

Effect of Superheated Steam Treatment on Changes in Moisture Content and Colour Properties of Coconut Slices

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Abstract— Drying is one of the methods to preserve the quality and prolong the shelf life of food. Coconut meat was sliced and dried using superheated steam oven at 140°C, 160°C and 180°C. Drying was carried out at different drying time (5, 10, 15, 20, 25 and 30 minutes). The effect of drying temperature and time on the moisture content and colour properties (L, a, b and BI) of the coconut slices were studied. The temperature and time significantly ($p < 0.05$) affected the moisture loss and colour values of coconut slices during superheated steam drying. The moisture content decreased with increased drying temperature and time. The values of L decreased with drying temperature and time. The a and b value of coconut slice dried at 140°C decreased initially then increased with time. Coconut slices dried at 160°C had their a values increased up to 20 minutes then decreased and b values increased up to 20 minutes then fluctuated. The a and b values of coconut slices dried at 180°C showed fluctuation. BI values of coconut slices increased with increasing drying time and temperature.

Keywords— Coconut slices; Superheated steam drying; Moisture content; Colour

I. INTRODUCTION

Coconut (*Cocos nucifera* Linn) is one of the most widely cultivated and used tree in the world and is regarded as one of the most significant of all palms. Its nut provides a nutritious source of meat, juice, milk, and oil that has fed and nourished populations around the world for generations. At the same time, coconut tree also produce furniture, decorative materials, medicine and many more products [1]. Due to its versatility in many applications especially in the tropical and subtropical regions, the tree is also known as “tree of life” [2].

Similar to all high moisture fruits and vegetables, coconut meat has a very short shelf life and prone to microbial degradation. Hence, drying and preservation of coconut meat is very significant for further processing. Thermal processing is one of the main approaches of food preservation to inactivate enzymes, prevent the growth of deteriorative microorganisms which causes decay and reduce water activity via dehydration. However, during this method of handling, food material may be exposed to temperatures that cause undesirable effects on their quality and organoleptic properties mainly due to physiochemical changes in the tissue during drying [3], [4], [5].

Superheated steam dries materials by adding sensible heat to raise its temperature above the corresponding saturation temperature at a particular pressure. A drop in temperature will not result in condensation of the steam, in condition that the temperature is still higher than the saturation temperature at the operating pressure. The moisture evaporated from the product becomes part of the drying medium and does not need to be drained except when the pressure exceeds a set point, at which the extra steam may be released [6], [7]. Using superheated steam as a drying medium is beneficial since it could lead to energy saving if the exhaust (superheated steam) is used elsewhere in the plant and is not charged by the dryer. The oxygen free drying environment of superheated steam also improves product quality since no oxidation or combustion reaction taken place. In addition, risks of fire or explosion hazard could also be avoided. Closed system of superheated steam dryer enable odours, dust or toxic compounds to be removed and collected before in contact with the environment. Superheated steam also allows sterilization, pasteurization and deodorization of food product during drying [6], [8], [9], [10].

An object's colour is one of the most significant quality factors and plays a major role in processing, appearance and consumer acceptability of food materials. Visual appearance of a food is the first impression made by a consumer at the

point of purchase [4]. Colour of fruits and vegetables are derived from natural pigments including water soluble anthocyanins (red, blue), betalains (red), flavonoids (yellow), fat-soluble chlorophylls (green) and carotenoids (yellow, orange, and red) [11]. Colour can be associated with other traits such as nutritional, sensory and visual or non-visual defects and aids to regulate them immediately [12]. Factors such as enzymatic browning and non-enzymatic (maillard reactions), and processing environments like temperature, time, pH, acidity and oxidation, are responsible for the destruction of pigment and colour changes of food during processing [14].

The colour measurements of food could be used as an indirect way to determine the colour change, since they are faster and simpler than chemical analysis. Hunter colour parameters lightness (L), redness(a) and yellowness (b) have been widely used for describing visual colour changes during thermal processing of fruits and vegetables, providing useful information for quality control [3], [4], [5], [13]. For L value which measures the luminosity of sample, the value ranges from 100 for a perfect white to 0 for a perfect black. Positive a value indicates redness while negative value indicates greenness. Positive b value indicates yellowness and negative value points to blueness. Browning index (BI) symbolizes the purity of brown colour and has been reported as a crucial parameter in drying processes where enzymatic and non-enzymatic browning occurs [3], [4], [5].

While there are many literature studies on the quality changes of food processed by superheated steam, no work has been done on coconut slices. The purpose of this work is to study the effect of different drying condition of superheated steam on the moisture content and colour properties of coconut slices.

II. METHODS

A. Sample Preparation

Mature coconut samples were purchased from a wet market in Pulau Penang, Malaysia. They were stored at 4°C in refrigerator. Prior to the drying experiments, the samples were taken out from the refrigerator and left for about 45 minutes at room temperature. Then, they were opened and the mature coconut meat was sliced manually to the size of 1.3- 1.5mm thick, length of 60-65mm and breadth of 11-12mm.

B. Drying

Superheated steam oven (Healsio, AV-1500V, SHARP, Japan) in superheated steam mode was used for drying the coconut slices. The oven was preheated to the drying temperature. The drying was carried out at 140°C, 160°C and 180°C. Drying time of 5 minutes, 10 minutes, 15 minutes, 20 minutes, 25 minutes and 30 minutes was used for each drying temperature. Each drying condition was done separately and the dried sample was packed in polyethylene plastic bags before further analysis.

C. Moisture Determination

Dried coconut slices were subjected to moisture content determination using Mettler Toledo HB43-S Halogen Moisture Analyser immediately after each treatment of

drying. The drying temperature operated by the analyser was 115°C, approximately 4g of sample was used for each measurement. Determination for each treatment was done in triplicate.

D. Colour Measurement

The surface colour of the dried coconut slices were measured using spectrophotometer (CM-3500D Minolta Spectrophotometer, Minolta, Japan). The instrument was calibrated before the experiments with a zero calibration box and a white calibration plate. Pulsed xenon arc lamp with reflectance of d/8 is the light source. 8mm measuring head hole was used and each measurement time lasted 2.5 seconds. The coconut slices was scanned at 3 different locations to determine the average L , a , b values during the measurements. Browning index (BI) were calculated from the Hunter L , a , b values and used to describe the colour change during drying.

$$BI = \frac{[100(x - 0.31)]}{0.17}$$

where

$$x = \frac{(a + 1.75L)}{(5.645L + a - 3.012b)}$$

E. Statistical Analysis

Statistical analysis was conducted using IBM SPSS 21.0 (IBM Corp., Armonk, NY, USA). All data were analysed using analysis of variance (ANOVA). Duncan's test was used for multiple comparisons of mean values. Mean values were considered at 95% significant level ($\alpha = 0.05$).

III. RESULTS AND DISCUSSION

The changes in the moisture content of coconut slices during drying by superheated steam at 140°C, 160°C and 180°C as a function of drying time were presented in Fig. 1. It could be clearly seen that drying at 180°C leads to more drastic moisture loss compared to 140°C and 160°C. While drying at 140°C gave a more gradual moisture loss to the coconut slices. At 95% confidence interval, the drying temperature and drying time of superheated steam significantly affect the moisture loss during drying process.

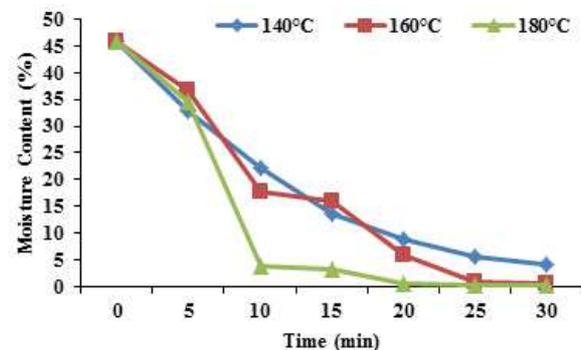


Fig. 1 Changes in the moisture content of coconut slices during different treatments of superheated steam drying.

Fig. 2-5 illustrates the changes in L , a , b and BI values of coconut slices dried at different temperature and time respectively. The applied two-ways ANOVA showed that

temperature and time significantly ($p < 0.05$) affected the colour properties of coconut slices during superheated steam drying. L values for superheated steam drying showed relatively moderate decrease as time elapses. The L value of coconut slices dried at higher temperature (180°C) and longer time declined faster. It indicated that, higher processing temperature and longer drying time causes higher level of darkening. Similar results were reported for the L value of the coconut research done by Niamny and Devahastin [15].

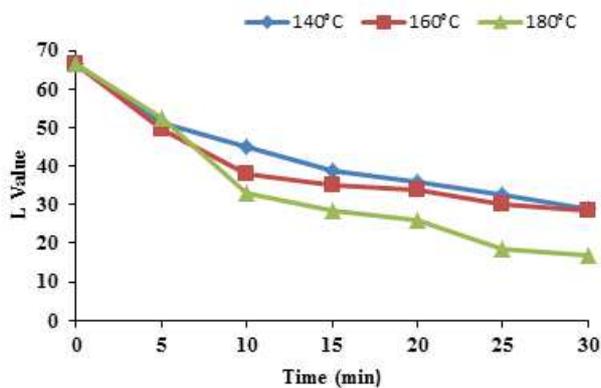


Fig. 2 Changes in L value of coconut slices during different treatments of superheated steam drying.

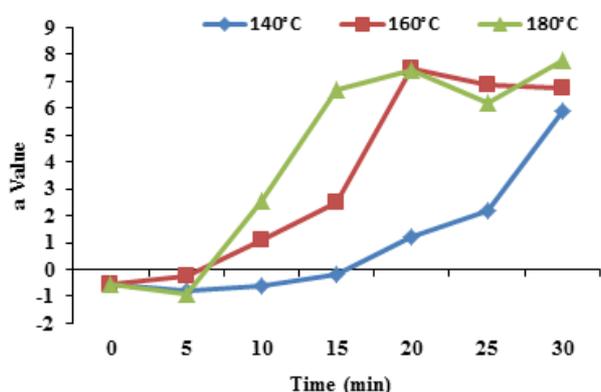


Fig. 3 Changes in a value of coconut slices during different treatments of superheated steam drying.

The a value shows the redness of the products. The variation of a value during drying is shown in Fig. 3. There was gradual decrease in a value at the initial period of superheated steam drying at 140°C and 180°C . No initial decrease in a value was observed in superheated steam drying at 160°C . The a value of coconut slices dried at 160°C increased sharply then start to decrease slightly after drying of 20 minutes. At the same time, different trend was observed in superheated steam drying at 180°C , where the a value decreased slightly after 20 minutes drying time then increase again after 25 minutes. Increased of a value during drying could be due to the formation of browning. The browning pigments formed in this study could be due to non-enzymatic browning caused by Maillard reaction. Maillard reaction occurs when amino acids and reducing sugars, proteins and/or other nitrogen-containing compounds are heated together [12].

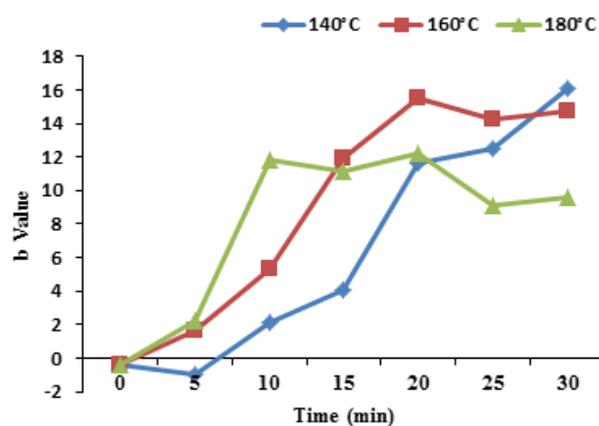


Fig. 4 Changes in b value of coconut slices during different treatments of superheated steam drying.

The b values which shows the yellowness of coconut slices during superheated steam drying is presented in Fig. 4. Gradual decrease in b value was observed at the initial period of superheated steam drying at 140°C , and then the value increased with extending of drying temperature. No initial decrease in b value in superheated steam drying at 160°C and 180°C . However, the b value of coconut slices dried at 180°C showed fluctuations. Different trend was observed in coconut slices dried at 160°C where the b value after drying time of 20 minutes decreased slightly then increased again.

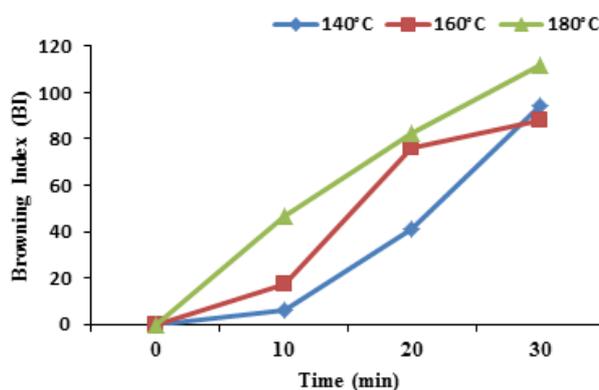


Fig. 5 Changes in browning index of coconut slices during different treatments of superheated steam drying.

The effects of superheated steam drying temperature and drying time on the browning index of coconut slices are presented in Fig.5. Browning index enable more accurate estimation of drying time at which browning is initiated. The BI increased as drying temperature and time increased. BI of coconut slices dried at 140°C increased in a trend that is persistent while coconut slices dried at 180°C rise sharply.

IV. CONCLUSIONS

The effects of superheated steam drying temperature and drying time on the moisture content and colour properties of coconut slices were examined in this study. The moisture content of coconut slices decreased with extending of drying time and temperature. The lightness of coconut slices decreased with increased in drying temperature and time. It

was observed that the redness and yellowness of coconut slices dried at 140°C decreased initially then increased with time. Coconut slices dried at 160°C had their redness increased up to 20 minutes then decreased and yellowness increased up to 20 minutes then fluctuated. The redness and yellowness of coconut slices dried at 180°C fluctuated. In addition, the browning index values of coconut slices increased with increasing drying time and temperature.

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REFERENCES

- [1] P. G. Punchihewa, and R. N. Arancon. (2006) Coconut: Post harvest operations. *Asian and Pacific Coconut Community*. [Online]. Available: <http://www.apcc.org.sg>, and FAO, website: <http://www.fao.org>.
- [2] M. DebMandal, and S. Mandal, "Coconut (*Cocos nucifera* L.: Arecaceae): in health promotion and disease prevention," *Asian Pacific Journal of Tropical Medicine*, vol. 4, pp. 241-247, Mar. 2011.
- [3] M. Maskan, "Kinetics of colour change of kiwifruits during hot air and microwave drying," *Journal of food engineering*, vol. 48, pp. 169-175, May. 2001.
- [4] G. Dadali, E. Demirhan, and B. Özbek, "Color change kinetics of spinach undergoing microwave drying," *Drying technology*, vol. 25, pp. 1713-1723, Dec. 2007.
- [5] L. M. Bal, A. Kar, S. Satya, and S. N. Naik, "Kinetics of colour change of bamboo shoot slices during microwave drying," *International Journal of Food Science & Technology*, vol. 46, pp. 827-833, Apr. 2011.
- [6] C. Pronyk, S. Cenkowski, and W. E. Muir, "Drying foodstuffs with superheated steam," *Drying Technology*, vol. 22, pp. 899-916, Feb. 2007.
- [7] Z. Tang, and S. Cenkowski, "Dehydration dynamics of potatoes in superheated steam and hot air," *Canadian Agricultural Engineering*, vol. 42, pp. 43-49, 2000.
- [8] H. C., Van Deventer, and R. M. Heijmans, "Drying with superheated steam," *Drying Technology*, vol. 19, pp. 2033-2045, Feb 2007.
- [9] F. Karimi, "Applications of superheated steam for the drying of food products," *Int. Agrophysics*, vol. 24, pp. 195-204, 2010.
- [10] A. S. Mujumdar, and C. L. Law, "Drying technology: Trends and applications in postharvest processing," *Food and Bioprocess Technology*, vol. 3, pp. 843-852, Apr. 2010.
- [11] D. M. Barrett, J. C. Beaulieu, and R. Shewfelt, "Color, flavor, texture, and nutritional quality of fresh-cut fruits and vegetables: desirable levels, instrumental and sensory measurement, and the effects of processing," *Critical reviews in food science and nutrition*, vol. 50, pp. 369-389, Apr. 2010.
- [12] P. B. Pathare, U. L. Opara, and F. A. J. Al-Said, "Colour measurement and analysis in fresh and processed foods: a review," *Food and Bioprocess Technology*, vol. 6, pp. 36-60, Jan. 2013.
- [13] J. Ahmed, U. S. Shivhare, and G. S. V. Raghavan, "Thermal degradation kinetics of anthocyanin and visual colour of plum puree," *European Food Research and Technology*, vol. 218, pp. 525-528, Mar. 2004.
- [14] D. Rodrigo, A. Van Loey, and M. Hendrickx, "Combined thermal and high pressure colour degradation of tomato puree and strawberry juice," *Journal of Food Engineering*, vol. 79, pp. 553-560, Mar. 2007.
- [15] C. Niamnuy, and S. Devahastin, "Drying kinetics and quality of coconut dried in a fluidized bed dryer," *Journal of food engineering*, vol. 66, pp. 267-271, Jan. 2005.