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Original Research Article

Effect of pre-treatment and drying temperature on physical properties, bioactive compounds and antioxidant activity of Gac powder

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ABSTRACT

Gac fruit *(Momordica cochinchinensis* (Lour.) Spreng) has high content of bioactive compounds, especially carotenoids. These carotenoids are currently in special demand as they are natural antioxidants with potential to prevent chronic disease such as cancers. The objective of this research was to study the effect of pre-treatment and drying temperature on physical properties of gac powder. Bioactive compounds (total carotenoid content) and antioxidant activity of gac powder were investigated. Gac aril and pulp mixture, or gac peel samples were applied with different pre-treatment (blanching or soaking in ascorbic acid) and dried by tray dryer at 50 or 60ºC until the moisture content reached 6%. Bulk density of the samples was in the range of 0.3691-0.6920 g/mL. The highest water solubility index (WSI) was found in aril and pulp mixture sample soaked in ascorbic acid and dried at 50°C (43.70± 2.25 %) ($p<0.05$). The aril and pulp mixture with blanching and dried at 50ºC showed the highest redness (a*) (26.01±0.15), with lightness (L*) of 23.55±2.43 and yellowness (b*) of 33.87±0.82 ($p<0.05$). In addition, aril and pulp mixture sample, blanched and dried at 50ºC had the highest value in total carotenoid content (93.49±11.35 mg β-carotene/100 mL samples), total phenolic compound (467.44±7.64 µg GAE/g), DPPH (43.57±1.61 mmol Trolox/100g) and FRAP value (598.22±18.59 µmol AAE/100g) compared to other samples ($p<0.05$). In conclusion, using blanching as pre-treatment and drying temperature at 50°C could prevent the loss of bioactive compounds and antioxidant activity of the gac aril and pulp mixture during tray drying process. The finding of this study could be applied in the waste utilization process from gac fruit.

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INTRODUCTION

Momordicacochinchinensis (Lour.) Spreng, or usually known as Gac (in Vietnam), Fakkao (in Thailand), Bhatkerala (in India), Moc Niet Tu (in China) and Makkao (in Laos) (Kubola et al. 2011). It is known

that gac is grown in many countries in Southeast Asia. Vietnam is its origin country and usually uses gac as colorant for "xoigac" or red rice (Aoki et al. 2002). In Thailand, gac fruit is usually cooked as vegetable in immature period (Kubola et al. 2011). Recently, gac fruit has entered commercial production as a functional food such as functional drink and supplement.

Gac flesh contains red soft and sticky arils covering hard seed (Tinrat et al. 2014). Nowadays, gac has been popular but the peel is the part that not commonly consumed. It shows that the peel (18%) has become high waste in the commercial production. The high amount of antioxidant and carotenoid in the skin can be developed to be a new product. Gac's pulp and aril contains β-carotene and lycopene extraordinarily in high amounts, approximately ten times higher than other vegetables that rich of antioxidants. Lycopene is associated with reduce risk of certain types of cancer, such as prostate cancer, digestive-tract cancers and lung cancer (Goula and Adamopoulos 2005). In addition, beta-carotene converts to vitamin A in the body (Kim et al. 2007). Fruits and vegetables conversion factor is that 12 mg of β-carotene will produce 1 mg of vitamin A. Vitamin A is very good for pregnant and breastfeeding women. Vitamin A is needed for maturation of the embryo, the lung development, and overall the development of the baby (Strobel et al. 2007).

Food containing carotenoid is gaining public interest. According to Sullivan (2004), the European market for carotenoids supplement was worth US $348.5M in 2003 and was estimated to annually grow by 2.7% to reach $419.6M in 2010. Annual consumer survey over a period of five years showed that prevalence of supplement use fluctuated within the range of 64% to 69% from 2007 to 2011, and the prevalence of regular supplement use ranged from 48% to 53%, with no statistically significant differences from year to year (Dickinson et al. 2014). It shows that the consumer interested in consuming supplement is increasing year by year. Detailed results from the 2011 survey confirmed that supplement use increases with age and is higher in women than men. The reasons of consuming supplement are for overall health and wellness and to fill nutrient gaps in the diet (Dickinson *et al.* 2014).

Gac fruits are seasonal and have a short shelf life (Vuong and King 2003). Gac fruit harvest time is during September to December (Vuong and King 2003). The powder forms are very convenient for lengthen the shelf life of gac fruits. The main benefits of powder forms, as compared with fresh fruits and vegetables, are the potential for long storage at ambient temperature, and a significant reduction in the cost for transportation and storage (Fellows 2000). Nowadays, large varieties of drying techniques are used for producing powder in the food industry. Many factors, such as the characteristics of the food material to be dried, the quality of the desired final product and processing costs, that is, energy and space requirement must be considered (Tang and Yang 2004). Many local gac farmers could not develop their products because the limitation of equipment. Tray dryer is the simplest and cheapest drying machine that can support domestic industry. However, technique selection to preserve gac powder is essential in order to maintain the good quality and high yield of a potential natural source of lycopene, β-carotene and colour for the supplement. In addition, temperature and time of the drying process must be considered to give the minimal reduction of polyphenolic compound. Objectives of this research were to study the optimum process for gac powder production from gac skin and investigate the physical and chemical properties of gac powder.

MATERIALS AND METHODS

Chemicals and reagents

Folin–Ciocalteu's phenol reagent, gallic acid (≥ 99%), trichloroacetic acid (TCA), monosodium phosphate monohydrate, disodium phosphate heptahydrate and methanol (HPLC-grade) were purchased from Fluka (Buchs, Switzerland). Trolox ((±)-6-Hydroxy-2,5,7,8-tetramethylchromane-2-carboxylic acid) and DPPH (2,2-diphenyl-1-picryhydrazyl) were purchased from Aldrich-Fisher (Steinheim, Germany). Potassium hexacyanoferrate [$K_3F_e(CN)_6$] and anhydrous sodium carbonate were purchased from Merck (Darmstadt, Germany). Ascorbic acid and ferric chloride (FeCl3) were purchased from Ajax Finechem (Seven Hills, Australia). Water was purified with a Milli-Q water purification system (Millipore, Bedford, USA). All other chemicals and solvents in this study were of analytical grade.

Samples preparation

The gac fruit was purchased from local farmer in Chiang Rai in ripe development stage. Gac fruit was cleaned and aril, pulp and peel were separated. Aril-seed part was separated manually using a sieve. Pulp and aril (without seed) was then mixed using a blender. The aril-pulp mixture and peel were then treated with two different pre-treatments: soaking in ascorbic acid (AA) or hot water blanching. The samples were dipped (ratio of gac and dipping solution was 1:3) in 1% w/v ascorbic acid for 5 minutes (Tuyen 2010) or blanched in hot water at 80°C for 2 minutes. The pre-treated gac fruits were then dried using a tray dryer as described by Rao *et al.* (2008). The treated samples were placed uniformly on stainless steel trays. Aril-pulp mixture was poured on the tray which has covered by cheesecloth in a thin layer whereas the skin was spread on the tray. The samples were dried at two different temperatures, 50°C and 60°C, at a constant airflow velocity of 0.7 ms^{-1} (Tuyen 2010). The drying treatment was stopped when the sample reached 6% final moisture content. After that, the samples were cooled at room temperature. The dried samples were then ground using a hammer mill on 1.2 mm meshed size. The powders were sealed in a vacuum bag. The sample preparation combination is shown in Table 1.

Table 1. Gac samples from different fractions, pre-treatment methods and drying temperatures.

Trt.	Fruit Fraction	Pre-Treatment	Temperature	Abbreviation
1	Aril-Pulp Mixture	Blanching	50ºC	AP-B50
2	Aril-Pulp Mixture	Blanching	60ºC	AP-B60
3	Aril-Pulp Mixture	Soaking in AA	50ºC	AP-A50
4	Aril-Pulp Mixture	Soaking in AA	60ºC	AP-A60
5	Peel	Blanching	50ºC	P-B50
6	Peel	Blanching	60ºC	P-B60
7	Peel	Soaking in AA	60ºC	P-A50
8	Peel	Soaking in AA	50ºC	P-A60

Determination of water solubility index (WSI)

The water solubility index (WSI) was determined using the method by da Silva et al (2009) with modifications. Gac fruit powder (0.1 g) and distilled water (10 mL) were vigorously mixed in a 50 mL centrifuge tube, mixed vigorously used vortex for 10 seconds, incubated in 37°C water bath for 30 minutes and then centrifuged for 15 minutes at 3000 rpm. The supernatantwas carefully collected in a pre-weighed beaker and oven dry at temperature of 103°C. The WSI (%) was calculated as the percentage of dried supernatant with respect to the amount of the original 0.1 g gac fruit powder.

Determination of bulk density (BD)

2 g of gac powder was added into an empty 10 mL graduated cylinder and held the cylinder on a vortex vibrator for 1 minute, according to the method described by Goula et al. (2004). The ratio of mass of the powder and the volume occupied in the cylinder determined the bulk density value.

Determination of moisture content

Gac powder samples (2.000 g) were placed in moisture can and heated in an oven at 103±2˚C for overnight to constant weight. The moisture content was then calculated from the weight differences (AOAC, 2002). All tests were performed in triplicate.

Determination of water activity (a_w)

The water activity was measured by using water activity meter (Novasina AWC500, Switzerland).

Preparation of gac powder extract

Gac powder (1 g) was extracted for 2 hour with 10 mL of 80% methanol at room temperature on an orbital shaker set at 180 rpm. The mixture was centrifuged at 1400 g for 20 minute and the supernatant was decanted into a 15 mL vial. The supernatant was combined and used for the total phenolic compound, DPPH radical scavenging activity and ferric reducing antioxidant power (FRAP). The experiment and measurements were done in triplicate (Abu Bakar et al. 2009).

Determination of total polyphenol content (TPC assay)

The total polyphenol content was determined according to the method described by Abu Bakar et al. (2000) and ISO 14502-1 (2005) with slightly modifications. Gac powder extracts were diluted (5 fold) with distilled water. The diluted extracts were added into tubes containing 5.0 mL Folin-Ciocalteu's reagent diluted (1:10) in distilled water and stored in the dark place at room temperature for 5 minutes. Then, 4 mL of 7.5% w/v sodium carbonate (Na_2CO_3) solution was added. The mixture was kept at room temperature for an hour and then measured the absorbance at 765 nm using water as blank. The concentration of polyphenols in samples was derived from a standard curve of gallic acid ranging from 0 to 100 µg/mL gallic acid. The TPC was expressed as gallic acid equivalents (GAE), i.e. GAE g/100 g dry weight (DW).

Determination of DPPH radical scavenging activity (DPPH assay)

The DPPH assay was determined according to the method described by Anesini et al. (2008) with slightly modifications. Gac powder-extracts were mixed with an aliquot of 1,950 µL of 60 µM DPPH radical in methanol. DPPH (0.0024 g) dilute in 100 mL of 99.8% methanol was needed to make 60 µM DPPH. The reaction mixture was vortex-mixed and let to stand at room temperature in the dark place for 30 minutes. Absorbance at 517 nm was measured using methanol as a blank and Trolox as a standard. The control and standard were subjected to the same procedures as the sample except that, for the control, only distilled water was added, and, for the standard, the extract was replaced with 0-1,000 µM Trolox standard. Trolox (0.0250 g) was needed to make a standard stock solution (10,000 µM). The DPPH radical scavenging activity of herbal tea was expressed in terms of millimole equivalents of Trolox (TE) per 100 grams of dry sample.

Determination of ferric reducing antioxidant power activity (FRAP assay)

The ferric reducing antioxidant power activity (FRAP assay) was determined according to the method described by Tinrat et al. (2014). A 1 mL aliquot of each extract was mixed with 2.5 mL of phosphate buffer (0.2 M, pH 6.6) and 2.5 mL of a 1% potassium ferric cyanide [$K_3Fe(CN)_6$] solution. Sample was incubated for 30 minutes at 50°C. After incubation, sample was added by 2.5 mL of 10% trichloroacetic acid. The feculences and supernatant were separated by centrifugation at 6,000 rpm for 10 minutes. A 2.5 mL aliquot of supernatant was mixed with 2.5 mL of water and 0.5 mL of 0.1% aqueous ferric chloride. The absorbance was recorded at 700 nm using a spectrophotometer. L-ascorbic acid was used as a standard curve in the range of 0-1000 µmol/100mL.

Determination of total carotenoid content

Gac powders (0.1 g) were extracted with 10 mL of solvent, which is a mixture of n-hexane and acetone (v/v 3:2). The residue was extracted with 5 mL of solvent four times using a magnetic stirrer until colorless. The extracts were combined and washed with 25 mL of distilled water twice to remove acetone, each time in a separating funnel. A drop of saturated NaCl solution was added to separate the acetone. The extract was combined and used for the total carotenoid content assay. The experiment and measurements were done in triplicate (Tran et al., 2008). The extracts were diluted (10-fold) and measured the absorbance using a spectrophotometer at 473 nm wavelength. A 0.0010 g of β-carotene standard mixed with n-hexane in 100 mL volumetric flask was needed as standard solution (1000 µg/100 mL). Standard curve was performed in a range 0-75 µg/100 mL.

Statistical analysis

Data were expressed as means ± standard deviation. The data were also subjected to analysis of variance (ANOVA) and Duncan's multiple range tests using SPSS 16.0 for Windows. The significance level of $P<0.05$ was considered significantly different. The 2^3 factorial design was used to express the differences between the treatments.

RESULTS AND DISCUSSION

Effect of pre-treatment and temperatures on the physical characteristics of gac powder

The effect of pre-treatment and different drying temperatures on the color characteristic of powder is shown in Table 3. The statistical results showed that fruit fraction, pre-treatment, and drying temperature significantly affected the lightness of samples ($p<0.05$). However, interaction between pre-treatment and temperature were not significantly affected the value of L* ($p>0.05$). Moreover, the interaction between fruit part and pre-treatment and between fruit part and temperature significantly affected the lightness ($p<0.05$). Lightness of products increasing was significantly obtained by blanching treatment ($p<0.05$). The highest lightness was recorded in the P-B60. It was in accordance with results of Piga et al. (2004) which blanching figs had higher value of lightness than that of

untreated fruits. Lightness of aril-pulp gac powder was increasing while decreasing the drying temperature. On the other hand, the lightness of peel was increasing while temperature increasing.

Fruit part and pretreatment were significantly affected the redness of powder ($p<0.05$). In addition, there was no significant effect of drying temperature on redness ($p>0.05$). Peel of gac fruit showed lower redness than the aril-pulp. Generally, the sample soaked in ascorbic acid before drying at 50°C showed the highest redness value in comparison with blanched samples (Table 2). It was in accordance with Carvajal et al. (1997) that studied effect of ascorbic acid addition on the colour of paprika pepper. The study showed that paprika pepper with adding of ascorbic acid as pre-treatment gave higher value of redness than others.

Fruit part, pre-treatment, and temperature significantly affected the yellowness (b*) of powder ($p<0.05$). However, interaction between pre-treatment and temperature and between fruit part, pre-treatment and temperature did not significantly affect the value of yellowness (b*) ($p > 0.05$). Powder with aril-pulp mixture treated with ascorbic acid and dried at 60 °C showed the highest value of yellowness (b*).

Table 2. L*, a* and b* of six dried samples

No.	Sample	L*	a*	b*
1	AP-B50	47.36±1.60^{c}	10.74±1.11^{f}	26.14±3.35^{c}
2	AP-B60	25.65±0.87^{d}	18.81±0.44^{c}	34.25±0.57^{b}
3	AP-A50	23.55±2.43^{d}	26.01±0.15^{a}	33.87±0.82^{b}
4	AP-A60	21.99±1.54^{d}	23.48±0.15^{b}	39.72±2.97^{a}
5	P-B50	62.15±0.16^{a}	14.94±0.07^{d}	28.80±0.69^{c}
6	P-B60	66.46±3.82^{a}	10.10±0.56^{f}	27.47±1.41^{c}
7	P-A50	52.46±0.17^{b}	11.68±0.14^{e}	28.32±0.07^{c}
8	P-A60	52.19±6.15^{b}	10.16±0.56^{f}	27.47±1.41^{c}

Values are expressed as means ± SD (n=3).
Different letters in the same column indicate significant difference at $p<0.05$.

The bulk density and water solubility index (WSI) are shown in Table 3. The bulk density of gac powder was significantly affected by the drying temperature, pre-treatment and fruit fraction ($p<0.05$). Increasing of drying temperature decreased the bulk density ($p<0.05$).

Table 3. Bulk density and WSI of six dried samples

Trt	Sample	Bulk Density (g/mL)	Water Solubility Index (%)
1	AP-B50	0.69±0.02^{a}	43.70±2.25^{a}
2	AP-B60	0.64±0.43^{ab}	32.35±2.53^{c}
3	AP-A50	0.65±0.02^{ab}	36.42±3.11^{b}
4	AP-A60	0.61±0.02^{bc}	25.56±1.57^{d}
5	P-B50	0.56±0.03^{d}	15.46±1.52^{e}
6	P-B60	0.51±0.01^{e}	12.71±1.06^{ef}
7	P-A50	0.57±0.05^{cd}	11.55±1.02^{f}
8	P-A60	0.37±0.02^{f}	15.99±1.47^{e}

Values are expressed as means ± SD (n=3).
Different letters in the same column indicate significant difference at $p<0.05$.

Effect of pre-treatment and temperatures on the chemical characteristics of gac powder

The effects of pre-treatment and different air drying temperatures on the physicochemical properties of gac fruit powders are shown in Table 4. Results showed all sample reached moisture content 5.92-6.62 %. It was in accordance with Tran *et al.* (2008) who studied about gac fruit powder. Final moisture content of the powder was 5.80-6.40 %. Drying temperature at 60ºC decreased moisture content faster than 50ºC drying temperature. Generally, in air dryer, increasing drying temperature resulted in greater loss of water in the powder. It is because of higher rate of heat transfer into particles, causing faster water removal.

Water activity (a_w) is useful to predict the growth of bacteria, yeasts and moulds. High water activity in the product may participate in chemical/biochemical reactions, which might deteriorate texture, flavor, color, taste, nutritional value of a product, and the shelf life . For a food that has a long shelf life without relying on refrigerated storage, acidity level (pH) or the level of aw needed to be controlled. According to UNPA (2013), the deterioration of dried food supplement powder caused by microorganisms and biochemical reactions can be prevented at aw lower than 0.6. In this study, aw of products were significantly affected by fruit part and pre-treatment ($p<0.05$). Combination of fruit part-temperature and pre-treatment-temperature significantly affected water activity value. Water activity may reduce when temperature increase. When high pressures, water behaves similar to solutions with increasing salt content so the water activity reduces with increase pressure (Koop et al., 2000). Additionally, the average of aw powder ranged from 0.36 to 0.54 (Table 4) therefore the dried samples were safe from microbial deteriorationIt can be concluded to be safe of microbiological deterioration. Moreover, aw of aril-pulp powders is lower than peel powders ($p<0.05$). Water activity is reduced by the presence of salt and sugar (Koop et al., 2000).

In this study, the bulk density of gac powder was significantly affected by the drying temperature, pre-treatment and fruit fraction ($p<0.05$). Increasing of drying temperature decreased the bulk density ($p<0.05$). Bulk density values were not significantly affected by interaction of pre-treatment and fruit part ($p>0.05$). This is in accordance with the study by Kha (2010) that increasing inlet air drying temperature resulted in reducing bulk density of gac powder.

The water solubility index (WSI) of gac powder was not significantly affected by the interaction of drying temperature and pretreatment and fruit fraction ($p>0.05$), but it was significantly affected by the three factors ($p<0.05$). In this study, the range of WSI samples ranged from 15.46 to 43.70 %. Solubility of the gac powders using vacuum drying ranged from 35.94 to 39.07 % (Kha et al., 2010). The water solubility index of peel was so low, and it could be considered for further research. It could be due to a high content of liposoluble substances, such as carotenoids and tocopherol, a significant level of fatty acids, and high level of insoluble pulp in the original aril (Kha et al. 2010). The low value of WSI of peel can be consider to

Table 4. Chemical characteristics of six dried samples

Trt.	Sample	Drying time (hour)	Moisture content (%)	a_w
1	AP-B50	24	6.00±0.18^{b}	0.38±0.03^{b}
2	AP-B60	18	5.92±0.18^{b}	0.39±0.03^{b}
3	AP-A50	24	6.11±0.17^{ab}	0.36±0.02^{a}
4	AP-A60	18	6.24±0.38^{ab}	0.49±0.04^{b}
5	P-B50	20	6.01±0.17^{ab}	0.51±0.04^{b}
6	P-B60	16	6.62±0.13^{a}	0.50±0.01^{b}
7	P-A50	20	6.16±0.41^{ab}	0.55±0.01^{a}
8	P-A60	16	6.14±0.23^{ab}	0.52±0.03^{a}

Values are expressed as means ± SD (n=3).
Different letters in the same column indicate significant difference at p<0.05.

Effect of pre-treatment and drying temperatures on the bioactive compounds of gac powder

Table 5 shows TPC and TCC values. The results showed that AP-A50 had the highest value of TPC (467.44±7.64 µg GAE/100g), and the least TPC value was observed in P-B50 which was not significantly different with P-B60 (15.67±1.02 µg GAE/100g) (p<0.05). Aril-pulp powder showed that temperature had important roles in a loss of bioactive compounds. Table 5 shows that there was significantly difference on TCC value (p<0.05). The highest TCC value was noted in AP-A50 (93.49±11.35 mg β-carotene/100g), and the least TCC value was P-B60 (32.40±22.32 mg β-carotene/100g) but not significantly different with P-B50 (39.16±4.05 mg β-carotene/100g), on the other side, P-A50 showed the highest value of TCC in powder from peel (58.44 mg/100g of powder).

The results showed that pre-treatments are effective in maximize the retention of bioactive compound. Blanching can prevent the loss of bioactive compound because blanching process removed the soluble solids from the tissue matrix. Ascorbic acid can effectively prevent the loss of bioactive compound because its beneficial role of antioxidant activity. In this study, ascorbic acid as pre-treatment can prevent the loss of carotenoid better than blanching treatment. It was in agreement with the study by Chen et al. (2007). They reported that mangoes soaked in an ascorbic acid solution (1%) before hot air drying preserved the carotenoid content better than blanching treatment. Drying temperature also affected to bioactive compound. Fresh aril and peel of gac fruit had higher TPC value that reported by Kubola et al. (2011). It showed that drying decreased bioactive compound. It was caused by heat sensitivity of bioactive compound (Orphanides 2013). According to Kha et al. (2010), increasing drying temperature will also decrease the bioactive compound.

Aril-pulp carotenoid was much higher than that of dried carrot (110 mg/100g of powder) (Muratone et al., 2008). The highest total carotenoid content of peel powder was observed in ascorbic acid and drying at 50°C (58.44 mg/100g of powder). It was much higher than other dried fruits such as cherry tomatoes (36 mg/100g of powder), pumpkin (14 mg/100g of powder) (Muratone et al., 2008). Therefore, it can be used for powder supplement.

In TPC, the interactions between fruit parts and pre-treatment and between fruit parts and temperature were significantly affected TPC and TCC values (p < 0.05). In aril-pulp powder, drying temperature significantly affected total carotenoid content (p<0.05.) However, using ascorbic as a pre-treatment in peel samples showed significantly higher TCC than using hot water blanching (P<0.05).

Table 5. Total carotenoid content (TCC) and total phenolic compounds (TPC) of six dried samples

Trt.	Sample	TCC (mg β-carotene/100g)	TPC (µg/100g)
1	AP-B50	77.54±16.38^{b}	454.00±13.73^{a}
2	AP-B60	57.81±28.39^{c}	259.72±16.75^{c}
3	AP-A50	93.49±11.35^{a}	467.44±7.64^{a}
4	AP-A60	58.35±48.02^{c}	302.06±29.77^{b}
5	P-B50	39.16±4.05^{d}	85.78±2.86^{e}
6	P-B60	32.40±22.32^{d}	62.45±3.23^{e}
7	P-A50	58.44±45.37^{c}	144.56±5.33^{d}
8	P-A60	56.59±36.03^{c}	126.44±11.17^{d}

Values are expressed as means ± SD (n=3).
Different letters in the same column indicate significant difference at p<0.05.

Effect of pre-treatment and drying temperatures on the antioxidant activity of gac powder

Antioxidants are substances that neutralize free radicals or their actions (Sies, 1996). Antioxidants are able to neutralize free radicals and act at prevention, interception and repair stages (Devasagayam 2004). Table 6 shows antioxidant activity of gac powder. The result showed that AP-A50 had the highest value of DPPH (43.57±1.61 mmol Trolox/100g), and the least DPPH value was P-B60 (15.67±1.02 mmol Trolox/100g) (p<0.05). Aril-pulp powder showed that temperature had an important role in a loss of antioxidant activity. Table 6 shows that there was significantly difference on FRAP value (p<0.05). The highest FRAP value was noted in AP-A50 (598.22±18.59 mg/100g), and the least FRAP value was found in P-B60 (194.00±7.84 mg /100g). In addition, P-A50 showed the highest value of DPPH (39.70±1.32 mg/100g) and FRAP (464.44±16.95 mg /100g) among the samples from peel. This study indicates that aril-pulp powder prevention of antioxidant loss was affected by the drying temperature. Reduction of antioxidant activity was caused by thermal treatment (Kha et al. 2010). Miranda et al. (2009) reported that higher antioxidant activity of *Aloe vera* gel which dried at lower temperatures showed higher antioxidant activity. In this study showed that FRAP value was higher than DPPH value, which was in accordance to the study by Kubola et al. (2010). They reported that aril extract showed the highest FRAP value. Fruit parts, pre-treatment and temperature affected the DPPH value of samples (p<0.05).

CONCLUSIONS

In conclusion, using ascorbic acid as pre-treatment and drying at 50°C could prevent the loss of antioxidant in the process of making gac powder using air dryer. The utilization of gac peel as a powder supplement can be considered because high of carotenoid and antioxidant. Further study needs to be conducted to increase the quality of peel powder and antioxidant stability during process.

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REFERENCES

Abu Bakar, M.F., Mohamed, M., Rahmat, A. and Fry, J. 2009. Phytochemicals and antioxidant activity of different parts of bambangan *(Mangiferapajang*) and tarap (*Artocarpusodorastissimus*). Journal of Food Chemistry, 113, 479-483

Anesini, C., Ferarro, G. E and Rosana, F. 2008. Total polyphenol content and antioxidant aapasity of commercially available tea (*Camellia sinensis*) in Argentina. Journal of Agricultural Food Chemistry, 56: 9225-9229.

AOAC. 2002. Properties of Water in Foods. Washington DC: AOAC.

Aoki, H., Kieu, M.T.N., Kuze, N., Tomisaka, K., Chuyen, V.N. 2002. Corotenoid pigments in gac fruit (*Momordica cochinchinensis* Spreng). Bioscience Biotechnology and Biochemistry, 66 (11), 2479-2482.

Carvajal, M., Martínez, M.R., Martínez-Sánchez, F. and Alcaraz, C.F. 1997. Effect of ascorbic acid addition to peppers on paprika quality. Journal of the Science of Food and Agriculture. *75*(4), 442-446.

Chen, J.P., Tai, C. Y. and Chen, B.H. 2007. Effects of different drying treatments on the stability of carotenoids in Taiwanese mango (*Mangifera indica L.*). Food Chemistry. *100*(3). 1005-1010.

Devasagayam, T.P.A., Tilak, J.C., Boloor, K.K., Sane, K.S., Ghaskadbi, S.S. and Lele, R.D. 2004. Free radicals and antioxidants in human health : current status and future prospects. Journal of Associate Physicians India, 52, 794-804.

Da Silva, C., de Carvalho, P. and Andrade, C. 2009. The effects of water and sucrose contents on the physicochemical properties of non-directly expanded rice fluor extrudates. Ciencia e Tecnologia de Alimentos, 29, 661-666.

Dickinson, A., Blatman, J., El-Daszh, N. and Franco, J.C., 2011. Consumer usage and reasons for using dietary supplements: report of a series of surveys. Journal of American College Nutrition, 33(2), 176-82.

Fellows, P.J., 2000. *Food Processing Technology : Principles and Practice 3rdedition*. Cambridge : Woodhead Publishing.

Goula, M.A. and Adamopolos, K.G., 2005. Stability of lycopene during spray drying of tomato pulp. LWT-Food Science and Technology 38: 479-487.

Goula, M.A., Adamopoulos K.G. and Kazakis N.A. 2004. Influence of spray drying conditions on tomato powder properties. J. Drying Technology 22 (5) : 1129-1151.

International Organization for Standardization. 2005. ISO 14502-1: Determination of Substances Characteristic of Green and Black Tea Part 1 Content of Total Polyphenols in Tea-Colorimetric Method Using Folin-Ciocalteu Reagent. Hongkong: Hongkong Polytechnique University.

Kha, T.C., 2010. Effects of different drying processes on the physicochemichal and antioxidant properties of Gac fruit powder.*Thesis.* Newcastle (AU) : The University of Newcastle.

Kim, M.Y., Giraud, W.D. and Driskell, A.J., 2007. Tocopherol and carotenoid contents of selected Korean fruits and vegetables. Journal of Food Composition and Analysis, 20, 458-465.

Koop, T., Luo, B., Tsias, A. And Peter, T. 2000 .Water activity as the determinant for homogeneous ice nucleation in aqueous solution. Journal of Nature, 406, 611 – 614.

Kubola, J. and Sirithon, S., 2011. Phytochemicals and antioxidant activity of different fruit fractions (peel, pulp, aril and seed) of Thai gac (*Momordica cochinchinensis* Spreng). Journal of Food Chemistry, 127, 1138-1145.

Miranda, M., Maureira, H., Rodríguez, K. and Vega-Gálvez, A. 2009. Influence of temperature on the drying kinetics, physicochemical properties, and antioxidant capacity of Aloe Vera (*Aloe Barbadensis* Miller) gel. Journal of Food Engineering, 91(2), 297-304.

Muratore, G., Rizzo, V., Licciardello, F. and Maccarone, E. 2008. Partial dehydration of cherry tomato at different temperature and nutritional quality of the products. Food Chemistry, 111 (4), 887-891.

Orphanides, A., Goulas, V. and Gekas, V. 2013. Effect of drying method on the phenolic content and antioxidant capacity of spearmint. Czech Journal of Food Science, 5(31), 509-513.

Piga, A., Pinna, I., Özer, K. B., Agabbio, M., Aksoy, U. 2004. Hot air dehydration of fig (*Ficus carica* L.): Drying kinetics and quality loss. International Journal of Food Science and Technology, *39*(7), 793-799.

Rao, A.V. and Rao, L.G. 2007. Carotenoids and human health. Pharmacological Research, 55(3), 207-216.

Strobel, M., Tinz, J. and Blesalski, H.K. 2007. The importance of β-carotene as a source of vitamin A with special regard to pregnant and breastfeeding women. European Journal of Nutrition, 40(1), 1-20.

Sullivan, F. 2004. European spending on carotenoids to pass $400 M mark by 2010. *Focus on Pigments 2004 (*5) : 3

Tang, J. and Yang, T. 2004. Dehydrated vegetables: Principles and systems. In Y.H. Hul, S. Chazala, D.M Graham, K.D Murell, and W.K Nip (Eds.). *Handbook of vegetable preservation and processing.* New York: Marcel Dekker.

Tran, T.H., Nguyen, M.H., Zabaras, D. and Vu, L.T.T. 2008. Process development of Gac powder by using different enzymes and dying techniques. Journal of Food Engineering, 85, 359-365.

Tinrat, S., Akkarachaneeyakorn, S. and Singhapol, C. 2014. Evaluation of antioxidant and antimicrobial activities of *Momordicacochinchinensis* Spreng (gac fruit) ethanolic extract. Journal of International of Pharmaceutical Sciences and Research, 5(8), 3163-3169.

Tuyen, C.K., 2010. Effects of Different Drying Processes on the Physicochemical and Antioxidant Properties of Gac Fruit Powder. *Thesis.* Newcastle : The University of Newcastle Australia

United Natural Products Alliance [UNPA]. 2013. Shelf life recommendation for supplements guidelines for manufacturers. https://unpa.com/assets/news_resource/asset/5/Shelf_life_recommendations_for_supplements_27.11.13.pdf [18 Desember 2014]

Vuong, L.T. and King, J.C., 2003. A method of preserving and testing the acceptability of Gac fruit oil, a good source of beta-carotene and essential fatty acids. *Food and Nutrition Bulletin,* 24

Wang, N. and Brennan J.C., 1995. Changes in structure, density and porosity of potato during dehydration. Journal of Food Engineering, 24(1), 61-76.