EFFECTS OF AIR-DRYING TEMPERATURE ON THE PHYSICOCHEMICAL AND ANTIOXIDANT PROPERTIES OF THE GAC ARIL (*MOMORDICA COCHINCHINENSIS SPRENG*)

● DANG THI NGOC DUNG - LUONG THI DIEM TRANG - NGUYEN NGOC CHAU - DANG THI NGOC HA

ABSTRACT:

Momordica cochinchinensis Spreng (Gấc in Vietnamese) has high bioactive substances, especially high concentration of carotenes (lycopene and β-carotene). These carotenes are special thanks to their natural antioxidants which are potential to prevent and treat cancers. This study presents an overview on the effects of air-drying temperature on the physicochemical and antioxidant properties of the Gac aril during the cold drying process. This study aims to make the cold-dried Gac produc as a potentially valuable food source of pro-vitamin A and lycopene. This study finds out the optimum air temperature of cold drying process for Gac aril. This study's findings reveal that the strict temperature control plays an important role in the cold-dried Gac airl production as it maintans physicochemical and antioxidant properties of Gac airl.

Keywords: *Momordica cochinchinensis Spreng*, Gac, physicochemical properties of Gac aril, antioxidant, cold-drying, air-drying temperature, air velocity.

1. Introduction

Gac *(Momordica Cochinchinensis Spreng)* is an indigenous Vietnamese fruit, botanically classified in the Cucurbitaceae family (T.H.Tran et al, 2007). Many parts of Gac such as seeds, oil or root can be used as traditional medicine (Loi, 1991). The Gac arils have been mainly used as a colorant in steamed momordica glutinous rice "Xôi gấc" a familiar dish for breakfast as well as a traditional dish in other spe-cial ceremonies such as engagement, wedding and lunar new year in Vietnam (T.H.Tran et al. 2006). In South Vietnam, Gac is harvested all months; in North Vietnam, Gac is seasonally harvested from October to February (Dang Thi Tuyet Nhung, 2010). Gac is an important source of bioactive molecules that protect human cells against the detrimental effect of free radicals. The main antioxidants present in Gac aril are the oxygenated carotenoids (lycopene, carotene, xanthophylls, lutein) (Tuyen Chan Kha et al, 2010; Vuong L.T, 2000), as well as phenolic compounds (Jittawan Kubola et al, 2011). Lycopene has been reported to be associated with reduced risk of certain types of cancer, such as prostate cancer, digestive-tract cancers and lung cancer (Goula & Adamopoulos, 2005). Beta-carotene converts to vitamin A in the body (Kim, Giraud, & Driskell, 2007). This is essential for the health and proper development of the cell membranes (Jittawan Kubola et al, 2011). Other studies also confirmed that Gac aril contained a large amount of lycopene and beta carotene (Aoki, Kieu, Kuze, Tomisaka, & Chuyen, 2002; Ishida, Turner, Chapman, & McKeon, 2004; Tran, Nguyen, Zabaras, & Vu, 2008). Therefore, some new products from Gac such as Gac oil capsules, Gac oil in ethanol were introduced to the global markets (Tran et al., 2008). However, little information on cold-drying conditions on the physicochemical and antioxidant properties of the Gac aril has been published. The objectives of this study were to compare the effect of temperature, time, air velocity in drying processing in physicochemical and antioxidant activity of dried Gac aril, and to analyze the change of moisture content, carotenoids, â carotene, lycopene by different cold-drying conditions.

2. Materials and methods

2.1. Sample preparation

Gac fruit of 1100÷1500g average weight were purchased from local market in Ho Chi Minh City, Vietnam during from February to June. Fully ripe Gac fruits had red color covering more than 2/3 of their skin that selected and stored at 2÷6⁰C. Prior to experiments, the Gac were removed from cold storage and kept at ambient for 2h. The whole Gac fruit was scooped out.

The red aril surrounding the seeds was completely separated, dried at different air-drying temperature, air velocity.

2.2. Apparatus

The cold drying system DSL-P-L-T-02 controlled by PLC was used to dry Gac (Fig 2): supported by Faculty of chemical & Food Technology, UTE, Vietnam used for dried Gac aril was able to produce low relative humidity (0-50% RH) and variable temperature in the range from 20 to 50⁰C.

2.3. Drying experiment

The conditions applied in the experimental

Fig 1. Gac fruit

setups used for the drying of Gac aril samples are based on a factorial design:

Influence study of air-drying temperature on physico-chemical and antioxidant properties of dried Gac aril samples:

Factorical design: Air-drying temperatute: 30-34-38⁰C

Influence study of drying time on physico-chemical and antioxidant properties of dried Gac aril samples:

Factorical design:

- Air-drying temperatute: 34-38⁰C
- Drying time: 11-12-13-14-15-16h

Quality parameter: moisture content (%), lycopene (mg/kg), β-carotene (mg/kg), peroxyde index (Meg/kg)

2.4. Statistical analysis

The effect of air-drying temperature, air velocity on each parameter was estimated using Statgraphics Plus 5.0 *(Statistical Graphics Corp., Herndon, VA, USA)*. The results were analyzed by an analysis of variance (ANOVA). Differences between the media were analyzed using the least significant difference (LSD) test with a significance level of a = 0.05 and a confidence interval of 95% (p-value <0.05). The multiple range test (MRT) included in the statistical program was used to demonstrate the existence of homogeneous groups within each of the parameters. All determinations were carried out in triplicates.

2.5. Physicochemical analysis

The crude protein content was determined using the Kjeldahl method with a conversion factor of 6.25 (AOAC No. 960.52). The lipid content was analyzed gravimetrically following Soxhlet extraction (AOAC No. 960.39). The crude ash content was estimated by incineration in a muffle furnace at 550°C (AOAC No. 923.03). The available carbohydrate was estimated by difference. The equilibrium moisture content of dried Gac aril sample was determined by means of AOAC method No. 934.06. All methodologies followed the recommendations of the Association of Official Analytical Chemists (AOAC (1990)).

All measurements were done in triplicate.

2.6. Determination of β carotene and lycopene

The β carotene and lycopene were determined using the methods spectrophotometer of Nagata and Yamashita (1992).

3. Results and discussion

3.1. Effect on physicochemical properties

Table 1. The chemical composition of Gac aril material

Unit of the chemical composition	g/100g Gac material	Capacity
Moisture	%	77 25± 3.4
Crude glucid	g	10.43±0.45
Lipid	g	7.93±0.55
Crude fibre	g	1.89±0.32
Crude protein	g	2.19±0.23
Ahs	mg	0.69±0.02
Peroxyde	meq/kg	0
β - carotene	mg/kg	60.3
Lycopene	mg/kg	121

Table 1 shows the mean values of the proximate analysis of Gac fresh aril samples including moisture, crude glucid, lipid, crude fiber, crude protein, ahs, lycopene, β carotene, peroxyt index. Contents of fresh Gac aril are similar to those reported by Aoki et al. (2002) and Vuong et al. (2006) reported the concentrations of carotenoids ranging only from 0.380-0.408 mg/g aril and 0.083-0.769 mg/g aril for lycopene and beta carotene respectively.

In this study, lycopene and beta carotene concentrations in Gac aril exceed those in other fruits and vegetables reviewed by Bauernfeind (1972) and Aoki et al. (2002). Lycopene concentration found in Gac aril, which is the edible portion of Gac fruit, was about 20 times higher than the lycopene concentration in edible portion of red watermelon and about 4 times higher than the lycopene concentration in concentrate tomato (processed product), which are the highest lycopene containing fruit and processed product in the review of Maiani et al., (2009). Furthermore, when compared to a range of other fruits and vegetables the β-carotene level in Gac fruit is the highest (Aoki et al, 2002, Ishida et al, 2004; Tran et al, 2008). Vuong (2000) stated that Gac fruit has the highest β-carotene content of the edible plants of Northern Vietnam. For example it is eight times higher than the level in carrots, which are commonly recognized as being high in β-carotene.

3.2. Effect on moisture content

Gac aril samples were dehydrated at 30°C, 34°C and 38°C. The drying dehydration of Gac aril samples are shown in Fig 1 and Table 2. As it can be observed, air-drying temperature had an important influence on the drying rate, similar result for dried orange was researched by M. Carme Garau et al (2007). As expected, longer drying periods were required at lower drying air temperatures, whereas higher temperatures promoted shorter drying times. For example, after 16 hours, air-drying temperature at 30, 34, 38°C, the moisture Gac aril samples were 9.72, 6.93, 4.7 (%). The highest drying rate was observed in the air drying process at 38⁰C, whereas the lowest was at 30⁰C. Table 2 shows that moisture content of dried Gac aril samples got < 7÷8%:

- At 30⁰C, drying time 18h: moisture content 8.01%
- At 34⁰C, drying time 15h, moisture content 7.66%
- At 38⁰C, drying time 12h, moisture content 7.07%

The moisure decreased as the air temperature increased ($p < 0.05$). Similar results for dried fruits and vegetables products were also found by Piga et al. (2004), Singh et al. (2006), Schultz et al. (2007), Vega-Gallaz et al., (2008), and Yadollahinia et al. (2009), Tuyen C.K et al, 2010.

Different letters in the same column indicate that the values are significantly different ($p<0.05$).

3.3. Effect on lycopene, β carotene content

Table 2 shows the content of moisture, β-carotene, lycopene and perxoyde index in the dried Gac aril samples. The dried Gac aril was dried at 38⁰C contains a high quantity of lycopene (314.4 mg/kg d.m), at 34⁰C contains 233.4 (mg/kg d.m), 30⁰C contains 194.0 (mg/kg d.m). Some researchs reported temperature could be increase lycopene (Jittawan Kubola, 2011). When using hot air drying process, dried sample was used hot air drying process contains lycopene content (0.82mg/g DW) highest than dries sample was used FIR process (0.67mg/g DW) and low

Table 2: The effect of air-drying temperature on moisture content, lycopene, β-carotene and peroxide index of dried Gac aril samples

Quality index	Air temperature (0C)		
	30	34	38
Time (h)	18	15	12
Moisture content (%)	8.01±0.20[a]	7.66±0.27[b]	7 07±0.24[c]
Lycopene (mg/kg DM)	194±7.20[a]	233 4±4.59[b]	314.4± 4.33[c]
β-carotene (mg/kg DM)	147.8±3.10[a]	142.6±4.01[a]	129 2±2.78[c]
Peroxyde (meq/kg DM)	ND	1.31±0.01[b]	1.35±0 04[b]

Fig 2: The effect of air-drying temperature on moisture content of Gac aril samples

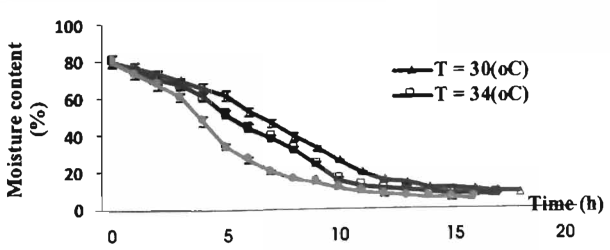

Table 3: The effect of drying time on moisture content, lycopene, β-carotene and peroxide index of dedried Gac aril samples

Quality index	Air-drying temperature (ºC)	Drying time (h)					
		11	12	13	14	15	16
Moisture (%)	34	12.08±0.2^{Aa}	10.24±0.34^{Ab}	9.66±0.30^{Ac}	8.28±0.23^{Ad}	7.66±0.2A^{e}	6.93±0.18^{Af}
	38	8.45±0 24^{Ba}	7 07±0.23^{Bb}	6.28±0.21^{Bc}	5.63±0.2^{Bd}	5.02±0.21^{Be}	4.7±0.1^{Bf}
Lycopene (mg/kg DM)	34	233.8±5.06^{Aa}	258.6±6.71^{Ab}	257.6±7.20^{Ab}	240.4±5.89^{Ab}	233.4±5.45^{Ae}	209.2±6.23^{Af}
	38	319.8±6.72^{Ba}	314.4±8.32^{Bc}	308±5 33^{Bb}	259.2±6 05^{Ad}	248.2±6.37^{Be}	237.6±5.38^{Bf}
β-carotene (mg/kg DM)	34	114.0±4.29^{Aa}	152.0±3.07^{Ab}	151 8±4.01^{Ab}	146.4±5.11^{Ab}	142.6±5.60^{Ab}	120.2±6 01^{Af}
	38	131.6±3.07^{Ba}	129.2±5.13^{Bb}	124±3.10^{Bc}	112.8±4.36^{Bd}	103±4.07^{Be}	90.6±4.10^{Bf}
Peroxide (meq/kg DM)	34			0 67±0.01^{Ac}	0 89±0.01^{Ad}	1.31±0 01^{Ae}	1 4±0.01^{Af}
	38	0 9±0.01^{Ba}	1.35±0.02^{Bb}	1.6±0.01^{Bc}	2.02±0.03^{Bd}	2.89±0.01^{Be}	3.17±0.02^{Bf}

Data are expressed as the average±standard deviation for three replicates. Values in the same column having the same letter (A, B) for each parameter are not significantly different at a confidence level of 95%. Values in the same row having the same letter (a, b, c, d, e and f) for each parameter are not significantly different at a confidence level of 95%.

humidity process (LRH) (0.56mg/g DW) (Jittawan Kubola, 2011). In addition, all trans lycopene were lost 25% in emulsion when increase temperature (Ax, Mayer-Miebach et al , 2003). Schierle et al. (1996) reported lycopene isomeric of tomato could increase in oil higher than in water. Besides, at 38ºC short drying time (12h), moisture content (7.07%) are suitable for lycopene extraction. It can be seen that reason caused lycopene content increase double. At 30ºC and long drying time (18h) could be not suitable for trans lycopene isomeric. Dried Gac aril (was dried at 30ºC in 18hours) contains β-carotene (147.8 mg/kg dm), and at 34ºC, 15h contains β-carotene 142.6 (mg/kg), no significant differences ($p<0.05$). Morever, dried Gac aril was dried at 38ºC, 12h contains β-catotene content (129.2 mg/kg dm).

Table 3 shows with drying time 11h, dried Gac aril (dried at 34ºC) contains β-carotene 114.0 (mg/kg) lower than dried Gac aril (dried at 38ºC) contains 131.6 (mg/kg). This could be explained due to moisture of dried Gac aril (dried at 34ºC) contains 12.08% that impossible for extract â carotene from Gac aril. Morever, dried Gac aril was dried at 38ºC contains 8 45(%) moisture are advantageous moisture for extract (Vũ Đức Chiến, 2007). From 12÷16hours, β-carotene content of dried Gac aril (dried at 34ºC) is (152.0÷120.2 mg/kg) higher than dried at 38ºC (129.2÷90.6 mg/kg dm) because of Gac aril was dried at high temperature could be contact to oxy in air in long time. β-carotene could be loss (Tuyen Chan Kha, 2010).

It can be observed (Table 3) that an increase in drying temperature has an important effect on the total carotenoids ($p<0.05$). Drying time from 11 to 16 hours, dried Gac aril was dried at 38°C contains lycopene (319.8÷237.6 mg/kg dm) higher than at 34°C, lycopene content (233.8÷215.2 mg/kg), this result is similar to result on Table 2, drying temperature is higher, lycopene content is higher. However, dried Gac arils were dried at 34°C, 38°C lost lycopene content by drying time. Dried Gac aril was dried at 380C lost high lycopene content, from 11÷16 hours lost 82.2 (mg/kg dm), but after 13÷16h lycopene content lost from 308 mg/kg to 237.6mg/kg dm. However, at 34°C, lycopene was lost ½ content with at 38°C (from 233.4 mg/kg to 209.2 mg/kg).

Increasing correlation between carotenoids and total phenolic content has been reported during food dehydration (Deepa et al., 2007). However, data on the effects of drying on lycopene, β-carotene of vegetables are conflicting due to several factors, like drying method, drying temperature used as well as oxy factor. Food processing is generally believed to be responsible for a depletion of naturally occurring antioxidants. Carotenoids are light and temperature sensitive, so high temperature, long processing time, light and oxygen have been shown to have effects on their degradation (Vuong LT et al, 2006, Tuyen Chan Kha, 2010).

3.3. Effect on peroxide index

Table 2, peroxide index (PI) was affected by the drying temperature, PI increased with temperature. However, PI showed no significant differences ($p<0.05$). (Table 2) The highest PI value was 1.35 meq/kg dm at 38°C, this could be explained due to lipid was oxidant through the surface during rehydration (Vuong et al, 2000). PI value was not set at 30°C. Therefore, compare with some others drying methods, PI value was low (used the cold-drying method). The researchs reported temperature could be increase PI value. PI value was 5.1 meq/kg dm when dried Gac aril was dried at 50°C (Vu Duc Chien et al, 2010).

Table 3, the highest PI value was 3.17 meq/kg dm when Gac aril was dried at 38°C, 16h; PI value was 1.4 (meq/kg) (34°C, 16h). Oxidantation was clearly temperature dependent, as it increased with increasing dehydration temperature (Vuong et al, 2000).

4. Conclusions

The above results confirmed that Gac is an invaluable source of carotenoids, especially lycopene and β-carotene. It is also a unique fruit that can supply aril enriched in carotenoids (fresh Gac aril has 60.3 mg/kg β-carotene and 121 mg/kg lycopene and dried Gac aril has 158.2 mg/kg β-carotene and 340.4 mg/kg lycopene).

The effect of air-drying temperature on physicochemical and antioxidant properties of the hydrated Gac aril samples due to during cold-drying between 30 and 38°C, drying time 11-16 hours, air velocity 9m/s were investigated. When Gac arils were dried at 34, 38°C in 11÷13h, carotenoid concentrations in the aril increased slightly. The ratio lycopene/beta carotene in Gac aril was very high and about 2÷3 fold higher than that in fresh Gac aril, it could be explained when Gac was dried at 34÷38°C, was suitable condition for carotenoid extraction. However, both lycopene and beta carotene degraded quickly in Gac aril under long drying time 13÷16h. The higher drying temperature, the higher PI value. PI value increased with dying time. It is suggested that carotenoids, PI value in dried Gac aril can be better preserved using low temperature condition, low drying time ■

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ẢNH HƯỞNG CỦA NHIỆT ĐỘ SẤY ĐẾN TÍNH CHẤT HOÁ LÝ VÀ CHỐNG OXY HOÁ CỦA MÀNG HẠT GẤC *(MOMORDICA COCHINCHINENSIS SPRENG)*

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TÓM TẮT:

Gấc chứa các chất có hoạt tính sinh học cao, đặc biệt là các carotene (lycopene và β–carotene). Các carotene có vai trò đặc biệt vì chúng là chất chống oxy hóa tự nhiên có khả năng ngăn ngừa và hỗ trợ điều trị một số bệnh ung thư. Nghiên cứu này xác định ảnh hưởng của nhiệt độ trong quá trình sấy lạnh lên các tính chất hóa lý và khả năng chống oxi hóa của màng hạt Gấc. Mục đích của nghiên cứu nhằm tạo ra sản phẩm màng hạt Gấc khô - một loại thực phẩm có hàm lượng tiền vitamin A, lycopene cao. Nghiên cứu đã tìm ra nhiệt độ sấy tối ưu cho quá trình sấy lạnh màng hạt Gấc và xác định việc kiểm soát nhiệt độ trong quá trình sấy lạnh màng hạt Gấc đóng vai trò quan trọng trong việc duy trì các giá trị hóa lý và hàm lượng các chất chống oxy hóa.

Từ khoá: Gấc, tính chất hoá lý của màng hạt Gấc, chống oxy hoá, sấy lạnh, nhiệt độ sấy, vận tốc không khí.