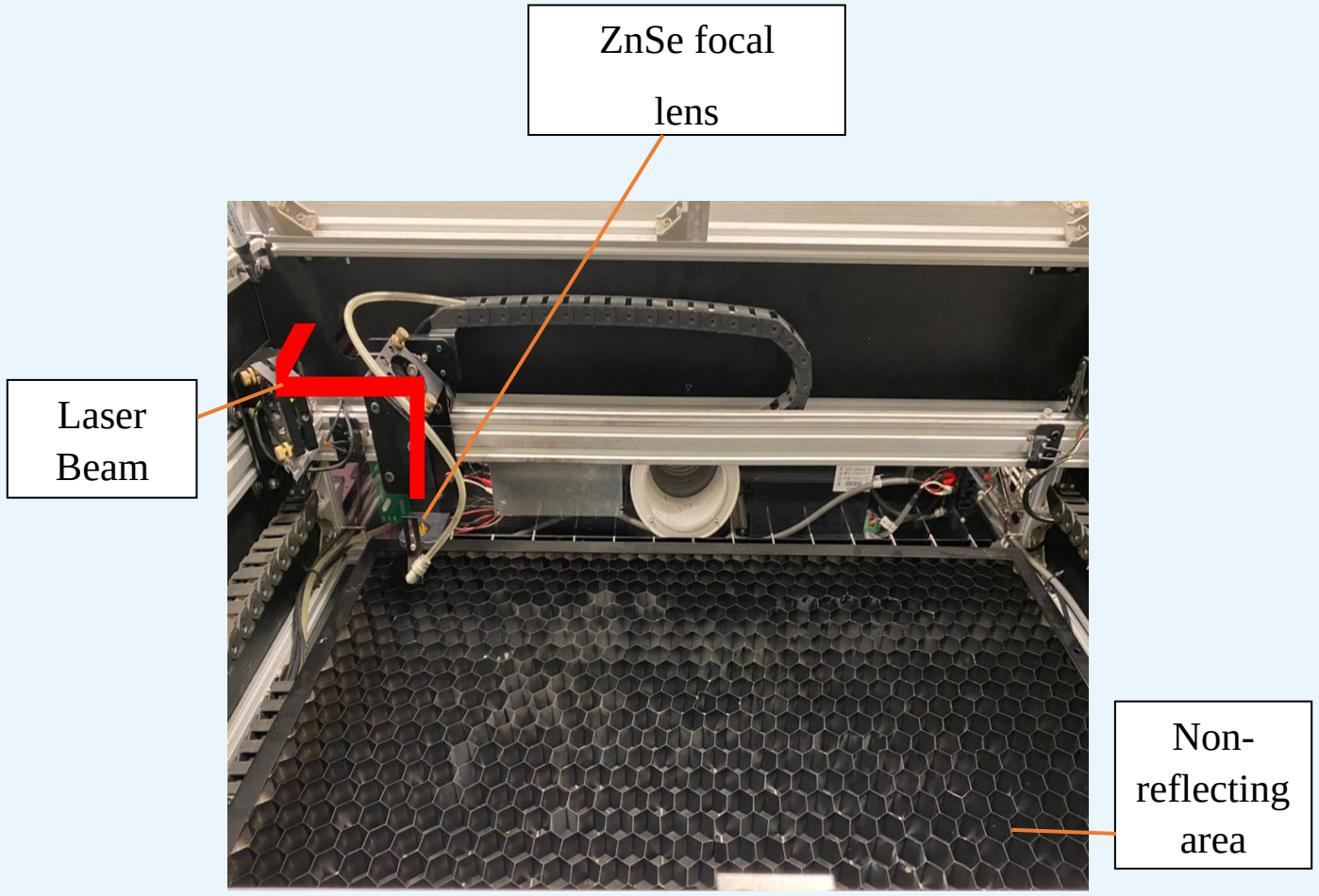

Figure 3: CO_2 laser machine

RESPONSE SURFACE METHODOLOGY (RSM) OPTIMIZATION

- The experimental design will be conducted with the help of Minitab software version 21 to determine the effect of three independent variables; laser power (0.8-1.0 W), drying speed (7-11 mm/s) and number of laser passes (3-5) on heat affected zone (HAZ).
- RSM paired Box–Behnken design (BBD) is used to model how the process variables affect the response variables.

RESPONSE SURFACE METHODOLOGY (RSM) OPTIMIZATION

Table 1: Independent variables and their levels in a designed experiment

Codes	Independent Parameters	Unit	Low-Level	High-Level
A	Laser power	W	0.8	1.0
B	Drying speed	mm/s	7	11
C	Laser passes	-	3	5

RESPONSE SURFACE METHODOLOGY (RSM) OPTIMIZATION

Table 2: Sets of experiments based on Box-Behnken design

Experiment Parameters				
No. Standard Order	Run Order	Laser Power	Drying Speed	Number of Passes
1	7	0.8	7	4
2	9	1.0	7	4
3	4	0.8	11	4
4	2	1.0	11	4
5	6	0.8	9	3
6	5	1.0	9	3
7	1	0.8	9	5
8	12	1.0	9	5
9	13	0.9	7	3
10	15	0.9	11	3
11	10	0.9	7	5
12	8	0.9	11	5
13	11	0.9	9	4
14	3	0.9	9	4
15	14	0.9	9	4

MORPHOLOGICAL ANALYSIS

Scanning electron microscopy (SEM; TM3030, HITACHI) will be used for obtaining micrographs of the dried peppers and their microstructure.

FUNCTIONAL GROUP ANALYSIS

- Fourier-transform infrared spectroscopy (FTIR) analysis will be conducted using ATR-FTIR spectroscopy on a Shimadzu Fourier Transform Infrared Spectrophotometer, Model IRAffnity-1S.
- FTIR is performed with Attenuated Total Reflection (ATR) method in the range of 4000 to 600 cm^{-1} wavenumbers.

THERMOGRAVIMETRIC AND DIFFERENTIAL THERMAL ANALYSIS (TGA–DTA)

Differential thermal analysis (DTA) and thermogravimetric analysis (TGA) will be conducted in a nitrogen gas atmosphere using Shimadzu DTG-60H simultaneous DTA-TG (Differential Thermal Analysis-ThermoGravimetric) in the temperature range 25–600°C.

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THANK YOU