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
during thermal processing of fruits and vegetables, providing
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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
dicates 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
cocnut 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.

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BI = \frac{100(a - 0.34)}{0.17}
\]

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
cocnut slices. At 95% confidence interval, the drying
temperature and drying time of superheated steam
significantly affect the moisture loss during drying.

![Fig. 1 Changes in the moisture content of coconut slices during different treatments of superheated steam drying.](image)

Fig. 2-5 illustrates the changes in L, a, b and BI values of
cocnut 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 Niamnuy and
Devahastin [15].

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].

The $b$ value 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.

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

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