

EVALUATION OF DRIED STRAW MUSHROOM (*Volvariella volvacea*) CHARACTERISTICS DRYING BY FAR INFRA RED

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ABSTRACT

A study of the application of far infrared (FIR) radiation designed for drying sliced-straw mushroom. Far Infrared (FIR) radiation with 25-1000 μ m of wavelength was selected. FIR irradiation was effective in decreasing drying time while minimizing changes in color. The objective of the study was to evaluate: (1) the empirical performance of FIR dryer; (2) physical and chemical characteristics of dried product such as color, ascorbic acid, flavor, and chlorophyll. The treatments of the experiment was limited to the temperature variations and the data analyses was conducted to identify the drying rate of sliced-straw mushroom at specified temperatures of FIR radiation (50, 60, 65 and 75 °C). The nutrients content as well as the physical and chemical characteristics are discussed. The FIR radiator with 8.7 μ m of long wave is set at optimum distance between conveyor and FIR rays (18 \pm 2 cm) with tunnel temperature at range 60 °C. The color's appearance of dried sliced-straw mushroom by FIR method was significantly consistent by blanching treatment with 0.1% *sodium metabisulphite* solution. the rehydration ratio of the dried mushroom was 65.42 \pm 5.08%. This study concludes that the application of FIR drying technology is a prospective method to produce high quality of dried sliced-straw mushroom.

Keywords : far infrared, straw mushroom, physical-chemical characteristics of dried mushroom

ABSTRAK

Evaluasi karakteristik pengeringan jamur merang kering (*Volvariella volvacea*) menggunakan *Far Infra Red* (FIR).

Makalah ini memaparkan hasil studi penerapan radiasi *Far Infra Red* (FIR) yang dirancang untuk pengeringan jamur merang (*Volvariella volvacea*). Radiasi FIR dengan panjang gelombang 25-1000 μ m dipilih sebagai pengering yang digunakan dalam penelitian ini. Radiasi FIR efektif dalam menurunkan waktu pengeringan dengan perubahan warna minimal. Tujuan dari studi ini mengevaluasi (1) Kinerja teknologi pengeringan FIR; (2) karakteristik fisiko kimia produk kering meliputi warna, asam askorbat, aroma dan klorofil. Pembahasan meliputi laju pengeringan jamur merang dalam bentuk irisan pada suhu 50, 60, 65 dan 75 °C. Kandungan nutrisi maupun karakteristik fisiko kimia. Radiator FIR dengan panjang gelombang 8,7 μ m dengan jarak optimum antara konveyor dan FIR radiator (18 \pm 2 cm) serta suhu lorong pada rentang 60 °C. Penampilan warna produk jamur hasil pengeringan dengan metoda pengeringan FIR dan proses blansir dengan 0,1% larutan Natrium meta bisulfate menghasilkan produk dengan rasio rehidrasi sebesar 65,42 \pm 5,08%. Hasil studi ini menyimpulkan bahwa penerapan teknologi pengeringan FIR merupakan metoda yang prospektif untuk menghasilkan jamur kering yang berkualitas.

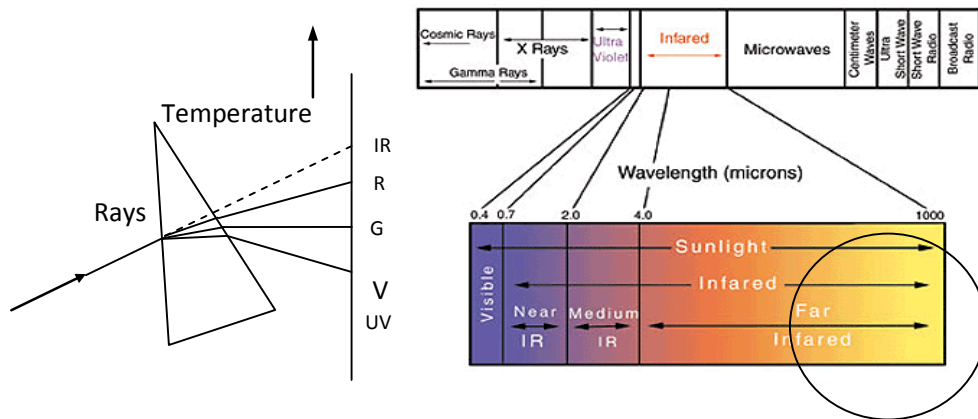
Kata Kunci: far infrared, Jamur merang, karakteristik fisiko kimia.

INTRODUCTION

To produce high quality using an efficient drying process with minimal changing of physical and chemical characteristics, a suitable drying method is required. The selection of an alternative drying system should focus on the method that minimize quality deterioration due to

perishable food. The drying capability is specified with moisture reduction around 80-90%wb or 11.5 to 32 MJ of required energy¹.

Most dried vegetables are prepared using hot-air dryer; however, this method is not suitable for food dehydration of those ingredients used in instant foods, since the rehydration rate of the vegetables is too slow. Freeze drying is a competitive alternative process for this



Note: IR: Infrared; R: Red; G: Green; V: Violet; UV: Ultra Violet

Figure.1. Far Infrared (FIR) rays and wavelength

application, but it is comparatively expensive. The Far Infrared drying method is expected to represent a new process for the production of high quality dried foods at low cost.

Infrared light lies between the visible and microwave portions of electromagnetic spectrum (Fig. 1). Infrared light has a range of wavelengths, just like visible light and “far infrared“ is closer to the microwave region of the electromagnetic spectrum. Moreover, the wavelength of FIR radiation is about 25-1000 μm^1 and vegetables have infrared absorption wavelength in this region. For this reason, FIR radiation was selected as a prospective technology to be used for drying purpose.

The effect of FIR in the drying process (Figure 2) shows that the cuticle of material, which was dried by FIR, doesn't burn. The cuticle has the function to keep the moisture of the material to maintain flexibility. Moisture adheres to the surface of material. The moisture is a cluster of molecules of water. FIR cut the cluster by the resonance energy. The molecule that absorbs energy rushes into air. A molecule of the material also receives

energy. But it cannot rush into air because it is hindered to move by the structure of the material. The activated molecule re-activates the cluster of molecules in the material.

Vegetables with their varieties have specific color, taste, flavor and physical properties are important as the source of quality performance. The low quality of most vegetables being a perishable food is caused by the lack of awareness about post harvest handling and processing technology. FIR irradiation was effective at decreasing drying time while minimizing changes in color².

Any processing of the raw material can be expected to result in loss of nutrients, chlorophyll degradation or conversion to isomeric that has a smaller nutrient's activity nutritional value. FIR heating can be controlled easily to create delicate heating condition for savory aromas and the mild tastes³. FIR heating may have allowed a given pasteurization target level to be achieved at lower temperatures than that by conductive heating, while maintaining enzyme activity level⁴.

Radiated`absorption occurred in the whole of

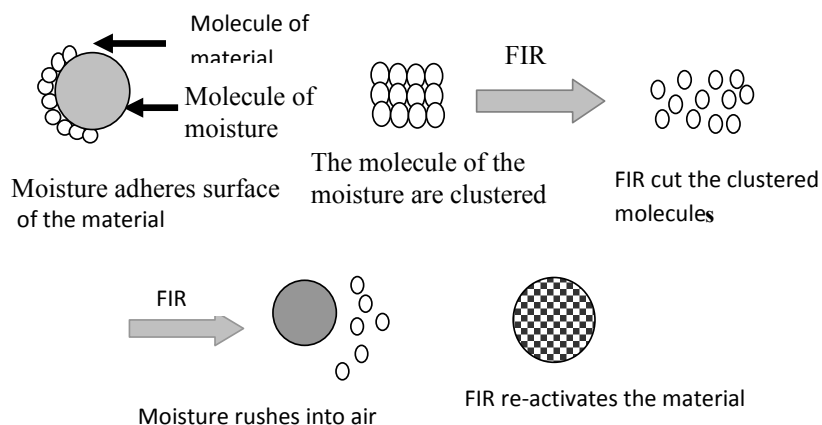


Figure. 2. Effect of FIR radiation in drying process

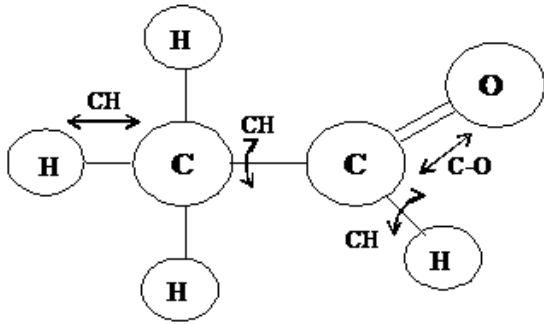


Figure 3. Dynamic molecules with oscillation frequency of FIR convert to temperature increase

dynamic molecules of the material with the similar oscillation frequency as FIR electromagnetic wave to increase the temperature Figure 3.

Kompany *et al.*⁵ investigated the retention of five major flavor components of cultivated mushrooms during freeze-drying and the effect of process conditions on the kinetics of loss of these components. The loss of volatiles was independent of the volatility of the compound and the relative loss for 1-octen 3-ol was more important than that of other components, whatever the operating conditions were.

Far infrared radiation has excellent radiation characteristics and high-energy conversion rates and this can be achieved by using ceramic-coated radiators³. Using such a radiator, the dehydrating synergy, generated by far infrared radiation heating, the drying of welsh onion resulted in significant positive effects on chlorophyll content. However, it is important that the FIR energy is adjusted so as not to cause deterioration of the quality of the sample, since the sample's surface temperature rises and causes deterioration of the color when FIR energy is too great. Mongpranet *et al.*⁶

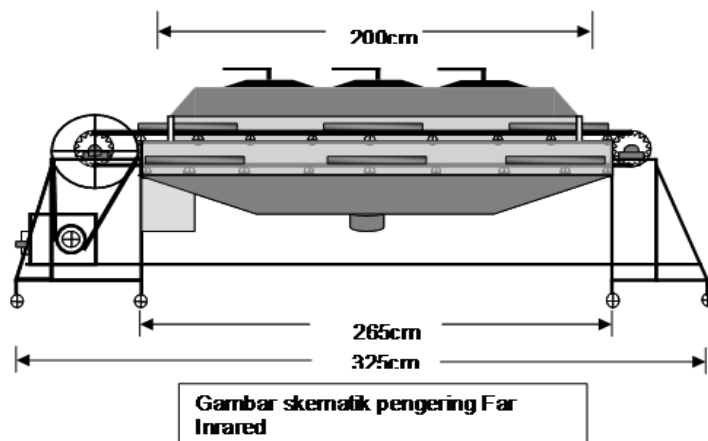
reported that the radiation intensity influenced the a^* for rehydrated onions, and the L^* and E^*_{ab} for dehydrated onions. Prabhanjan *et al.*⁷ concluded in his work that microwaves decrease drying time, but that they alter the color of the food. Meanwhile Tein *et al.*⁸ showed that drying in vacuum can produce food that possesses new texture. Sawai *et al.*⁴ studied FIR radiation as a method for thermal processing for food stuff. The application of FIR in thermal processing was expected to improve the hygiene of working environments by eliminating the need for a heating medium.

In this paper a study of the application of far infrared (FIR) radiation designed for drying sliced-straw mushroom is developed and the study was aimed at evaluating: (1) the empirical characteristics of dried sliced-straw mushroom (*Volvariella volvacea*) by FIR radiation; (2) physical and chemical characteristics of dried product such as color, ascorbic acid, flavor, and chlorophyll.

MATERIAL AND METHOD

Material

The research was conducted in Karawang Post Harvest Research Station, Indonesian Center for Agricultural Postharvest Research and Development (ICAPRD), from 2003 to 2005. The material comprised of straw mushroom. The fresh mushroom was obtained from local farmers in Karawang, West Java, Indonesia and supporting material such as laboratory chemical agents and facilities such as drying apparatus. The FIR dryer was designed and constructed as a part of this research program (Figure 4). The FIR dryer is a continuous movable conveyor type dryer powered by an electric motor with one Hp and connected to a speed



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Components:

1. Control panel box
2. Lower conveyor
3. Exhaust fan
4. Drying tunnel
5. Upper conveyor
6. FIR Radiator
7. Transmission pulley
8. Gear box reducer

Figure 4. Schematic of Far Infrared dryer⁹

Table 2. Specification of FIR Dryer

No	Components	Specification
1	Capacity (kg input/hour)	2,5
2	Fuel	LPG
3	Gas pressure	9 Kgf/min
4	Consumption	0,3 kg/hour
5	Dimension (L x W x H)	300 x 40 x 75 cm
6	Power driver	1 hp (electric motor)
7	Transmission system	stainless steel chain
8	Radiator	3 units
9	Energy (Kkal/hr)	2000
10	Radiation temperature (°C)	40-100°C
11	Exhaust air velocity	1,17 m/s
12	Conveyor speed	1 m/min
13	Long wave (Wien Law)	8,7 μm (60°C)*

*) Wien constant of long wave 2.897

reducer (gear box) with 60% reduction. The main thermal source consisted of three FIR radiators of 2000 Kcal/hr and those are fueled by one unit of 42 kg of Liquefied Petroleum Gas (LPG) tanks. The dryer is also equipped with an exhaust fan of 0.1 Hp powered. The specification of the FIR dryer is mentioned in Table 2.

Methods

The fresh mushroom was obtained from local farmers in Karawang, West Java, Indonesia. The drying procedure for sliced-straw mushroom (*Volvariella volvacea*) is as followed: After rinsing the straw mushrooms were sliced (3-4 mm thickness). They were then soaked in 0.1% *natrium meta bisulphyte* solution to inactivate enzymatic browning during thermal heating, followed by blanching into hot water (80°C) for 30 seconds. The blanched-sliced straw mushrooms were spread on a wire mesh trays in a single layer. Drying was done in the FIR dryer described in Fig.4. The FIR dryer was designed in such a way that the slices of mushrooms on the trays could be heated by FIR radiation on a movable wire conveyor. The dryer was equipped with a thermometer. The samples were picked up at a pre-defined time interval for measurement of the moisture content changes during the drying process and for measuring other quality components.

Measured Parameters

The parameters were analyzed during the experiment at chemical laboratory as follows.: moisture content by oven method (AOAC), ascorbatic acid was measured by Spectrophotometer. The flavor was determined through volatile reduction substance (VRS) with gas chromatography method. Chlorophyll determination

was measured by spectrophotometer method. Color was detected by using a Chromameter. Rehydration was evaluated with gravimetric method.

Ascorbic acid measurement (Spectrophotometer)

Sample of 50-100 gram were mixed and blended with the equivalent weight of 6% of HPO₃. The blended sample was mixed with 100 ml of 2% HPO₃ and then 5 ml of the solution was added to 10 ml of indophenol’s solution. Afterward the absorbance of final treated samples was measured on 518 nm of long wave using a spectrophotometer. The resulting data from the spectrophotometer were compared to the standard curve.

Volatile reducing substance (VRS) determination

The mixture of 5 gram of samples with 100 ml of distilled water is heated for 15 minutes and then filtered using a screener. The filtered sample was extracted with diethyl ether until a 50 ml solution was reached. This solution was analyzed by gas Chromatography method.

Rehydration Test

The measurement of water rehydration rate was 200 g of distilled water were brought to temperature of 85-90 °C in a constant temperature water bath. Then a precisely weight of 1 gram of the dried material was placed in a wire gauze basket and soaked for 20 minutes. The samples were centrifuged to remove free water and the weight of each was taken¹⁰. The ratio of the mass of samples after the water rehydration to the predrying mass of the sample was calculated as a recovery ratio¹¹.

Chlorophyll Test

Chlorophyll test was done by means of pigment absorbance analyses at 652 nm of long wave. The total chlorophyll is calculated as follows:

$$\text{Total chlorophyll} = \frac{D_{652} \times 1000}{4.5} \text{ (mg/g of fresh leaf)}$$

Where:

D₆₅₂ : Chlorophyll pigment absorbance at 652 nm long wave
 43.5 : Specific chlorophyll pigment absorbance at a definite long wave

RESULTS AND DISCUSSION

Drying Characteristics

The position of FIR radiator is set at optimum distance (18±2 cm) between conveyor-FIR rays and tunnel temperature at range 60°C. The FIR ray radiated the material and cut the cluster of the moisture molecule directly without air-drying media. This phenomenon

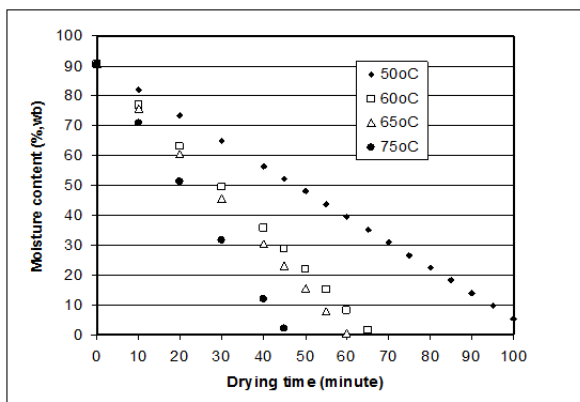


Fig. 5. Moisture content falling during drying process at different temperature

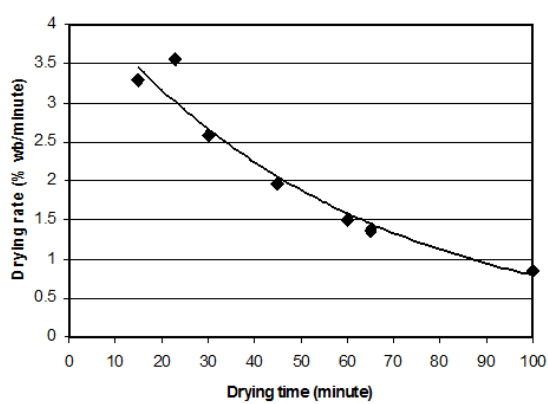


Fig. 6. Relationship between drying rate and drying time resulted in the high drying rate.

The moisture change during the drying process at different radiation temperature is shown in Fig. 5. The variation of the drying condition on moisture content change showed that four different conditions of FIR radiation gave different results in drying rate.

It is noted that the FIR energy was adjusted in order to prevent quality deterioration of the sample, since the sample's surface temperature rised and caused deterioration of the color when FIR energy was too great. On average the drying rate at the specified temperature indicated the trend to a relatively constant rate of drying rate as shown in Fig. 6. The relationship between drying rate and thermal radiation temperature (Fig. 7) showed the condition as stated in equation (1) with a correlation coefficient (R) of 0.989.

$$DR = 4,4268e^{-0,017\theta} \quad 50 \leq T < 100^{\circ}\text{C} \quad (1)$$

where : DR : Drying Rate (%/minute)

T : temperature ($^{\circ}\text{C}$) ; θ : time (minute)

Table 3. Color measurement results of sliced mushroom

Parameter	Fresh	Dried
L	50.50±5.80	82.87±1.55
a	6.78±1.76	5.87±1.67
b	32.57±6.55	24.3±1.60

Table 4. The comparison between fresh and dried sliced-mushroom quality

Components	Fresh	Dried
Moisture content (% w.b.)	89.05±1.15	8.17±1.80
Ascorbic acid (mg/g)	6.577±0.16	3.443±0.203
Chlorophyll (mg/100g)	1.247±0.019	1.516 x10-4 ± 0.661 x10-4
VRS (ppm)	12.61±0.10	5.1±0.15
Ash content (%)	1.133±0.104	5.067±0.011

2. Color Test

The color test showed that the dried sliced-straw mushrooms with FIR dryer had low variation in brightness as shown in Table 3. The results were significantly consistent.

The higher L values of dried products showed better in freshness appearance. The lower value of (a+) indicated a lower redness and this was consistent color appearance of the dried sliced-mushroom. The lower value of (b+) is a sign of less yellowness. In this case, browning was minimized from the heating treatment. The chemical quality of dried mushroom is shown in Table 4.

The ascorbic acid content as well as the VRS of the dried product showed almost 50% decreased due to sensitivity to heat treatments, while the chlorophyll content greatly changed in the dried sliced because of the low existance of chlorophyll pigment. The increase in ash content is a sign of the increased occurrence of the cut hydro-carbon molecule chains. This phenomenon indicated that the high temperature exposure on the surface of the material gave the significant effect in removing the moisture adhered to the surface of the material. At the average level, the rehydration ratio of the dried mushroom was 65.42±5.08%.

CONCLUSION

The FIR ray radiated the sliced-straw mushroom and cut the cluster of the moisture molecules directly without air-drying media. This phenomenon resulted in the high drying rate. FIR irradiation was effective at

decreasing drying time as well as minimizing changes in color. The application of FIR in sliced straw mushroom drying under the optimal condition resulted in minimum changes of quality compared to the fresh product. The blanching treatment has reduced browning from the FIR heating treatment. The color of dried sliced-straw mushroom was significantly consistent by blanching treatment. This study showed that the application of FIR drying technology is a promising method to produce high quality dried sliced-straw mushroom and is recommended also for the advantageous energy utilization in food dehydration.

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