Comparison of Different Drying Methods and Preservatives on the Proximate Composition, Colour and Total Phenolic Content of Dried Ginger.

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ABSTRACT

The present work proposed to compare three different drying methods i.e. sun drying, vacuum oven drying and freeze drying of ginger to determine the proximate composition, colour analysis and total phenolic content. These dried gingers were preserved by using sugar (control), Tualang honey and Kelulut honey. It showed that freeze dried ginger presents the best result for retaining nutrients, colour and total phenolic content compared to other drying methods. For colour analyses, sun dried samples resulted in the lowest value of L* were 50.94, 51.24 and 52.22 for control, Tualang honey and Kelulut honey due to longer drying time and oxygen exposure. Among all preservatives used, Tualang honey produced the best quality of dried ginger as the highest total phenolic content was 26.73 mg gallic acid/g.

Keywords: Ginger, drying, proximate analysis, total phenolic content

INTRODUCTION

Ginger is one of the most widely used spices of the family Zingiberaceae (Jayashree et al., 2012). Ginger (Zingiber officinale) has been cultivated in many tropical and subtropical countries on account of its culinary and medicinal properties (Bartley & Jacobs, 2000). Ginger is usually consumed as a fresh paste, dried slices or powder, candy (crystallized ginger) or flavouring tea and also used as a condiment in the various industries of food and beverage due to its pungent constituents and aromatic volatile constituents. The chemical compositions of fresh ginger are different due to the differences in geographical locations, extraction and processing methods.

Honey is a natural sweet substance produced from the secretions of living parts of plants or excretions of plant-sucking insects. Honey bee deposits the nectar and sweet from the plant in the honeycomb and then be gathered, modified and stored to form honey (Kannan et al., 2009). Honey consists of variable compositions of the compounds depend on floral sources and geographic origin of the honey (Alvarez-suarez et al., 2009). In this study, two types of honey that were used which are Tualang honey and Kelulut honey.
Drying is a fundamental requirement to prolong the shelf life of the product. Drying process lessens the moisture content, decreases the growth of microbial as well as obstruct some chemical processes that lead to the reduction of aroma, nutrients, physical properties and antioxidant activity (Phoungchandang & Saentaweesuk, 2011). Drying method selection is important to ensure the product has the maximum nutrient content.

Processing method may also improve the properties of naturally occurring antioxidants or induce the formulation of new compounds having antioxidant properties, therefore the overall antioxidant activity of plant raw materials can remain unchanged or increased despite the eventual loss of ingredients (Tomaino et al., 2005). Thermal drying technologies have appeal to development in research in reducing cost operations, improving the product qualities including lowering the impact on the environment (Mujumdar & Law, 2010).

Use of drying machines will not only reduce the processing time and produce a good quality product, it will also reduce the dependence on the weather as well as lessen the spoilage and contamination of the product (Prasad et al., 2006). The aim of current work is to compare different drying methods and preservatives on the proximate composition, colour and total phenolic content of dried ginger.

**MATERIALS AND METHODS**

**Sample preparation**

Fresh gingers were purchased from the local market in Besut, Terengganu. The gingers were stored at 4 ± 0.5°C to slow down respiration, physiological and chemical changes (O'Connor-Shaw et al., 1994). Prior to drying, fresh gingers were washed, peeled manually, and cut into slices to the same length, width, and thickness (1cm x 1cm x 1cm). Sliced gingers were boiled in the boiling water for 15 minutes during the pre-treatment process before it was preserved with different types of preservatives. The samples were soaked in three different solutions which were sucrose solution (50% concentration), Tualang honey, and Kelulut honey and placed in a single layer on a tray. All experiments were carried out in triplicates.

**Drying method**

Pre-soaked sliced gingers with sucrose solution (50% concentration), Tualang honey, and Kelulut honey were dried at different drying methods; sun drying, vacuum drying and freeze drying. For sun drying method, sliced gingers were distributed evenly on the stainless steel trays and dried under direct sunlight at a temperature between 25-30°C from 8.00 am to 5.00 pm for three days. For vacuum drying, sliced gingers were dried at the temperature of the vacuum oven which was set at 60°C and 50 – 55 mbar for 36 hours. The freeze drying method of sliced gingers were carried out in a freeze dryer for 36 hours at a temperature of –40°C.

**Samples analysis**

**Determination on proximate composition**

Proximate values including moisture, ash protein, fat, crude fibre and carbohydrate were determined. All the analyses were performed in three replications. Moisture content was determined by using an air oven drying method. Ash content was determined using the dry ashing method, protein content was determined by the Kjeldahl method, fat content was determined by the Soxhlet extraction method and total dietary fibre was determined using Fibretherm system method.
Color analysis

The color of sliced gingers was determined by using Chroma Meter Minolta Model CR-400. It was expressed in terms of L*, a* and b* where L*=100 (white), L*=0 (black), +a*=red, -a*=green and +b* =yellow, -b* =blue. The Chroma Meter was first calibrated prior to analysis by using a white calibration plate.

Total phenolic content

The total phenolic content was determined by the spectrophotometric Folin-Ciocalteu method as described by Zae et al. (2020) with minor modifications. The dried ginger extracts (0.2 mL, 100mg/mL) were mixed with 1.5 mL of Folin-Ciocalteu reagent (previously diluted 5-fold with distilled water) and allowed to stand at room temperature for 5 minutes. Then, 1.3 mL of sodium bicarbonate solution was added to each mixture. The absorbance of the sample was measured at 750 nm using UV-VIS spectrophotometer after 90 minutes incubation at room temperature. Total phenolic content was calculated using regression equations from the standard curve of gallic acid. The results were expressed as milligrams of GAE per g of dried weight. Triplicate determinations were performed for TPC assays.

RESULTS AND DISCUSSION

Proximate composition

Moisture

Table 1 shows the moisture content of dried ginger. Freeze dried sample preserved with sugar as the control has the lowest moisture content which is 2.57% and sun dried sample preserved with Tualang honey has the highest moisture content which is 20.39%. This indicated the different of moisture content from these dried gingers because of dependent on variables as drying is conducted over time (Lee et al., 2013). Freeze dried samples showed the lowest values of moisture content for all types of samples as the freeze drying method has converted all of the water content in the ginger into ice crystals and dried it afterwards. On the other hand, dehydration by sun drying method evaporated the water content using heat.

Both Tualang and Kelulut honey recorded higher moisture content compared to the control sample because it is mainly due to the type of sugar, which are related to the glass transition temperature (Umesh Hebbar et al., 2008). It is also known that factors such as floral source, harvesting season, degree of honey maturity in the hive, and climatic factors can influence the moisture level in honey (Finola et al., 2007).

Table 1. Moisture content of ginger dried with different drying methods and preserved with three types of preservatives.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture content (%)</th>
<th>Control</th>
<th>Tualang honey</th>
<th>Kelulut honey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun Dried</td>
<td>15.78±0.33^b</td>
<td>20.39±0.09^b</td>
<td>19.65±0.07^b</td>
<td></td>
</tr>
<tr>
<td>Vacuum Dried</td>
<td>5.88±0.50^c</td>
<td>16.98±0.06^c</td>
<td>15.56±0.05^c</td>
<td></td>
</tr>
<tr>
<td>Freeze Dried</td>
<td>2.57±0.27^d</td>
<td>14.28±0.06^d</td>
<td>13.84±0.16^d</td>
<td></td>
</tr>
</tbody>
</table>

Values (a-d) with different superscript are significantly different from each other (p<0.05). Presented data are mean value of triplicate value with ±standard deviation.

Ash

The percentage of ash represents the inorganic content of the sample such as mineral content could be obtained. Table 2 shows the ash content of dried ginger for different drying methods of three types of preservatives. The
results show that the ash contents were varied based on the drying method and preservatives used. The highest amount of ash content was found in sun dried gingers preserved with about 3.26 to 3.81%. The heat from the sundry process was not consistent which depends on the climate and season at the time of drying leading to low disruption of the mineral elements in the samples compared to other types of drying where the temperature was consistent until the end of the drying process as it had been set before the process started.

However, the lowest amount of ash in dried gingers were freeze dried samples as 0.69, 0.94 and 1.15% per samples that preserved with control (sugar), Tualang honey and Kelulut honey. The determination of ash content is useful for predicting mineral and trace element contents. Therefore, among all of the three types of preservatives used, all of them had a similar range of ash content indicates a similar range of mineral content in these samples. Ash content in honey generally low as it is influenced by the chemical composition of nectar that varies according to the different botanical sources involved in the honey formation. As for sugars, the processing of sugars are the main reasons for having low ash content. Ash content can be reduced by maintaining proper filtration, sufficient washing during centrifugation of the sugar, and proper handling of the sugar during drying and screening. Ash content of refined granulated sugar must not exceed 0.015% by most standards.

Table 2. Ash content of ginger dried with different drying methods and preserved with three types of preservatives.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Ash content (%)</th>
<th>Control</th>
<th>Tualang honey</th>
<th>Kelulut honey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun Dried</td>
<td>3.26±0.02α</td>
<td>3.72±0.04α</td>
<td>3.81±0.02α</td>
<td></td>
</tr>
<tr>
<td>Vacuum Dried</td>
<td>1.55±0.16c</td>
<td>1.89±0.08c</td>
<td>2.03±0.05c</td>
<td></td>
</tr>
<tr>
<td>Freeze Dried</td>
<td>0.69±0.01d</td>
<td>0.94±0.06d</td>
<td>1.15±0.05d</td>
<td></td>
</tr>
</tbody>
</table>

Values (a-d) with different superscript are significantly difference from each other (p<0.05). Presented data are mean value of triplicate value with ±standard deviation.

Protein

Protein is an essential component of diet needed for the survival of animals and human beings whose basic function is to supply adequate amounts of required amino acids for nutrition. Table 3 shows, freeze dried ginger for all samples results in the lowest percentage of protein content about 1.72 to 2.26%. The result recorded in this study is in agreement with the work done by Odebunmi et al. (2010) who reported that spices have low crude protein content. The protein content was significantly different between drying methods used in these analyses.

Sugar had slightly low in protein content compared to Tualang honey and Kelulut honey due to low nitrogen content in the sugar compared to the Tualang honey and Kelulut honey. Dried ginger preserved with Kelulut honey preserved more protein than control (sugar) and Tualang honey. Protein contents in dried ginger preserved with Kelulut honey were 6.57, 4.22 and 2.26% for sun drying, vacuum drying and freeze drying, respectively. There were also slightly differences between Tualang and Kelulut honey due to the different floral nectars sources and enzymes added by the honey bees (Andarda & Telleria, 2009). During ripening process of honey, honey bees introduced different enzymes, such as amylase, invertase and glucose oxidase to help in the regulation of hydrogen peroxide production (Bogdanov et al., 2008). As a result, the protein content of honey was influenced by different enzymes added by the honey bees.
Table 3. Protein content of ginger dried with different drying methods and preserved with three types of preservatives.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Control</th>
<th>Tualang honey</th>
<th>Kelulut honey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun Dried</td>
<td>5.71±0.37&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.28±0.31&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.57±0.84&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Vacuum Dried</td>
<td>3.91±0.14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.06±0.24&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.22±0.05&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Freeze Dried</td>
<td>1.72±0.13&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.04±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.26±0.14&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values (a-d) with different superscript are significantly different from each other (p<0.05). Presented data are mean value of triplicate value with ±standard deviation.

Fat

Table 4 shows the fat content of dried ginger for different drying methods of three types of preservatives. The fat content for all samples were not significantly different when compared to drying methods and preservatives used. Sangwan et al. (2014) also reported almost similar fat content of ginger dried using solar and oven dried. Generally, sugars and honey had been reported in a few studies with little or no fat content (Chua & Adnan, 2014).

Table 4. Fat content of ginger dried with different drying methods and preserved with three types of preservatives.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Control</th>
<th>Tualang honey</th>
<th>Kelulut honey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun Dried</td>
<td>0.68±0.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.63±0.09&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.77±0.19&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Vacuum Dried</td>
<td>1.63±0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.67±0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.65±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Freeze Dried</td>
<td>0.84±0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.87±0.04&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.88±0.19&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values (a-d) with different superscript are statistically significant from each other (p<0.05). Presented data are mean value of triplicate value with ±standard deviation.

Crude Fibre

The crude fibre in food analysis is taken to mean the combustible residue that is left after the carbohydrate, fat and proteins have been removed. This residue is largely cellulose and also includes hemicellulose and lignin, and is that portion of the carbohydrate which is non-digestible and non-assimilable by a human. From Table 5, the crude fibre content of dried gingers prepared using sun, vacuum and freeze drying methods were almost similar on a dry matter basis. The lowest amount of crude fiber is 2.42% in freeze dried ginger preserved with Kelulut honey and the highest amount is 5.47% in control sun dried ginger.

Both Tualang and Kelulut honey recorded the highest percentage in crude fibre content compared to sugar preservatives used. These findings were consistent with previous studies, where there is low fibre content been reported in honey (Buba et al., 2013; Chua & Adnan, 2014; Bogdanov, 2016). According to Murray et al. (2001), honey was considered as low-fibre food in which the carbohydrate content of honey was mainly composed by sugar (glucose, fructose, sucrose) instead of indigestible carbohydrate and it mainly used as a natural sweetener.
Table 5. Crude fibre content of ginger dried with different drying methods and preserved with three types of preservatives.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Crude fibre content (%)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Tualang honey</td>
<td>Kelulut honey</td>
<td></td>
</tr>
<tr>
<td>Sun Dried</td>
<td>5.47±0.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.21±0.20&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.58±0.17&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Vacuum Dried</td>
<td>3.38±0.40&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.44±0.29&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.32±0.09&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Freeze Dried</td>
<td>2.65±0.05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.64±0.31&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.42±0.37&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

Values (a-d) with different superscript are statistically significant from each other (p<0.05). Presented data are mean value of triplicate value with ±standard deviation.

**Color analysis**

Colour is a crucial quality factor because it affects the acceptance of dried foods by the consumer. The average colour was expressed as the mean values for the three types of drying methods. The lower the mean value indicated that the lesser significant difference between the four drying methods used.

The CIELAB colour scale was an approximately uniform colour scale. In a uniform colour scale, the differences between points plotted in the colour space correspond to visual differences between the colours plotted. The CIELAB colour space was organized in a cube form. The minimum L* was zero, which represents black and the maximum L* was 100, which represents a perfect reflecting diffuser. The a* and b* axes have no specific numerical limits. Positive a* was red and negative was green. Positive b* was yellow and negative b* was blue (Hunter, 2008).

The colour parameters acquired from the drying processes are presented in Fig. 1. Freeze dried ginger resulted in the highest L* value between all of the samples were above 72.52. In addition, sun dried samples resulted in the lowest value of L* were 50.94, 51.24 and 52.22 for control, Tualang honey and Kelulut honey. This possibly due to longer drying time and oxygen exposure. The lower in L* values can be attributed to brown pigment formation during drying and the brown pigment in dried ginger was due to their high levels of reducing sugars in the fruits itself, which causes caramelization to occur during drying process (Adam et al., 2000; Inchuen et al., 2010). Values a and b for all samples were almost the same for different drying methods.

![Fig. 1. Colour analysis of ginger dried with different drying methods and preserved with three types of preservatives.](image-url)
Total phenolic content

Fig. 2 shows the relationship of total phenolic content between three different drying methods and preservatives of dried ginger samples. The analysis was conducted in a dark room to prevent oxidation to occur (Ozcelik et al., 2003). Total phenolic content of the freeze dried samples were 19.61, 26.73 and 24.27 mg gallic acid/g for control, Tualang honey and Kelulut honey, respectively. Freeze dried method used the lowest temperature compared to the other three types of drying. The high levels of phenolic content in freeze dried samples might be due to the formation of ice crystals within the plant matrix during freezing, which may cause greater disruption of the cell wall structure, allowing for accelerated liberation of cellular components and accessibility of the solvent (Chan et al., 2009).

Vacuum oven dried sample result showed a low total phenolic content which was less than 20 mg gallic acid/g. One of the properties of antioxidant was heat-sensitive. The heat-sensitive phenolic was degraded or bio transformed at high temperatures. The thermal processes deactivated oxidative and hydrolytic enzymes that may cause the loss of phenolic acids (Dewanto et al., 2002). Sun dried and vacuum oven dried used heat during the process resulted in lower total phenolic content in the dried ginger samples for all type of preservatives used.

Among all of the preservatives used, Tualang honey recorded the highest value of total phenolic content for all drying methods used in these analyses. According to Khalil et al, (2011) Tualang honey had a superior in phenolic content compared to other Malaysian honey including Kelulut honey. The difference in the results of the current study compared to the previous study probably due to the polyphenol extraction method, different sources of the honey and the storage conditions (Khalil et al., 2011). Phenols and flavonoids are natural polyphenolics that may render their effect via anti-oxidative action in biological systems, acting as scavengers of singlet oxygen, removing free radicals, activating antioxidant enzymes and inhibiting oxidases (Shetty & McCue, 2003).

![Graph showing total phenolic content of ginger dried with different drying methods and preserved with three types of preservatives.]

Fig. 2. Total phenolic content (mg GAE/g) of ginger dried with different drying methods and preserved with three types of preservatives.

CONCLUSION

The proximate composition, colour quality and total phenolic content of dried ginger depends on the drying method used. All things considered, freeze dried sample presents better results for retaining nutrients, better colour and keeping total phenolic content. This method applied with honeys as a preservative agent, and enrich the total phenolic content. Taking everything into consideration, the best quality of dried ginger is freeze dried sample preserved with Tualang honey.
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REFERENCES


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