Effect of different antioxidant ratios supplemented into mixture of Gac (*Momordica cochinchinensis* Spreng) seed membrane-carrier to total carotene; accelerated temperature to shelf-life of Gac powder

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ABSTRACT

Gac fruit, *Momordica cochinchinensis* Spreng, also known as baby jackfruit or sweet gourd, is one of the traditional fruits in Vietnam. Studies report that extraordinarily high levels of carotenoids, especially β-carotene and lycopene, are found in Gac fruit aril, the brightly coloured flesh covering the seeds. Gac fruit also contains significantly high levels of α-tocopherol (vitamin E) and of fatty acids. Due to regulatory issues and consumer demands, industrialized food products need to clearly state their shelf-lives, that is the time within their characteristics are kept at acceptable levels, in their packages. Nowadays consumers demand products with superior appearance, texture, taste and flavor whilst keeping their nutritional value. It is very important therefore, to preserve or enhance these constituents in processed Gac fruit products, particularly the high levels of carotenoids and the associated antioxidant activity. Dried Gac powder is usually the dried aril component having the high concentration of nutrients and colour. The aim of this study is to investigate various ratios of antioxidant supplementation such as vitamin C and vitamin E into the mixture of Gac and carrier; and to develop a method to investigate the changes of total carotene content of Gac powder product in accelerated temperature to find out the appropriate temperature and shelf-life of product storage. Our result shows that vitamin C at content of 2000ppm (according to weight of wet material) supplemented into the mixture of Gac and carrier gives the highest total carotene content; carotene content maintains at 70% in comparing with the beginning content in three months at 10^0C or five months at 5^0C in condition of absent oxygen and light.

Key words: *Gac fruit, antioxidant supplementation, carotene, accelerated temperature, shelf-life*

INTRODUCTION

Gac fruit, *Momordica cochinchinensis* Spreng, is botanically classified as Family Cucurbitaceae, Genus *Momordica*, and Species *Cochinchinensis*. It is also known as baby jackfruit, sweet gourd or cochinchin gourd in English. The fruit is one of the traditional fruits in Southeast Asia in general, and in Vietnam in particular. In Vietnam, Gac fruit is most commonly prepared as "Xoi Gac" (the Gac aril cooked in glutinous rice) for Tet (Vietnamese New Year) and wedding celebrations.

The Gac plant can be cultivated from seeds or root tubers, and grows as devious vines that are separate male and female plants. It can be commonly seen in Vietnam growing wild or in domestic settings with the vines growing on lattices in rural homes or in gardens. Two months after planting root tubers the plant will start flowering; flowering usually begins in April and continues until August or September.

Momordica Cochinchinnensis Spreng *(Gac)* is botanically classified as follows:

Family: Cucurbitaceae

Genus: Momordica

Species: Cochinchinnensis

Fruits of Momordica cochinchinensis are big, denselyaculaeate, green in color and when ripe, become dark orange or red. Unlike the bitter gourd (Momordica Charantia), the exocarp (rind) of the gac fruit is hard, and covered with conical points one eighth inch high. There are two shapes of gac fruit available in Vietnam, oblong and almost round, however there are no differences in the ways the fruits are used or consumed. There are also variations among different fruits with respectto their spine and fruit tips. In some fruits, the spines are smooth and dense, whereas insome, they are hard and thinly arranged. The oblong types are 6-10cm in length and round types are 4-6 cm in length. In Vietnam, the oblong fruit weighs between 500gand 1600g and can be 10 to 13 cm long. Unlike bitter gourd, which is mostly harvested in the developmental stages, gacfruits in Vietnam are only picked at maturity when the fruit is bright red and seeds are hardened.

The mesocarp of the momordica cochinchinensis(gac) fruit is 1/2" thick, spongy and orange in color. The core is divided into cartilaginous chambers containing bright red fleshy seed pods. Each fruit has on average between 15 to 20 seeds. Seed are round, compressed and sculptured. Seed membrane and kernels contain oil and are used in traditional medicine. There is no record of any use of the mesocarp. The average weight of the pulp is about 19% of the total fruit weight. An average gacfruit weighing 1kg yields approximately 190g of fruit pulp and 130g of seeds. The seed pulp of a ripe momordica cochinchinensis fruit is bright red in color and has a palatable bland to nutty taste.

Figure 1. Ripen Gac fruit

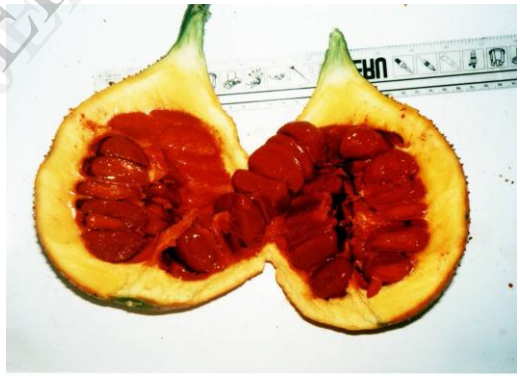


Figure 2. Fresh Gac fruit component

Several studies have reported that Gac fruit contains extraordinarily high levels of carotenoids, especially carotenes and lycopene, in comparison to other fruits and vegetables containing lycopene and β-carotene. According to Bauernfeind (1972) and Aoki et al. (2002), the lycopene concentration in Gac fruit is at least five times higher than in other fruits analysed (rosehip, pitanga (Brazil), tomato (USA), guava (pulp), water melon, papaya and grapefruit). Furthermore, when compared to a range of other fruits and vegetables the β-carotene level in Gac fruit is the highest. 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 recognised as being high in β-carotene [5].

Carotene

Since carotenoids are the major component in Gac fruit, it is important to review the carotenoid pigments in terms of their structure, classification and distribution. In general, carotenoids are

isoprenoid compounds, containing eight isoprenoid units whose order is inverted at the molecule centre; these are widely distributed in nature as red, yellow and orange pigments. More than 600 different carotenoids have been identified from natural sources; however, approximately twenty-four carotenoids commonly occur in foods and fourteen carotenoids have been identified in human serum (Dutta et al., 2005; Xianquan et al., 2005). Carotenoids are chemically divided into two groups, carotenes and xanthophylls. The first group is the highly unsaturated hydrocarbons, known as carotenes, which contain no oxygen. Xanthophylls contain one or more oxygen functional group (most commonly hydroxyl, keto, epoxy, methoxy or carboxylic acid groups) at particular sites on the terminal rings. Additionally, carotenoids are also classified as primary and secondary. The primary carotenoid group includes compounds required for photosynthesis, such as β-carotene, violaxanthin, and neoxanthin. The secondary classification includes carotenoids that are localised in fruits and flowers; these are α-carotene, β-cryptoxanthin, zeaxanthin, antheraxanthin, capsanthin and capsorubin (Delgado-Vargas et al., 2000) [5].

Food Product Shelf Life

In order to meet consumers' expectations for high-quality products, food industries must conduct shelf-life studies that many times include the assessment of several analytical and sensory properties. However, whenever a new product is to be launched onto the market, defining which are the most relevant properties to monitor, as well as their cut-off criterion, is the subject of strong debate. Besides, for products with long estimated shelf-lives, accelerated studies have to be conducted and a third parameter has to be estimated: the acceleration factor which defines the correlation between the different storage conditions [2, 6]

The principal mechanisms involved in the deterioration of processed foods are as follows:

1. Microbiological spoilage sometimes accompanied by pathogen development.

2. Chemical and enzymatic activity causing lipid breakdown, color, odor, flavor, and texture changes.

3. Moisture and/or other vapor migration producing changes in texture, water activity and flavor.

Formulation and processing variables which affect these mechanisms and which can be used to control deterioration include: (1) moisture and water activity; (2) pH; (3) heat treatments; (4) emulsifier systems; (5) preservatives and additives; and (6) packaging [6].

The kinetics of shelf-life testing

The prediction of shelf life for food products is based on the application of the principles of temperature dependent chemical reaction kinetics. These reaction rates, as Figure 1 depicts, depend on product composition as well as environmental factors, i.e., temperature, humidity, atmosphere, etc. Basic to any predictive use of reaction kinetics is that the relationship between the measurable changing reaction parameter and time be linear. Quality loss follows the equation: $dQ/dt = k(Q_A)^n$ [6]

where dQ/dt is the change in the measurable quality factor A, with time, k is the rate constant in appropriate units, and n is the order of the chemical reaction of the quality factor. The order of reaction for most quality attributes in food products is either zero, first or second. In zero order reactions, the rate of loss of the quality factor is constant or linear and the resulting curve will be linear on a linear plot. First order reactions are not linear but are dependent on the amount of the quality factor that remains in the sample at the time. In these types of reactions, a linear prediction curve is constructed using semi-logarithmic coordinates. Typical first order reactions are: (1) rancidity, (2) microbial growth and death, (3) microbial production products, (4) vitamin losses in dried foods, and (5) loss of protein quality.

The Concept of Q_{10}

One of the most frequently asked questions regarding shelf-life studies have to be: "One week at 100°F equal how many weeks at room temperature?" The answer depends on the type of product and the mode of degradation involved. Each of the chemical deterioration reactions requires a certain amount of energy to get started. This is called activation energy, measured in kcal/mol. The higher the activation energy is for a reaction, the greater the acceleration with increases in temperature. A simple way to express this acceleration is to use the Q_{10} concept. Q_{10} is the increase in the rate of the reaction when the temperature is increased by 10 degrees centigrade (18°F). For example, if a food has a stability of 20 weeks at 20°C and 10 weeks at 30°C, then the Q_{10} will be 20/10 or 2. The rate of reaction being followed is doubled for the 10°C temperature rise. This value can be calculated from the data of most storage tests where the product has been stored at two or more temperatures regardless of whether or not they are 10°C apart [2, 6].

Typical shelf-life study design

The first step in setting up a shelf-life study is to select one of the degradation reactions which are expected to occur in the product at typical storage temperatures, can be measured, and can be used as an index of quality loss. As discussed, these could include lipid oxidation, vitamin loss, gain or loss of moisture, etc. means the more accurate the analysis, the more precise the shelf-life prediction [2, 6]

Next, select the package that you want to protect the product in the distribution channels. This will enable you to generate data more pertinent to the product's actual shelf life. Storage temperature conditions should then be chosen which fit the product and give reliable results in a reasonable amount of time. Common temperatures used would be 20, 30, 40, and 55°C (68, 86, 104, and 131°F). At least two temperatures are required with three or four preferred for more accurate predictions. A control, stored at 0°F, can also be used. The frequency of the analytical testing is the next important decision. The higher the storage temperature, the more frequent should be the testing [6]

Labuza has developed the following equation for testing frequency: $F_2 = f_1 \times Q_{10}^{\Delta/10}$

where f_1 is the time between tests at the higher temperature, f2 at the lower temperature, and "delta" is the difference in degrees centigrade between the two. For a product with a Q10 of 2, tested each week at 30°C, the frequency at 20°C would be: $f_2 = 1 \times 2^{10/10}$ or $f_2 = 2$ weeks

Many studies have reported about Gac

- Hiromitsu Aoki et al. (2002) determined carotene in Gac and concluded lycopene in Gac seed membrane with carotenoid concentrations to 380µg/g, 10 fold higher than those in any of the plant sources [5].
- L.T.Vuong et al. (2005) determined the acceptance of Gac supllementation to Vietnamese children. Results showed that vitamin A in Vietnamese children body was higher in Gac consumption than using β-carotene synthetic. They Vuong also reevaluated β-carotene content in fresh Gac fruit 408µg/g [4, 9].
- Tran Hoang Thao et al. (2007) produced Gac powder by different drying methods. They proved that freeze drying method retained the highest β-carotene content. They also researched pretreatment methods to detach Gac seed membrane more easily, including thermal and enzyme. Loss of carotene by these pretreatment methods was 35%. If these products kept in vacuum below 25^0C would maintain red color and carotene to 70% in 4 month [7].
- Nguyen Minh Thuy et al. (2009) manufactured variety of Gac products such as: dried Gac seed membrane, jelly, gum, paste, oil and juice. They also proved the change of carotene in Gac seed membrane after 6 days harvested [1].

- Dang Thi Tuyet Nhung et al. (2009) evaluated the change of lycopene and β-carotene in Gac seed membrane and Gac oil during preservation. Gac seed membrane primarily contained lycopene 2.378 – 3.728mg/g (raw material), β-carotene 0,257 – 0,379mg/g (raw material), carotene stabilized within the first one week by strongly decomposed in the second week of preservation. Gac oil extracted from seed membrane with addition of 0.02% BHT, it could be preserved 15 to 19 weeks at 5^0C, 40^0C, 60^0C; lycopene and β-carotene also reduced dramatically [3].
- Tuyen Chan Kha et al. (2010) produced Gac powder by using spray drying method with maltodextrin supplementation. They concluded that the appropriate drying process to keep red color was in temperature 120^0C, 10% maltodextrin as carrier material (w/v) [8].

MATERIAL AND METHODS

Raw Gac fruit source

Gac fruits *(Momordica cochinchinensis* Spreng*)* are originally collected from Trang Bang, Tay Ninh province, Vietnam when they are in half ripen stage. They are kept 6 days and then experimented.

Figure 3. Gac cultivation farm

Figure 4. Overal ripen Gac after 6 days

Raw material preparation

Gac fruits are choped into two parts, collect seed membrane, discard seed. In our experiments, we only use seed membranes without seed, pulp and skin.

Antioxidant

L(+)-Ascorbic acid in white crystal is provided from Shanghai Yuking Chemtech Co., Ltd.
D-alpha - tocopherol 96% is purchased from Jiangsu Xixin Vitamin Co., Ltd.

Effect of vitamin C addition to caroten content in Gac powder

Experimental parameter:

- Concentration of vitamin C supplementation into carrier gelatin: maltodextrin (0.5:0.5) is 1000ppm, 2000ppm, 3000ppm, 4000ppm (wet material).
- Control sample: Gac seed membrane being steamed in 6 minutes.

Fixed parameter:

- Gac seed membrane after being pretreated in preserved in refrigerator 5^0C, 15 minutes.
- Sample weigth: 35g raw Gac seed membrane.

- Scatter sample in drying: 0.2g/cm^2.
- Temperature of drying: 60^{o}C.
- Moisture content of sample after being dryed: 6 ± 1%.

Target parameter:

- Total carotenoid µg/g Gac seed membrane (dry matter).

Effect of vitamin E addition

Experimental parameter:

- Concentration of vitamin E supplementation into carrier gelatin: maltodextrin (0.5:0.5) is 1000ppm, 2000ppm, 3000ppm, 4000ppm (wet material).
- Control sample: Gac seed membrane being steamed in 6 minutes.

Fixed parameter:

- Gac seed membrane after being pretreated in preserved in refrigerator 5^{0}C, 15 minutes.
- Sample weigth: 35g raw Gac seed membrane.
- Scatter sample in drying: 0.2g/cm^2.
- Temperature of drying: 60^{o}C.
- Moisture content of sample after being dryed: 6 ± 1%.

Target parameter:

- Total carotenoid µg/g Gac seed membrane (dry matter).

Comparison the mixing methods among carrier (gelatin:maltodextrin) and antioxidants

Experimental parameter:

- Compare the results of caroten content in Gac seed membrane in three groups: (1) with carrier gelatin: maltodextrin 0.5:0.5; (2) vitamin C supplementation optimized among 1000 ppm, 2000 ppm, 3000 ppm, 4000 ppm; (3) vitamin E supplementation optimized among 1000 ppm, 2000 ppm, 3000 ppm, 4000 ppm.
- Gac seed membrane being steamed in 6 minutes.

Fixed parameter:

- Gac seed membrane after being pretreated in preserved in refrigerator 5^{0}C, 15 minutes.
- Sample weigth: 35g raw Gac seed membrane.
- Scatter sample in drying: 0.2g/cm^2.
- Temperature of drying: 60^{o}C.
- Moisture content of sample after being dryed: 6 ± 1%.

Target parameter:

- Total carotenoid µg/g Gac seed membrane (dry matter).
- β- carotene µg/g Gac seed membrane (dry matter).

Storage of Gac powder in accelerated temperature

Experimental parameter:

- Total carotene at begining, after 1 days, 2 days,...etc until carotene reduction > 80% compared to begining at 45^{0}C, 55^{0}C to calculte the real time of preservation.

Fixed parameter:

- Temperature storage: 55^{0}C, 45^{0}C.
- Packing: sample be packed in vaccum in two layes PA/PE with alluminum carton layer outside.

Target parameter:

- Total carotenoid µg/g Gac seed membrane (dry matter).

RESULTS AND DISCUSSION

Effect of vitamin C addition to total caroten content in Gac powder

In this experiment, we gradually increase vitamin C concentration (0ppm, 1000ppm, 2000ppm) into raw material before drying; we can obviously see total carotene loss decreased respectively. If we continue increasing vitamin C concentration (3000ppm, 4000ppm), we get no significant total carotene increment. Through ANOVA analysis, total carotene isn't significantly different at 2000ppm, 3000ppm, 4000ppm ($\alpha = 0.05$).

Vitamin C plays role as an anti-oxidant. While contacting to oxyen, it will be oxidized first so it can protect carotene in drying step. Because the amount of oxidable carotene is in limit so we don't need to use too much vitamin C. We choose vitamin C concentration 2000 ppm supplemented into raw material before drying (wet material).

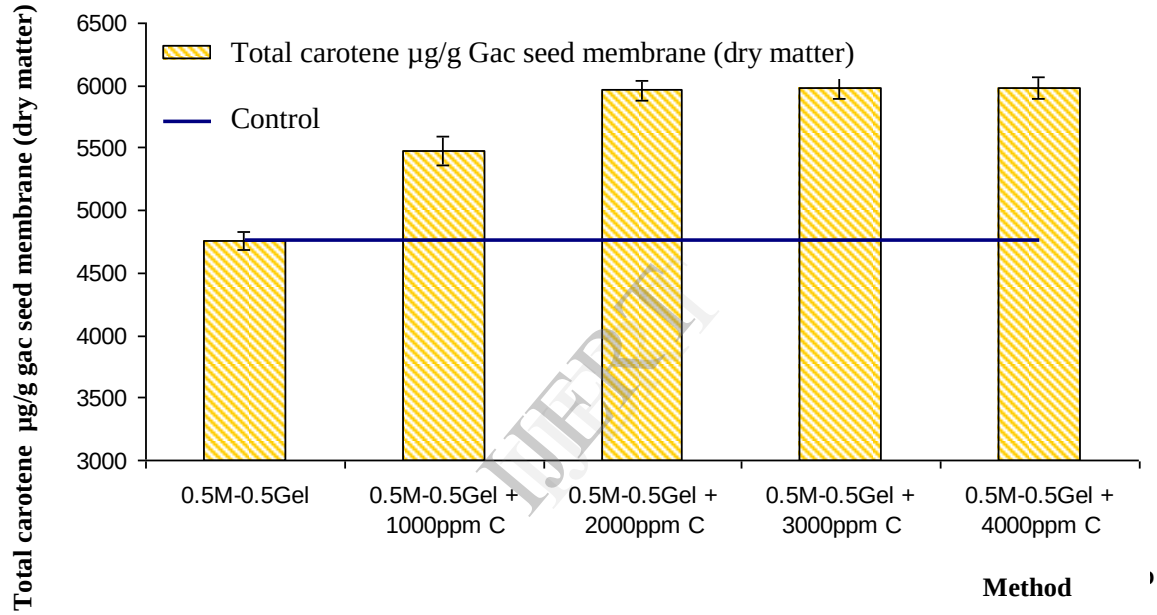


Figure 5. Effect of vitamin C concentration supplemented into Gac seed membrane to carotene content in gac powder (µg carotene/g gac seed membrane) (dry matter)

Table 1. Effect of vitamin C concentration supplemented into Gac seed membrane to carotene content in Gac powder

Method	Replication	Average of carotene (µg/g seed membrane) (dry matter)	Difference to control (%)
0.5M-0.5Gel (Control)	3	4756.43[a]	0.00
0.5M-0.5Gel + 1000ppm C	3	5476.42[b]	15.14
0.5M-0.5Gel + 2000ppm C	3	5962.69[c]	25.36
0.5M-0.5Gel + 3000ppm C	3	5984.52[c]	25.82
0.5M-0.5Gel + 4000ppm C	3	5987.44[c]	25.88

Effect of vitamin E addition to total caroten content in Gac powder

In this experiment, we gradually increase vitamin E concentration (0ppm, 1000ppm, 2000ppm) into raw material before drying; we can obviously see total carotene loss decreased respectively. If we continue increasing vitamin E concentration (3000ppm, 4000ppm), we get no significant total carotene increment. Through ANOVA analysis, total carotene isn't significantly different at 2000ppm, 3000ppm, 4000ppm ($\alpha = 0.05$).

Vitamin E plays role as an anti-oxidant. While contacting to oxygen, it will be oxidized first so it can protect carotene in drying step. Because the amount of oxidable carotene is in limit so we don't need to use too much vitamin E. We choose vitamin E concentration 2000 ppm supplemented into raw material before drying (wet material).

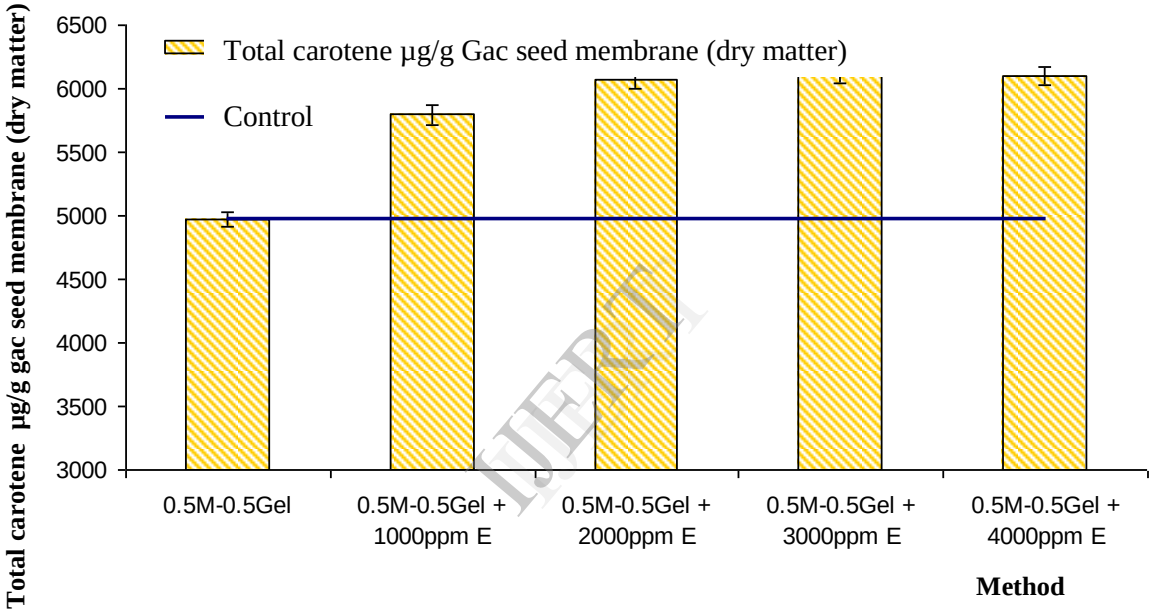


Figure 6. Effect of vitamin E concentration supplemented into Gac seed membrane to carotene content in gac powder (µg carotene/g gac seed membrane) (dry matter)

Table 2. Effect of vitamin E concentration supplemented into Gac seed membrane to carotene content in gac powder

Method	Replication	Average of carotene (µg/g seed membrane) (dry matter)	Difference to control (%)
0.5M-0.5Gel (Control)	3	4971.43[a]	0.00
0.5M-0.5Gel + 1000ppm E	3	5793.52[b]	16.54
0.5M-0.5Gel + 2000ppm E	3	6073.85[c]	22.18
0.5M-0.5Gel + 3000ppm E	3	6105.78[c]	22.82
0.5M-0.5Gel + 4000ppm E	3	6104.39[c]	22.79

Comparison the mixing methods among carrier (gelatin:maltodextrin) and antioxidants

Basing on ANOVA analysis at significant level $\alpha = 0.05$, we can completely see the significant differences while using carrier maltodextrin: gelatin at ratio 0.5: 0.5 (w/w), 2000ppm vitamin C or 2000ppm vitamin E supplementation in respect of total carotene (µg/g gac seed membrane) and higher than control sample (steaming 6 minutes, without carrier). Moreover, we can conclude some important points as follow:

- Maltodextrin: gelatin at ratio 0.5: 0.5 (w/w) with 2000ppm vitamin C show the best result, 89% higher than control sample.
- Maltodextrin: gelatin at ratio 0.5: 0.5 (w/w) with 2000ppm vitamin E show the best result, 80% higher than control sample.
- Maltodextrin: gelatin at ratio 0.5: 0.5 (w/w) without antioxidant show the best result, 45% higher than control sample.

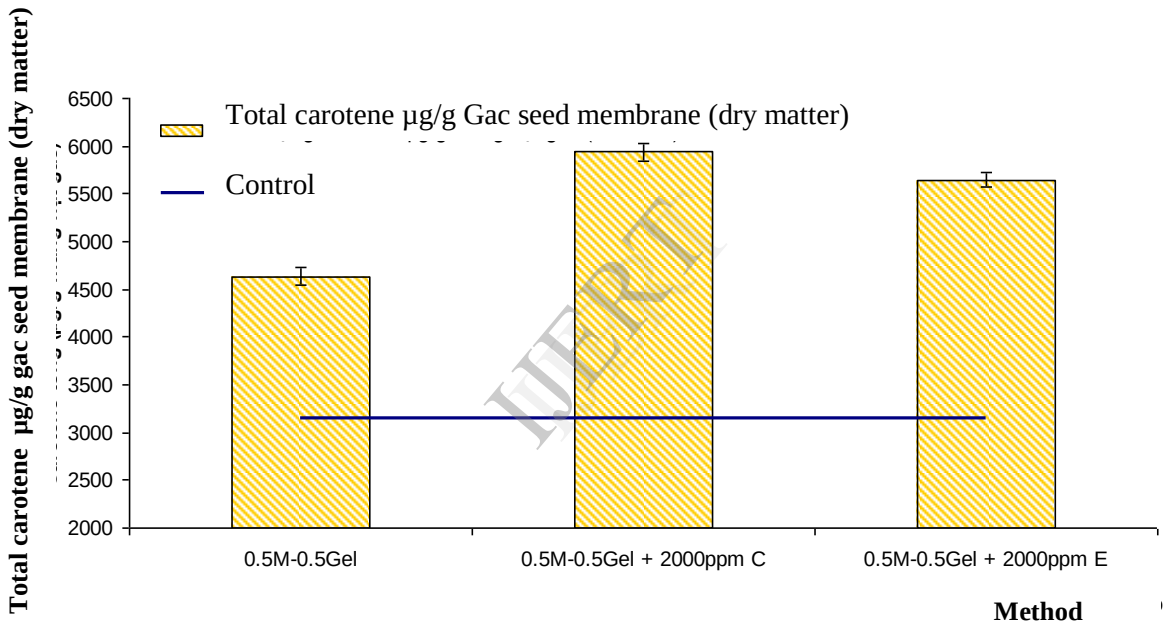


Figure 7. Effect of different anti-oxidants to total carotene (µg/g Gac seed membrane) (dry matter)

Table 3. Effect of different anti-oxidants to total carotene

Method	Replication	Average of carotene (µg/g seed membrane) (dry matter)	Difference to control (%)
Control	3	3138.17[a]	0.00
0.5M-0.5Gel	3	4636.64[b]	44.85
0.5M-0.5Gel + 2000ppm C	3	5939.32[d]	89.26
0.5M-0.5Gel + 2000ppm E	3	5643.37[c]	79.83

From above experiments, we comprehensively defined the role of each supplement added into gac seed membrane pretreated. Maltodextrin – gelatin protects raw Gac material out of oxygen in drying step. Vitamin C and vitamin E which are supplemented to seed membrane-carrier will be anti-oxidant in drying step because they will be primarily oxidized.

According to our results, vitamin C addition at 2000ppm will be superior to vitamin E 2000 ppm regarding total carotene. So we finally select the treatment method using: carrier: Gac seed membrane 1:1; maltodextrin: gelatin 0.5: 0.5 (dry matter); 2000ppm vitamin C addition.

Determine β-carotene by High Performance Liquid Chromatography (HPLC)

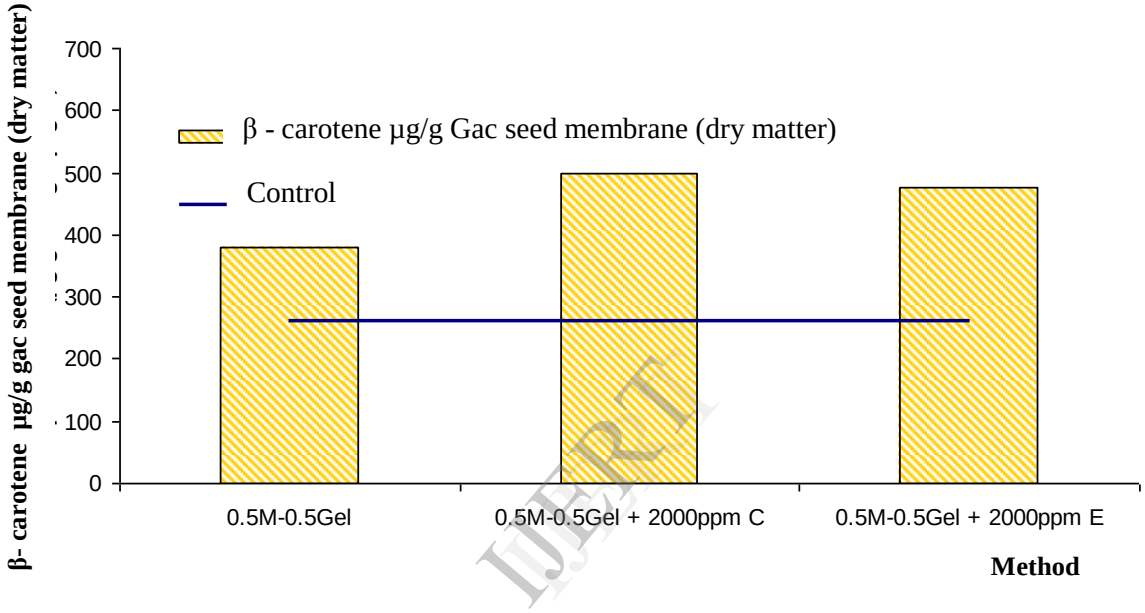


Figure 8. Effect of different anti-oxidants to β-carotene (µg/g Gac seed membrane) (dry matter)

Table 4. Effect of different anti-oxidants to β-carotene

Method	Replication	Average of carotene (µg/g seed membrane) (dry matter)	Difference to control (%)
Control	1	261.14	0.00
0.5M-0.5Gel	1	378.82	45.07
0.5M-0.5Gel + 2000ppm C	1	499.44	91.26
0.5M-0.5Gel + 2000ppm E	1	475.00	81.89

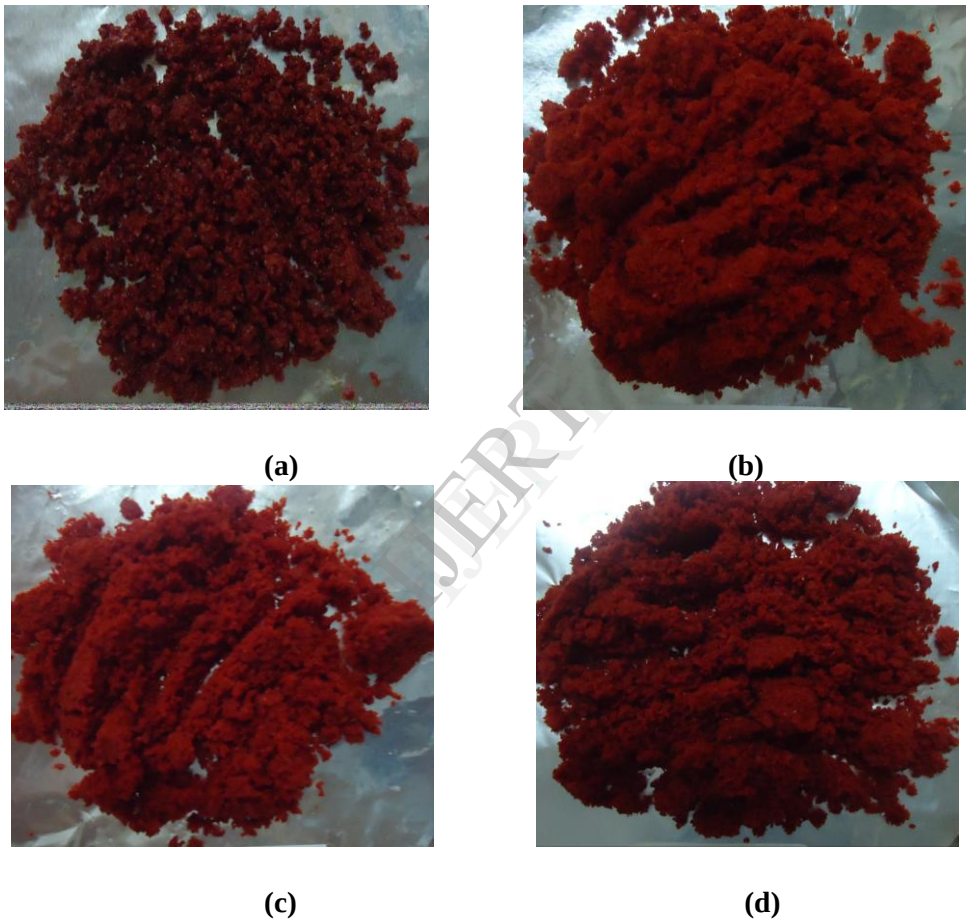
Analysis results of the β-carotene determined by HPLC and photography method are equivalent. We can conclude some important points as follow:

- Method using carrier: Gac seed membrane 1:1, maltodextrin: gelatin at ratio 0.5: 0.5 (w/w) with 2000ppm vitamin C shows the best result, higher 97% than control sample.
- Meanwhile, using carrier: Gac seed membrane 1:1, maltodextrin: gelatin at ratio 0.5: 0.5 (w/w) with 2000ppm vitamin E shows the second result, higher 82% than control sample.
- Maltodextrin: gelatin at ratio 0.5: 0.5 (w/w) without antioxidant shows the third result, higher 45% than control sample.

All three above groups, they are all superior to control sample regarding β-carotene (steaming 6 minutes without carrier). We also use HPLC testing method to check stability and nutritional value of Gac powder; results are as follow: protein (24.50%), total sugar (38.75%), lipid (11.24%).

From 1 kg raw Gac fruit, we get 200g seed membrane (20%), remove 80g seed (8%). Moisture of seed membrane is about 80% so 200g seed membrane is equal to 40g dry matter. In general, raw Gac fruit contains about 4% dry matter of seed membrane.

On our calculation for above experiments, we decide the pretreatment method by steaming in 6 minutes, carrier ratio 1:1, ratio of maltodextrin: gelatin 0.5: 0.5 (dry matter); addition of 2000ppm vitamin C will keep total carotene higher 2-3 times to control. Total carotene in gac powder (dry matter) is about 6000µg/g seed membrane; β-carotene is about 500µg/g seed membrane.



(a) **(b)**

(c) **(d)**

Figure 9. Gac powder

(a) without carrier;
(b) carrier: Gac seed membrane (1:1), maltodextrin: gelatin (0.5: 0.5);
(c) carrier: Gac seed membrane (1:1), maltodextrin: gelatin (0.5: 0.5, 2000ppm vitamin E;
(d) carrier: Gac seed membrane (1:1), maltodextrin: gelatin (0.5: 0.5), 2000ppm vitamin C

Effect of temperature in Gac powder storage

At temperature 55^{0}C

In our experiments, we regconize quite clearly that total carotene decrease day by days when preserving Gac powder at 55^{0}C. Although all samples are kept in vaccum and packed by two layers PA/PE, outer covered by alluminum paper; caroten is also decomposed owing to high temperature, carotene change from basic energy to exciting energy so molecue breakdown. Carotenase remained in powder or microorganism contaminated during processing will hydrolise carotene. Free peroxy, unsaturated fatty acid, O_2 available in Gac powder will react with carotene, change carotene structure and lose anti-oxidise activity, light absorbability. Moreover, oxygen permeated through bag or existed in packing environment will react with caroten after 6.5 days, total carotene decreases to 98%.

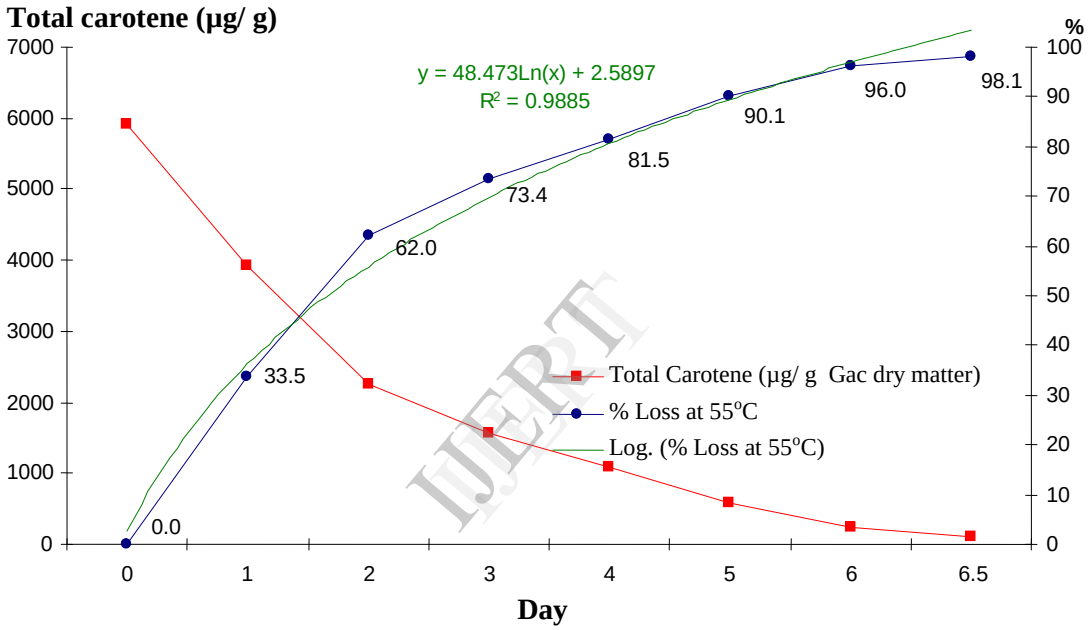


Figure 10. Effect of temperature 55^{0}C to total carotene in Gac powder (µg/g Gac seed membrane) (dry matter).

At temperature 45^{0}C

At temperature 45^{0}C in PA/PE bag, carotene declines slowly 2 - 3 times compared to 55^{0}C. According to Arrhenius, effect of temperature to reacting velocity can be expressed by the exciting molecules at high temperature.

Total carotene (micro g/

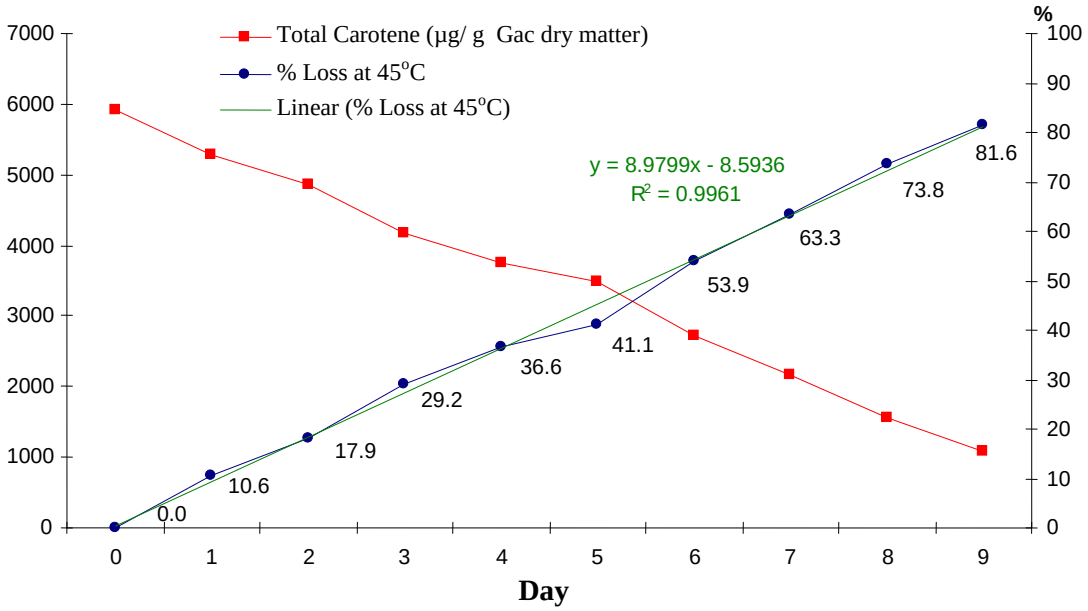


Figure 11. Effect of temperature 45^{0}C to total carotene in Gac powder (µg/g Gac seed membrane) (dry matter)

Determine the shelf-life of carotene in Gac powder

Calculating from figure 10 & 11, in order to get carotene 30% it should be keep within 1.76 days (55°C), 4.29 days (45°C).

Value of Q_{10}:

$$Q_{10} = \frac{4.2978}{1.7603} = 2.44$$

Storage duration at of Gac powder at 10^{0}C (carotene 30% reduction) will be:

$$F_2 = f_1 \times Q^{\frac{\Delta}{10}}{}_{10} = 1.76 \times (2.44)^{\frac{(55-10)}{10}} = 97.8 days \approx 3 months$$

Storage duration at of Gac powder at 5^{0}C (carotene 30% reduction) will be:

$$F_2 = f_1 \times Q^{\frac{\Delta}{10}}{}_{10} = 1.76 \times (2.44)^{\frac{(55-5)}{10}} = 152.8 days \approx 5 months$$

So we should keep Gac powder within 3 months at 10^{0}C or 5 months at 5^{0}C to maintain 70% carotene.

CONCLUSION

The effects of different treatments to total carotene and β-carotene of Gac fruit powder were investigated. Addition of some anti-oxidants such as vitamin C and vitamin E will be the appropriate approach to limit the carotene loss in drying step. Concentration of these vitamins should be 2000ppm based on wet material weight. Mixing carrier (maltodextrin: gelatin, 0.5:0.5) together with anti-oxidant (2000ppm vitamin C) will successfully preserve total carotene 2.3 times. Gac powder should be stored in sealed bags (PA/PE, aluminum foil) to strictly restrict oxygen and light. Preserving at 10^0C in 3 months or 5^0C in 5 months can maintain carotene 70%. We recommend further studies: compare different preserving methods such as vacuuming, inert gas to protect carotene, survey other packing materials to protect carotene during preservation, survey self-life of Gac powder at normal temperature.

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