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Effect of drying condition of Thai garlic (*Allium sativum* L.) on physicochemical and sensory properties

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Abstract

This research was conducted to indicate the suitable drying condition of dried garlic powder. The chopped and sliced fresh garlic was dried in hot air oven (40°C and 60°C). The drying process times for chopped and sliced garlic at 60°C (270 and 300 min) faster than 40°C (540 and 630 min). Those drying condition provided the moisture content in the range of 5.42–5.69 with low water activity in the range of 0.514–0.542. The drying temperature and processed condition also affected the colour value *(L^*, a^*, b^*)*. The lightness of dried garlic powder was in the range of 75.53–81.56. The a^* and b^* value also showed the significant difference with the value in the range of 3.20–4.48 and 23.93–31.05, respectively. Those demonstrated values were significant difference when the temperature was increased whereas the processed garlic size was smaller. The main volatile compounds and aroma characteristics of those dried garlic powders can also identify as allyl methyl sulfide (garlic), diallyl disulfide (onion), and diallyl trisulfide (fried garlic). The sensory evaluation from the chopped garlic at 60°C drying temperature provided the highest rating score in the range of 6.1–6.7, followed by the sliced garlic at 40°C drying temperature (5.9 – 6.7), the chopped garlic at 40°C drying temperature (5.3–5.8), and the sliced garlic at 60°C drying temperature (4.7–5.6), respectively. Those factors were found to be affected toward physicochemical, main volatile content, allicin content, and sensory properties of dried garlic powder which can indicate the suitable drying temperature and processed condition to achieve the good quality of dried garlic powder with acceptable sensory properties.

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Introduction

Garlic (*Allium sativum* L.) is liliaceous biennial herbaceous plants underground of garlic, spicy taste, strong garlic smell (Shan *et al.,* 2013). Thai garlic has many good properties, such as deliciousness, pungency purity, crispy and tasty product, mildew resistance, rot-fastness, storable character and high nutritive value. It has been widely used around the world for its characteristic flavour as a seasoning or condiment. Garlic is a rich source of phytonutrients, hence contributing to treatment and prevention of a number of diseases, such as cancer, obesity, cardiovascular diseases, diabetes, hypercholesterolemia, and hypertension (Pardo *et al.,* 2007).

Major volatiles of raw and heated garlic are reported as sulfur-containing compounds including dimethyl disulfide, dimethyl trisulfide, diallyl disulfide, and di-2-propenyl trisulfide (Papu *et al*., 2014). Some processing methods including cooking in soaked water, roasting, fermentation, steaming, hydrostatic pressure treatment, or autoclaving have been applied to modify the off-odor of garlic (Sharma and Prasad, 2006).

Biologically active substances of garlic can be divided into two main groups (Ma *et al*., 2011): (a) sulphur compounds and (b) sulphur-free active substances. Sulphur compounds, such as allicin, alliin, and ajoene, are a very important group of flavour compounds; the active substance of garlic, alliin, is sensorily inactive and biologically ineffective, after cell damage it is, however, enzymatically cleaved to form the characteristically smelly and

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effective garlic essential oil allicin. Allicin gives garlic its antibiotic properties and is responsible for garlic's strong odour; it is unstable (when exposed to air or at elevated temperatures) and degrades into various sulphur compounds, often volatile ones (monosulphides, disulphides and trisulphides), most of which contribute to the characteristic garlic odour.

Drying is an alternative to minimize the losses to the considerable volatile and active compounds. Garlic cloves with approximately 1.85 g water/g dry matter are dried to a safe moisture content of 0.06 g water/g dry matter. Currently hot air drying method is used for drying the garlic (Papu *et al.*, 2014). The preparation of many food products mostly go through drying process at least once at some point. Drying fruit and vegetable products is an important means of enhancing resistance to degradation due to a decrease in water activity (a_w). Heated air drying is the most commonly employed commercial technique for drying biological products (Singh *et al*., 2008). The dehydrated garlic product was the removal of water from fresh garlic, enabling savings in storage space and reducing the weight to be transported. Powdered garlic appears to contain the chemical profile as well as fresh garlic in a stabilised from therefore dried garlic powder has been widely used in many flavouring industries due to its stability of flavour and aroma, retention of colour, satisfactory in rehydration characteristics and drying rates during dehydration. The drying temperature using hot air oven and the processed fresh garlic were investigated in this research, as the objectives to indicate the suitable drying temperature and processed condition to produce dried garlic powder with the acceptable properties of dried garlic powder.

Materials and Methods

Material

Garlic (*Allium sativum* L.) was purchased from Muang Mai fresh market (Chiang Mai, Thailand). The original cultivated area is in Mae Tang District, Chiang Mai, Thailand. The garlic in this experiment was harvested during September, 2015.

Chemicals

Trizma® hydrochloride, L-Cystein, 5,5'-Dithiobis(2-nitrobenzoic) (DTNB), and Alkane standard Solution C8-C20 were purchased from SIGMA-ALDRICH., Co., Mo, USA. Ethanol, methanol, and dichloromethane (RCI Labscan Limited, Bangkok, Thailand) were obtained from Union Science Co., Ltd., Thailand. Sodium acetate trihydrate was purchased from BRIGHTCHEM SDN BHD (Pulau Pinang, Malaysia).

Preparation of dried garlic

Fresh garlic cloves were peeled and washed with cool, fresh water, then left to dry in the shade at room temperature (25°C). The experiment was designed using 22 Factorial with the variation of temperature (40°C and 60°C) and fresh garlic shape (chopped and sliced). The experiment was conducted in triplicate. The chopped garlic was prepared into fine pieces at approximately 2 × 2 mm while the sliced garlic was prepared into pieces at the 2 mm thickness. The prepared fresh garlic was taken to dry using circulated hot air oven at air velocity at 0.002 m/s with flow rate at 10 CFM (464CHMU, NAVALOY Co., Ltd., Bangkok, Thailand). The garlic was sampled out of the dryer every 30 min for evaluating moisture content. The time of drying for each condition was determined from drying curve which established the final moisture content of dried garlic was set at lower than 6%. The dried garlic from these conditions was collected and ground into powder using hammer mill (C31896, Armfield, Christy&Norris Ltd., England) at 0.5 µm. The garlic powder then stored in the vacuum seal package under 4°C for further analysis.

Moisture content and water activity of dried garlic powder

Five grams of garlic powder was weighted and taken to dry in hot air oven (FD 115, Serial 08-836864, Binder, Germany) at 105°C for 5 h to analyse for moisture content (AOAC, 2000, NO. 934.01). One gram of sample was also analyzed with water activity analyzer (AquaLab LITE, DECAGON Devices Inc., USA). All samples were measured in triplication.

Color measurement of dried garlic powder

The color was analyzed using Hunter LAB (Colorquest XE, Hunter Lab, USA). The light source was Illuminant D65. The CIELab color values were used with L^* (Lightness), a^*(negative value means green and positive value means red), b^* (negative value means blue and positive value means yellow).

Volatile compounds from dried garlic powder using Gas Chromatograph Flame Ionization Detector (GC-FID) and Gas Chromatograph Olfactometer (GC-O)

The volatile compounds of garlic were analysed using GC-FID (GC-2010, Shimadzu, Kyoto, Japan). The 10 g of dried garlic powder was extracted in 250 mL of dichloromethane for 2 h, afterward; the solvent was taken to evaporate at 40°C under adjusted pressure at 900 mbar (V800, Buchi, Switzerland). The evaporated extract was adjusted the concentration of 10 mg/mL the GC analysis. The GC-FID condition was applied from Singh *et al.* (2013) and Zhou *et al.* (2015). The garlic solution (1 µL) was injected through the injection port. Helium was used as a gas carrier at flow rate of 2.37 mL/min to convey the volatile compounds through DB-1 column (30 x 0.25 mm ID and 0.25 µm film thickness) (Model 122-1032, Agilent Technologies, Inc., USA). The air and hydrogen flow through the system were set at 50 mL/min and 30 mL/min, respectively. The injection port and the detector temperatures were set at 230°C and 280°C. The temperature programming was set as the following condition: The oven temperature was maintained at 50°C for 1 min and increased to 100°C at 8°C per min, then increased to 280°C at 9°C per min and held at 280°C for 2 min.

The gas chromatograph olfactometer (GC-O) was used to evaluate aromas characteristic from garlic solution through GC-FID connected with sniffing port (O275, 1017, GL Sciences Inc., Japan). The highly trained panel (n=2) evaluated and identified aroma characteristic with intensity level (weak, medium, strong).

Allicin content

The allicin content in dried garlic was analyzed following the method of Sariri *et al.* (2002). One gram of dried garlic was extracted in 30 mL of distilled water at 50°C, 2 h using magnetic stirring rod at speed of 50 rpm. The garlic solution was filtered prior to analyze the allicin content. Ten mL of garlic solution was mixed with 10 mL Trizma® hydrochloride (1M, pH8) and incubated for 15 min. The 50 mL of DTNB (2mM) which prepared 50 mM Sodium acetate trihydrate and 100 mL of L-Cysteine (20mM) were then added into the mixture and adjusted the volume into 1000 mL with distilled water. The prepared solution was analyzed under absorbance at 412 nm and calculated for allicin content in mg/g.

Sensory acceptance on dried garlic powder

The samples were prepared by serving in disposable closed lid plastic cups coded with three-digit number. Testing was performed in individual air-conditioned booths (25°C) in the Sensory Evaluation Laboratory (Sensory evaluation and Consumer testing unit, Division of product development technology, Faculty of Agro-Industry, Chiang Mai University, Chiang Mai, Thailand) and evaluated under white light, thus ensuring comfort and privacy. A complete block design was used. The dried garlic powder was prepared for sensory acceptance using untrained consumers (n=60) rated for attributes preference (appearance, color, aroma, and overall liking) with 9-point hedonic scale (Meilgaard *et al*., 2007).

Statistical analysis

All data were analyzed in triplicate and reported as mean±standard deviation of mean (S.D.) The Statistic analysis was conducted using SPSS 11.0 (SPSS Inc., IBM Corp., IL, USA) using the Duncan's multiple range test (DMRT) with significant level determined at 95% confident limit ($p < 0.05$).

Results and Discussion

Drying curves of garlic drying condition

The drying curves of chopped and sliced garlic can be shown in Figure 1. The drying curves of dried sample showed rapid changes of decreasing in the moisture content in the first 30 min, with the increasing of drying time. This can be explained through the evaporating of drying as suggested in Shama *et al.* (2001). The larger amount of moisture from sample was removed easier at the beginning of the process. The moisture content showed exponentially decreased with drying time and the drying happened in falling rate period. In this experiment, the moisture content of final dried garlic was focused to be less than 6% due to the good condition of dry product. The results showed significant difference of moisture content between different temperatures. The drying time of chopped garlic at 40°C; sliced garlic at 40°C; chopped garlic at 60°C and sliced garlic, 60°C were 540, 630, 270, and 300 min, respectively. At the same temperature, there was a significant change has been observed shape of garlic upon increasing the duration of time. This was establishing to be showed the same trend for all the study of drying temperatures. The significant changes were observed and higher moisture losses when the temperature was increased as suggested in Abano *et al.* (2011) and Puranik *et al.* (2011).

Moisture content and water activity

The moisture content and water activity of dried garlic powder were analyzed to compare the significant of drying temperature and shape of processed garlic. The results showed significant difference as shown in Table 1. The moisture content was decreased when the temperature was increased rapidly in first 30 to 60 min of drying process. The decreasing of moisture content with increasing of temperature happens because of the decreasing of water in the external resistance during the first drying phase (Figueira *et al*., 2004). The dried garlic from 60°C showed lower moisture content than 40°C in

Table 1. Physical properties of dried garlic powder using different temperature under difference processed shape

temperature (°C)	shape	moisture content (%)	water activity (a_w)	Color values L*	a*	b*
40	chopped	5.58±0.15^{Ab}	0.514±0.002^{Ab}	75.53±1.84c	3.62±2.93^{c}	23.93±4.95^{Bd}
	sliced	5.69±0.35^{Ba}	0.542±0.001^{Ba}	76.14±1.85^{b}	4.06±1.64^{b}	31.05±3.27^{Aa}
60	chopped	5.42±0.10^{Bc}	0.521±0.003^{Bb}	81.56±6.50^{Aa}	3.20±2.50^{Bd}	26.70±7.80^{Bc}
	sliced	5.57±0.48^{Ab}	0.531±0.001^{Ab}	80.11±7.31^{Ba}	4.48±2.05^{Aa}	28.28±1.13^{Ab}
p-value		0.009	0.003	< 0.001	< 0.001	< 0.001

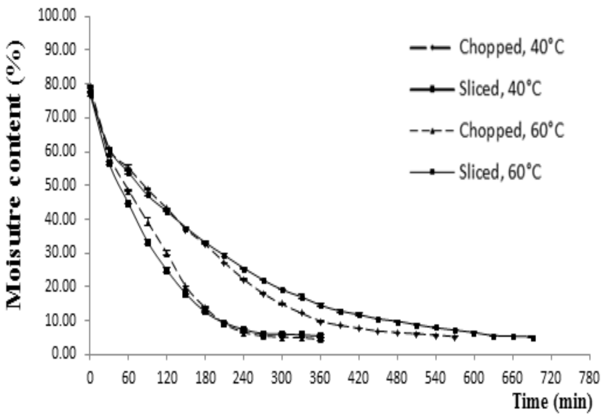

Figure 1. The drying curves of chopped and sliced garlic using hot air oven at 40°C and 60°C

both chopped and sliced garlic. This indicated that the higher temperature can lead the moisture content to be decreased faster as Madamba *et al*. (1996) observed a decreasing of moisture content with the increasing of temperature. Kaya *et al*. (2008) also suggested that an increasing of drying temperature can increase the rate of heat transfer and, consequently, reduced the total drying time. The shape of processed garlic also affected the moisture losses during drying time. The results also showed that the moisture content from chopped garlic was lower than sliced garlic in drying temperature of 40°C and 60°C. The moisture loss of water occurs differently because the water transfer mechanism occurs by mass diffusion. The moisture content from drying of a smaller size product appeared to be evaporated easier than bigger size product (Kingsly *et al.*, 2007). This can be indicated the greater ability to transfer water content of finer sample size than coarser sample size.

The water activity (a_w) from chopped garlic at 40°C of drying temperature showed higher water activity than others. It can be observed that the aw decreased when that temperature was increased. In this experiment, the values of aw at equilibrium from chopped garlic, 40°C; chopped garlic, 60°C, and sliced garlic, 60°C were decreased significant difference from sliced garlic at 40°C. The values for aw at equilibrium decreased significantly (p>0.05) with increase in temperature. As the study from Lertworasirikul and Tipsuwan (2008) suggested that the increase in temperature can be affected the aw at equilibrium significantly on dehydration of cassava. Moreover, the aw at equilibrium of dried garlic powder from all drying condition was lower than 0.6 which suggested that at this level those sample contained lower risk to microbiological activity to be occurred and where deteriorative chemical and biochemical reaction rates are reduced to a minimum (Toledo, 2007). Those reducing aw below 0.6 also indicated the prevention of microbiological spoilage (Ramaswamy and Marcotte, 2006). The moisture content and aw significantly decreased when drying temperature increased from 40°C to 60°C. This finding from this experiment conformed to the results of studies on tomato (Doymaz, 2014), peppers (Kaymak-Ertekin, 2002), and garlic slices (Zhou *et al.,* 2015). Those drying experiments can be explained the decreasing of moisture content and aw from the falling rate period which affected by the majority of the internal diffusion mechanism due to bound water from inside and the surface, altogether with the shrinkage of the product.

Color values changes

The results of color parameters from the hot air drying process of different conditions are shown in Table 1 as L^* (lightness), a^* (redness), and b^* (yellowness), respectively. The temperatures and processed garlic shape affected color values significantly. The L^* (lightness) of dried chopped garlic powder at 60°C showed the highest L^* value significantly from others. This can be explained that the lower temperature of drying can make the sample darker because of the longer period of time to dry the sample. This was discussed in Sacilik and Unal

(2005) studied on dehydrating garlic slices using a forced air dryer at 40°C and 60°C.

The a^* (redness) of dried garlic powder showed significant in all sample which suggested that temperature and shape of processed garlic affected toward the redness. The increasing temperature affected the redness to be decreased because of the higher temperature used longer drying time. The effect of longer drying time also applied on different shape of processed garlic. The smaller of the processed garlic shape affected the redness to be lower (Fante *et al*., (2015). The dried garlic showed the increasing of the redness when the temperature was increased as well as the smaller size of the processed garlic. The b^* (yellowness) of dried garlic powder also showed significant difference of yellowness in all dried sample. The results from this experiment showed the same trend from the effect of processed garlic shape. The bigger of the processed garlic shape affected the yellowness to be higher as presented in Fante *et al.* (2015) investigation. The changes of the yellowness can be related to Maillard reaction which was facilitated because of the more of oxygen and moisture involved in hot air drying, the higher of the yellowness can be perceived (Cui *et al*., 2003). In addition, the increasing of drying temperature of chopped garlic can caused the yellowness to be increased whereas the yellowness of sliced garlic was decreased as discussed in Sharma and Prasad (2001), who studied on Drying of garlic (*Allium sativum* L.) cloves by microwave—hot air combination. These concluded that the increasing of yellowness crowning can be increased when the drying temperature and time of drying was increased.

Analysis of volatile compounds from dried garlic powder using GC-FID

The volatile compounds analysis from dried garlic powder using GC-FID revealed three main volatile compounds as allyl methyl sulfide (AMS), diallyl disulfide (DD), and diallyl trisulfide (DT) were the major components of the garlic oil as shown in Figure 2. The analysis of main volatile compounds can be compared with the findings from Edris and Fadel (2002), who established the research on volatile compounds components in green garlic leaves and garlic cloves. These compounds are essential for giving the characteristic of pungent garlic flavor. Kim *et al*. (2011) also discovered the same results from the investigation on volatile distribution in garlic (*Allium sativum* L.) by solid phase microextraction (SPME) with different processing conditions.

The experiment revealed that AMS, DD, and DT from all drying condition showed significant

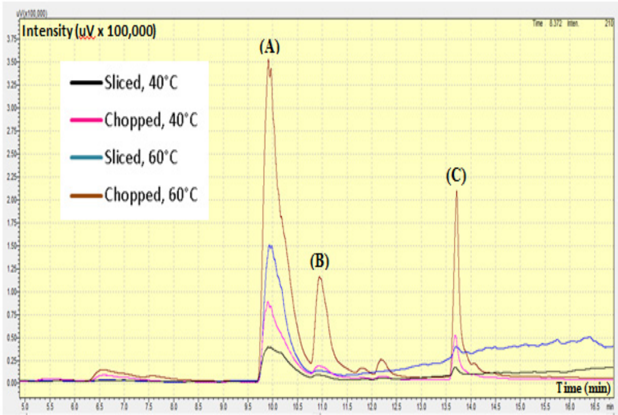

Figure 2. The volatile compounds characterisation and intensity of dried garlic powder using GC-FID; (A) allyl methyl sulfide, (B) diallyl disulfide, and (C) diallyl trisulfide

difference. The chopped garlic with drying temperature at 60°C showed the highest amount of AMS (6.17±0.01 mg/g), DD (5.39±0.0 mg/g), and DT (4.18±0.01 mg/g). The 2 × 2 factorial analysis also showed significant difference within both temperature and shape of the amount of AMS, DD, and DT, which suggested that temperature and shape of processed garlic affected those main volatile compounds of dried garlic powder (Table 2). The identification results were found to be agreed with that reported on Edris and Fadel (2002), whereas the amount of DT (32.32%) was higher than DD (31.35%) and AMS (11.40%). The different content of those allyl compounds happened to be affected during the increasing of temperature from 40°C to 60°C as the fluctuations showed that the temperature at 60°C provided high content of allyl compounds as suggested in Zhou *et al.* (2015). The studied drying of garlic slices and its effect on thiosulfinates showed that temperature at 60°C contained high content of thiosulfinates whereas the increasing of temperature over 60°C can decrease the content of thiosulfinates due to the variability of the degradation phenomenon and thiosulfinates content in the treated samples. Moreover, those three allyl compounds also considered to be potent garlic flavoring compounds and confirmed using GC-O as the following results.

Aroma characteristics from dried garlic powder using GC-O

The volatile compounds identification from previous experiment also taken to analysed for aroma characteristics using GC-O. The results showed that main aroma characteristics of AMS, DD, and DT can be defined as garlic aroma, cauliflower/onion aroma, and fried garlic aroma which conformed to Kim *et al*. (2011) and Shan *et al.* (2013). The main aroma characteristics analysis using GC-O revealed

Table 2. Analysis of variance of volatile compounds and allicin content of dried garlic powder using different temperature under difference processed shape

temperature (°C)	shape	garlic main aroma (mg/g d.b.)			Allicin (mg/g d.b.)
		Allyl methyl sulfide	Dimethyl disulfide	Dimethyl trisulfide	
40	chopped	1.71 ± 0.05^{Ac}	1.14 ± 0.02^{Bb}	0.85 ± 0.02^{Ab}	11.96 ± 0.12^{Bc}
	sliced	0.42 ± 0.01^{Bd}	1.34 ± 0.01^{Ab}	0.26 ± 0.01^{Bc}	12.57 ± 0.43^{Ab}
60	chopped	6.17 ± 0.01^{Aa}	5.39 ± 0.02^{Aa}	4.18 ± 0.01^{Aa}	18.88 ± 1.05^{Aa}
	sliced	2.77 ± 0.01^{Bb}	1.12 ± 0.01^{Bb}	0.84 ± 0.01^{Bb}	11.99 ± 0.13^{Bc}
p-value		< 0.001	< 0.001	< 0.001	< 0.001

*note: the different of capital letter in the same column indicated the significant difference ($p<0.05$) within same temperature.
The different of small letter in the same column indicated the significant difference ($p<0.05$) of all treatments.

that the chopped garlic at 60°C provided AMS, DD, and DT at medium level which higher than other samples. Those results were found to be related with analysis of volatile compounds from dried garlic powder using GC-FID, resulted the aroma intensity from the chopped garlic at 60°C was higher than the sliced garlic at 60°C, the sliced garlic at 40°C, and the chopped garlic at 40°C, respectively. Zhou *et al.* (2015) also suggested in their study that the thiosulfinates content was increased with an increase of hot-air drying temperature (40–60°C) which leads the intensity of main aroma to be increased. These incidents can be related to the activity change of enzyme during drying process, according to Abano *et al.* (2011) investigation showed that the increasing temperature of hot air drying toward 60°C tended to increase thiosulfinates content. It can suggest that the temperature involved to the disintegration and rearrangement of allyl-S-cysteine to become large amount of diallyl thiosulfinates when the temperature increased from 45°C to 55°C (Lagunas and Castaigne, 2008; Abano et al., 2011), so the main aroma intensity from the dried garlic powder at 60°C was found to be more intense than the dried garlic powder at 40°C.

Allicin content

The different amount of allicin content from dried garlic powder at different drying condition was shown in Table 2. The allicin content from the chopped garlic at 60°C provided the highest allicin content (18.88±1.05 mg/g d.b.), followed by the sliced garlic at 40°C (12.57±0.43 mg/g d.b.), the sliced garlic at 60°C (11.99±0.13 mg/g d.b.) , the chopped garlic at 40°C (11.96±0.12 mg/g d.b.), respectively. Table 2 demonstrated that the allicin content with different shape from the same drying temperature was significant difference which suggested that the shape of dried garlic affected the allicin content. The 40°C temperature showed that the sliced garlic contained higher allicin content whereas the 60°C showed that the chopped garlic contained higher allicin content. The significant content of the allicin content within the same temperature was difference because of the different of the moisture content. The lower moisture content can affect the allicin content to be higher, resulted from the increasing temperature that can denature and inactivate of the allinase in garlic at 40°C and 60°C and create more allicin in the drying process (Abano *et al.*, 2011). The comparison on different drying condition also showed the significant difference as temperature is the main effect. The significant increase of the allicin content was due to the increasing of thiosulfinates which are heat-sensitive compounds, and higher temperature can enhance allyl compounds into diallyl thiosulfinates as reported in Abano *et al*. (2011) and Puranik *et al*. (2012). The increasing trend of the allicin content using hot air drying can be found to be increased as the temperature increased from 40°C to 70°C, however the highest temperature of drying cannot be over 80°C as it is can cause allicin to start to breakdown which can lead to lower the allicin content (Ratti *et al.*, 2007; Lagunas and Castaigne, 2008).

Sensory acceptance on dried garlic powder

The sensory acceptance of different drying condition on dried garlic powder was analysed using 9-point hedonic scale; appearance, colour, aroma, and overall liking. All of the drying condition showed significant different as the small subscripted letter shown in Table 3. The sensory rating score of the chopped garlic at 60°C provided the highest rating

Table 3. Mean hedonic ratings (±standard deviation) using 9-point hedonic scale of dried garlic powder

temperature (°C)	shape	hedonic ratings of dried garlic attributes			
		Appearance	Color	Aroma	Overall liking
40	chopped	5.3±1.9^{Bc}	5.8±1.7^{Bc}	5.5±1.6^{c}	5.4±1.4^{Bc}
	sliced	6.1±1.5^{Ab}	6.7±1.3^{Ab}	5.9±1.6^{b}	6.1±1.4^{Ab}
60	chopped	6.7±1.3^{Aa}	6.7±1.3^{Aa}	6.1±1.6^{Aa}	6.3±1.5^{Aa}
	sliced	4.7±1.5^{Bd}	5.6±1.6^{Bd}	5.3±1.4^{Bd}	5.2±1.3^{Bd}
p-value		< 0.001	< 0.001	< 0.001	< 0.001

*note: the different of capital letter in the same column indicated the significant difference (p<0.05) within same temperature.
the different of small letter in the same column indicated the significant difference (p<0.05) of all treatments.

score in appearance (6.7±1.3), colour (6.7±1.3), aroma (6.1±1.6), and overall liking (6.3±1.5), followed by the sliced garlic at 40°C, the chopped garlic at 40°C , the sliced garlic at 60°C, respectively (Table 3). The results showed that there were significant difference of sensory attributes in both temperature and shape of garlic. The lower temperature of drying (40°C) expressed the sensory rating score of the sliced garlic higher than the chopped garlic, where the higher temperature (60°C) expressed the sensory rating score of the chopped garlic higher than sliced garlic. This indicated that the different temperature and shape can affect the sensory rating score differently, which can be explained from physical properties and main aroma compounds. The chopped garlic at 40°C and 60°C had drying time and moisture content lower the sliced garlic, resulted in higher drying rate due to higher moisture diffusion. The smaller pieces of processed garlic which possessed higher drying rate showed better sensory rating score due to main aroma compounds as shown in Table 2 that AMS, DD, and DT were higher as the garlic oil can emerge from the chopped sample more than the sliced sample. The similar result was found from the study on effect of different drying condition on the quality of garlic from Puranik *et al.* (2012). According to the sensory rating score, it was suggested that 60°C was the optimum temperature for drying chopped garlic with lower moisture content and higher sensory rating score.

Conclusion

In this research, the chopped garlic that dried at 60°C exhibited the lowest moisture content and water activity which were the suitable indicators for dry powder product. Those dried garlic powder also provided the highest amount allyl methyl sulfide (6.17±0.01 mg/g d.b.), diallyl disulfide (5.39±0.02 mg/g d.b.), and diallyl trisulfide (4.18±0.01 mg/g d.b.), and allicin (18.88±1.05 mg/g d.b.). It is also showed the colour value of L^* at the highest (81.56±6.50) which suggested that the sample possessed the higher lightness than others. In addition, the main volatile compounds of dried garlic powder from the chopped garlic that dried at 60°C were the highest amount of main volatile compounds. Those results were consistent to the sensory acceptance which revealed that the chopped garlic at 60°C showed the highest sensory rating score; appearance (6.7±1.3), colour (6.7±1.3), aroma (6.1±1.6), overall liking (6.3±1.5). In conclusive, the increasing temperature and the chopped processing can potentially increase main volatile compounds and allicin from dried garlic. The results obtained from this work indicated the suitable drying temperature and shape of processed garlic to acknowledge the maximum thiosulfinates content with good sensory quality of dried garlic powder. The dried garlic powder can potentially be applied into food products that need an addition of garlic flavour and aroma.

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