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COMPARATIVE STUDIES ON THE STABILITY OF VITAMIN C AND CAROTENOIDS OF SOME SLICED VEGETABLES AND FRUIT JUICES EXPOSED TO MICROWAVES AND γ-IRRADIATION

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ABSTRACT

The main purpose of this work was to maintain the integrity and contents of vitamin C and carotenoids. Carrots, sweet potatoes and mango were served as main sources of carotenoids while guava, lime and orange were considered as major reservoir for vitamin C. Two physical methods, i.e., microwave and γ-irradiation treatments were applied in order to keep vitamin C and carotenoids of the aforementioned natural sources. The samples were exposed to γ-irradiation doses at 0.5, 1.0, 1.5, 2.0, 2.5 and 3 KGy and microwave treatment for 1, 2, 3 and 4 min emitted from an oven fixed at low power setting. The results indicate that vitamin C and carotenoids of the samples were variably degraded depending upon the conditions of treatments. Microwave treatment caused decreases in the levels of vitamin C of lime, orange and guava and the extent of reduction was dependent upon the exposure time. On the contrary, microwave treatment induced small reduction of vitamin C of mango juice, sliced sweet potato and carrots. γ-irradiation treatment induced gradual and significant decreases in the vitamin C levels of lime, orange and guava juices. In contrast, γ-irradiation caused an increase in the levels of carotenoids for mango juice, sliced carrots and sweet potatoes. In general, γ-irradiation treatment was better than exposure to microwaves for retention of vitamin C and carotenoids and hence extending the shelf life of the food sources under study. The mode of action of these physical methods on vitamin C and β-carotene content is discussed.

Key words: Vegetables (carrots and sweet potatoes) and fruits (mango, guava, orange and lime), Vitamin C, Carotenoids, Microwaves, γ-irradiation.

INTRODUCTION

It is well known that any diet containing high levels of fruits and vegetables are protective against several diseases especially cardiovascular and epithelial cancers. In this respect, vitamin C intake reduces risk of several cancers, particularly oral cavity, esophagus, stomach and to a lesser extent colon and lung. Biological function of L-ascorbic acid can be defined as an enzyme co-factor, a radical scavenger and as a donor-acceptor in electron transport at the plasma membrane. Ascorbic acid is able to scavenge the superoxide and hydroxyl radicals, as well as regenerate α-tocopherol (Davey *et al.*, 2000). In fact, vitamin C retention is regarded as a significant markers of overall nutrition recovery (Jung *et al.*, 1995). It has been reported that vitamin C is most thermosensitive in the real fruit and vegetable products (Van den Broeck *et al.*, 1998). The rate of L-ascorbic acid degradation in orange and tomato juices increased with increasing temperature from 120 to 150°C (Lee *et al.*, 1977). In addition, there are numerous reports in the literature about the instability of ascorbic during storage (Robertson and Samaniego, 1986 and Lee and Nagy, 1988) and thermal processing (Howard *et al.*, 1994).

Carotenoids are important nutritional and biological compounds because of their provitamin A activity (Klaui and Bauernfeind, 1981). Of the various carotenoids, β-carotene is the most important (vitamin A precursor) because of its high degree of vitamin A activity and frequent occurrence in nature (Olsen, 1989 and Rodriguez-Amya, 1989). Due to the conjugated double bonds in carotenoid moieties they are both radical scavengers and quencher of singlet oxygen. Lower serum β-carotene levels have been linked to higher rates of myocardial infection among smokers (Rice-Evans *et al.*, 1997).

The findings of the aforementioned researchers indicate the necessity of keeping the levels of these vitamins in different vegetable and fruit juices. There several physical methods used to maintain the contents of vitamin C and carotenoids. Among these methods are microwaves and γ-irradiation. Microwaves are used in the food industry not only for thawing, drying and backing but also for other applications such as microbial control, enzyme inactivation and pest control (Rosenberg and Bogl, 1987). Gamma irradiation treatment can also be used to eliminate or greatly reduce the number of microbial counts, to extend its shelf-life or to produce a sterile shelf-stable products (Shay *et al.*, 1988).

The main objective of this study was to determine the contents of vitamin C in guava, lime and orange juices; carotenoids in sliced carrots, sweet potatoes and mango juice before and after exposure to microwaves at various times and gamma irradiation at different doses. In addition, comparison can be made to indicate the efficient physical method towards retention of vitamin C and carotenoids in model and food systems.

MATERIALS AND METHODS

Materials

Standards of vitamin C (99.7%) and β-carotene (97%) were purchased from Riedel- de Haën Co. (Riedel- de Haën AG, D-3016 Seeize 1) and Fluka Chemie (GmbH CH. 9471 Buchs, Switzerland), respectively. Catechol, Caffeic acid, Folin-Ciocalteau reagent were purchased from Sigma -Aldrich Chemical Co. (St. Louis, Mo, USA). Meta phosphoric acid (Glacial sticks) and acetonitril (HPLC grade) were obtained from LOBA Chemie PTV. LTD (Mumbai -India) and Sigma –Aldrich Chemical Co., respectively .

Natural sources of vitamin C and β - carotene

Fresh lime, orange, guava (as sources of vitamin C) and mango, carrot, sweet potato (as sources of β- carotene) were obtained from local markets at Giza governorate.

Microwave oven

A domestic microwave oven (CHFF FM 935 Q, Moulinex Electronic) was used for heating standards and natural sources of vitamin C and carotenoids . The frequency of the radiation emitted in this oven was 60 Hz. There were levels of settings or heating corresponding to low, moderate and full power. The microwave oven at full power provides 100 W.

Microwave Treatments

a. Standard vitamin C (Model system)

A known weight (100 mg) of standard vitamin C was dissolved in a known volume of distilled water (100 ml). Aliquots from the standard vitamin C solution, representing 3 mg, were placed on a turn table and drive which slowly rotated to ensure uniform heating during the experimental period. The vitamin C solutions were heated by microwaves for 1, 2, 3 and 4 min at low oven power setting, cooled down to room temperature and the volume was re-adjusted to the initial volume (3 ml) with distilled water and subjected to HLPC analysis. The microwave oven temperatures at various heating times (1, 2, 3 and 4 min) were 70°C, 87°C, 95°C and 97°C respectively. Unmicrowaved vitamin C was served as a control.

b. Natural sources of vitamin C (Food system)

Fresh and cleaned lime and orange fruits were manually squeezed while guava fruits were blended using a high speed blender. Equal volumes of m-phosphoric acid (6 %,w/v) and fruit juice were mixed then centrifuged at 3000 r.p.m for 5 min (Wilson and Shaw, 1987). The supernatant was separated and microwaved as already mentioned in the standard vitamin C. After exposure to microwaves, the volume was re-adjusted to the original volume with distilled water, cooled to room temperature and subjected to HPLC analysis. Unmicrowaved natural sources of vitamin C was served as a control.

c. Standard β- carotene (Model system)

A known weight (100 mg) of standard β-carotene was dissolved in acetonitril (100 ml) and portions (3 mg each) from this solution were individually microwaved for 1, 2, 3 or 4 min at low oven power setting. The standard solutions of β -carotene were cooled down to room temperature, re-adjusted to the initial volume (3 ml) with acetonitril and subjected to HPLC analysis. Unmicrowaved solution of standard β –carotene was served as a control.

d. Natural sources of β- carotene (Food system)

The fresh and cleaned mango fruits were blended using a high speed blender while carrots and sweet potatoes were sliced to about 0.5mm thickness. Mango juice (30 ml) and sliced carrots and sweet potatoes (10 g each) were microwaved for 1, 2, 3 or 4 min at low oven power setting. The unmicrowaved natural sources of β–carotene was considered as a control.

Irradiation Treatments

a. Standard vitamin C (Model system)

A known weight (100 mg) of vitamin C was dissolved in a known volume of distilled water (100 ml) . Aliquots (3 ml each) from this solution were frozen overnight (-18°C) before irradiation. The samples were irradiated at the National Center for Radiation Research and Technology, Nasr City, Cairo. The irradiation was conducted using Russian gamma cell, Model Isslevotel. Cobalt 60 was used as an irradiation source and average dose rate was 6 kGy/h. The irradiation doses were 0.5, 1, 1.5, 2, 2.5 and 3 kGy . After irradiation, the solution was cooled down to room temperature, and subjected to HPLC analysis. The non-irradiated standard vitamin C solution was served as a control.

b. Natural sources of vitamin C (Food system)

The fresh and cleaned lime and orange fruits were manually squeezed while guava fruits were blended using a high speed blender. A known volume from each juice (30 ml) was equally mixed with m-phosphoric acid (6 %, w/v), centrifuged at 3000 r.p.m for 5 min and irradiated at doses of 0.5, 1, 1.5, 2, 2.5 and 3 kGy. The supernatant was separated and subjected to HPLC analysis. The non-irradiated natural vitamin C was recognized as a control.

c. Standard β - carotene (Model system)

A known weight of β - carotene (10 mg) was dissolved in acetonitril (100 ml) and portion of this solution (3 ml) was freezed overnight (-18°C) before irradiation. The irradiation process was conducted as mentioned in standard vitamin C. The non-irradiated standard β-carotene was considered as a control.

d. Natural sources of β- carotene (Food system)

Fresh and cleaned mango fruits were blended using a high speed blender while carrots and sweet potatoes were sliced to about 0.5 mm thickness. An aliquots from mango juice (30 ml) and known weights (10 g) of sweet potatoes and carrots were irradiated as mentioned before. The non-irradiated natural sources of β–carotene (0 KGy) was served as a control.

Extraction of carotenoids

The extraction of carotenoids was conducted according to the method described by Mayer-Miebach and SpieB (2003). A known weights of sliced carrots and sweet potatoes (10 g each) and mango juice (30 ml) either fresh, microwaved or γ-irradiated were homogenized with acetone (50 ml) and filtered. The filtrate was shaken with petroleum ether (50 ml), washed several times with distilled water, dried over anhydrous Na_2SO_4 and evaporated under vacuum. Carotenoids were dissolved in a known volume of acetonitril and subjected to HPLC analysis .

Determination of total polvphenols

Total polyphenols was determined according to the method described by Gutfinger (1981). An aliquot (0.1 ml) from lime, orange or guava juice was diluted with distilled water (4.9 ml) followed by the addition of Folin-Ciocalteau reagent (0.5 ml). After 3 min, saturated Na_2CO_3 solution (1 ml, 35 %, w/v) was added, then the contents were thoroughly mixed and diluted to 10 ml with distilled water. The absorbance of this solution was measured after 1 h at 750 nm against a reagent blank. Caffeic acid served as a standard material for preparing the calibration curve covering the range 0-100 mg/10 ml .

Quantitative determination of vitamin C and β-carotene by high performance-liquid chromatograph (HPLC)

a. Vitamin C

A Hewlett Packard Model 1050 HPLC equipped with a C-18 hypersil Elite column (250 mm X4.6 mm, 5μ thickness) and UV detector set at 254 nm was used for quantitative determination of vitamin C. Isocratic elution solvent system consists of methanol and 1% H_3PO_4 (1:1, v/v) was used as a mobile phase at a flow rate of 0.7 ml/min. The analyses were carried out at ambient temperature in triplicates. The concentration of treated standard and natural sources of vitamin C were calculated from a standard curve.

b. β-carotene

HPLC instrument, as previously mentioned, was used for β-carotene determination (Mayer-Miebach and SpieB, 2003). The HPLC equipment was fitted with Zoarbx C-8 column (4.6 mm x 150 mm) and UV detector. Isocratic elution system consists of acetonitril and methanol (70: 30, v/v) with a flow rate of 1ml/min. The temperature of the column was fixed at 30°C and the UV detector was fixed at 450 nm.

Statistical analysis

The present data were subjected to analysis of variance and the least significant difference (LSD) test was calculated to allow comparison between the mean values of the studied parameters as outlined by Cochran and Cox (1992). The statistical analysis was performed using the microcomputer Statistical Package Statgraphics statistical system, version 2.6, serial No. 1357673 (Statistical Graphics Corporation, copyright USA).

RESULTS AND DISCUSSION:

It is well known that vitamin C and β-carotene play significant role in human being health. Fruit and vegetable juices are the basic sources of vitamins C and β-carotene. The production of fresh, unpasteurized orange juice has become more common and fills the consumer preference. In fact, the awareness and the increased demand for orange juice led to consume juice as natural as possible and without extensive processing. It has been reported by Fellers (1988) that refrigerated, fresh squeezed orange juices have a relatively short-life up to 14 days. The absence of pasteurization and preservatives allow the opportunity for the growth of bacteria and yeasts, spoilage, certain enzyme activity causing off-flavors and oxidation (Attaway *et al.*, 1989). There are several reports about the instability of vitamin C during storage (Robertson and Samaniego, 1986 and Lee and Nagy, 1988) and thermal processing (Howard *et al.*, 1994). Consequently, the present study was conducted to hault the microbial growth, denature several enzymes and extend the shelf-life of various fruit and vegetable juices. Therefore, two physical methods, i.e., microwaves and γ-irradiation, were applied to achieve the aforementioned goal.

Effect of microwave heating on vitamin C contents of model and food systems

Table (1) shows the effect of heating emerging from microwave oven fixed at low power setting. The microwave oven temperatures were 70°C, 87°C, 95°C and 97°C, corresponding to 1, 2, 3, and 4 min heating periods, respectively. In fact, a series of experiments was performed using the microwave oven at full and moderate power settings. The obtained results demonstrated that these power settings

Table (1): Effect of various exposure times of microwaves on vitamin C contents of Guava, Orange and lime juice.

Exposure time (min)	Standard vitamin C		Guava		Orange		Lime	
	Concentration (ppm)	Retention (%)	Concentration (ppm)	Retention (%)	Concentration (ppm)	Retention (%)	Concentration (ppm)	Retention (%)
0	1656^{a}	100	282^{a}	100	249^{a}	100	182^{a}	100
1	1185^{b}	71.55	279^{b}	98.93	204^{b}	81.92	130^{b}	71.42
2	934^{c}	56.40	273^{c}	96.80	151^{c}	60.5	90^{c}	49.20
3	830^{d}	50.12	252^{d}	89.36	133^{d}	53.41	16^{d}	8.7
4	776^{e}	46.85	224^{e}	79.43	106^{e}	42.57	nil	nil
LSD value at level P= 0.01	7.96		4.27		3.83		3.89	

Values in a column followed by the same letter indicate non-significant (P=0.01) increase in vitamin C content.

caused complete destruction of vitamin C. Therefore, it is advisable not to use the microwave oven at moderate or high power settings to pasteurize or sterilize the fruit or vegetable juices.

Mango juice and sliced vegetables (food systems) were treated in a similar manner to that of standard vitamin C (a model system) and hence comparison can be made to deduce such changes might occur with vitamin C of guava, lime and orange juices. The results indicate that the level of microwaved standard vitamin C after 4 min was about one-half the original concentration at the start of the experiment. The data in Table (1) and Figure (1) indicate that the fresh (non-microwaved) guava juice contained the highest level of vitamin C (282 ppm), being about 1.13 and 1.15 times as high as that of orange and lime juices, respectively. Hence, the concentration of vitamin C from the natural sources under study can be arranged in the following decreasing order: guava > orange> lime. Apparently, the sensitivity of vitamin C to microwave treatment depends on the origin of the natural source. In this respect, Roig *et al.* (1995) reported an overall greater retention of vitamin C in processed orange juice than in lime. As a general trend, the exposure to microwaves induced significant and gradual decreases in the vitamin C contents of standard and the natural sources. In other words, the increase of microwave oven temperature caused greater loss of vitamin C. In this respect, Saguy *et al.* (1978) reported that vitamin C is a typical heat sensitive nutrient.

The retention % of vitamin C after 4 min exposure time were 79.43%, 42.57% and nil for guava, orange and lime juices, respectively. It means that the natural sources containing the high level of vitamin C proned to least lowering effect upon exposure to microwaves. Figure 1 (A) shows clearly that lime juice which contains the lowest level of vitamin C was remarkably decomposed due to exposure to microwaves compared with guava juice which contains the highest level of vitamin C. Hence, one can conclude that guava juice was more stable towards microwave heating than that of other juices under study. This could be attributed to the presence of some associated compounds which prevent to a great extent the destruction of vitamin C in guava juice. In this respect, the total polyphenolic compounds, which is known to be strong antioxidant, were determined. The data show that guava juice had the higher total polyphenolic content (83.64 mg %), being about 2 and 5.6 fold as that of orange (42.69 mg %) and lime (15.79 mg %) juices, respectively.

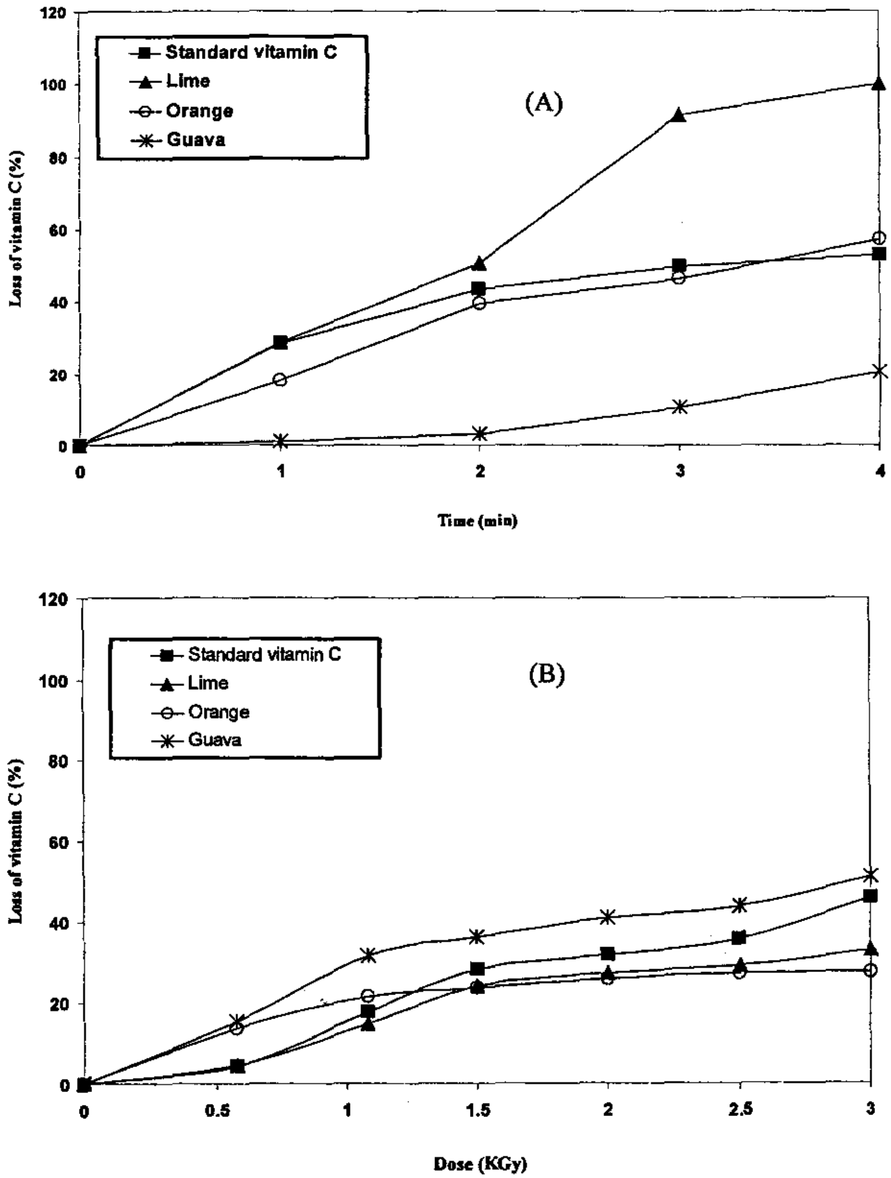


Fig. (1). Influence of microwaves (A) and γ -irradiation (B) on vitamin C contents of lime, orange, and guava juices.

These data are in line with the stability of vitamin C. Also, these findings might explain the lowest destruction vitamin C in guava juice.

Effect of γ-irradiation on vitamin C levels of guava, lime and orange juices.

Table (2) and Figure (1B) show the influence of various doses of γ-irradiation on the levels of standard and natural sources of vitamin C. The results show that there were significant and gradual decrease in vitamin C contents of the standard and food sources during γ-irradiation at the doses of 0.5, 1, 1.5, 2, 2.5 and 3 KGy. Here again, the γ - irradiation of standard vitamin C at a dose of 3 KGy caused destruction nearly equal to one-half the content of vitamin C at the beginning of the experiment. The retention values of orange, lime and guava juices after γ - irradiation at 3 KGy were 66.90%, 72.42% and 48.93%, respectively. This means that the destruction of vitamin C by γ-irradiation was not dependent upon its concentration at the start of the experiment.

The retention (%) values for standard vitamin C, guava, orange and lime juice after 4 min exposure time to microwaves were 46.85%, 79.43, 42.57 and nil, respectively. The retention (%) values for the same materials exposed to γ-irradiation at 3KGy were 54.0, 68.90, 72.42 and 48.93, respectively. This clearly indicate that the retention (%) of vitamin C by γ-irradiation treatment was greater than that of microwave heating method. It is well known that vitamin C is a thermosensitive and γ-irradiation treatment occurred at low temperature while microwave oven gives rise in temperature and hence increased vitamin C destruction with increasing the exposure time.

One would further interpret the mode of microwave action on vitamin C and carotenoids as follows. Most foods have a high proportion of water which in turn attracts the microwaves. There is a rapid vibration as these water molecules change direction towards the microwaves at a rate of about 2.5 billion times per second in a domestic oven. Thus, the water molecules become very excited and the friction occurring causes a considerable and rapid buildup of heat in the food itself. Consequently, the heating temperature and the mode of heating are together responsible for reducing the vitamin C content of the food system. In addition, Vikram *et al.* (2005) indicated that vitamin C degradation was high during microwave heating due to uncontrolled temperature generated during processing. In general, the

Table (2): Changes vitamin C contents of γ-irradiation contents of Guava, Orange and lime juice.

Treatment Dose (kGy)	Standard vitamin C		Guava		Orange		lime	
	Concentration (ppm)	Retention (%)	Concentration (ppm)	Retention (%)	Concentration (ppm)	Retention (%)	Concentration (ppm)	Retention (%)
0	1875^{a}	100	235^{a}	100	330^{a}	100	316^{a}	100
0.5	1794^{b}	95.68	199^{b}	84.3	285^{b}	80.30	302^{b}	95.56
1.0	1543^{c}	82.30	161^{c}	68.0	259^{c}	78.48	269^{c}	85.12
1.5	1344^{d}	71.68	150^{d}	63.2	252^{d}	76.36	240^{d}	75.94
2.0	1310^{e}	69.86	140^{e}	59.4	245^{e}	74.24	230^{e}	72.78
2.5	1206^{f}	64.32	103^{f}	56.7	240^{f}	72.72	224^{f}	70.88
3	1013^{g}	54.0	114^{g}	66.90	239^{g}	72.42	211^{g}	48.93
LSD value at level P= 0.01	3.47		2.65		6.18		3.04	

Values in a column followed by the same letter indicate non-significant (P=0.01) increase in vitamin C content.

retention values obtained by microwaves and γ-irradiation demonstrate that the exposure to γ-irradiation was much better than the treatment with microwaves in preserving vitamin C and extend the shelf-life of the natural juices. In this respect, Barbosa- Canovas *et al.*, (1998) reported that non-thermal pasteurization technology is required to apply in the processing of fresh vegetable juices to avoid the deleterious effects that heat has on the flavor, color and nutrient value of the foods.

Influence of microwaves on the levels of standard β-carotene and carotenoids in food system.

Table (3) and Figure (2A) indicate the influence of microwave heating at various periods (1, 2, 3 and 4 min) on the level of β-carotene. The results demonstrate that exposure of standard β-carotene (a model system) to microwaves for various peroids induced gradual and significant increase in its level, being about 1.63, 2.12, 2.31 and 2.64 times as great as the concentration at the start of the experiment. This means that exposure of standard β-carotene to microwaves caused significant increase by extending the experimental period.

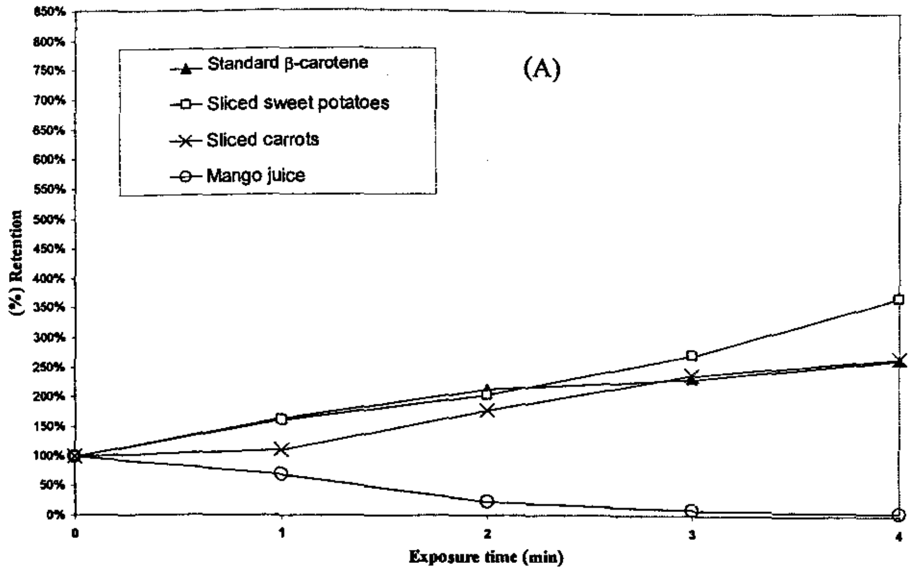
Fresh mango juice, as one of the food systems, was characterized by the highest content of β-carotene (4.73 mg%), approximately about 1.1 and 1.8 times as high as that in carrots and sweet potatoes, respectively. Exposure of sliced sweet potatoes and carrots to microwaves caused significant and gradual increase of β-carotene content over time. At the end of exposure time (4 min), β-carotene level was increased to about 3.70 and 2.68 times as great as that at the beginning of the experiment for sweet potatoes and carrots, respectively.

On the contrary, β-carotene content of mango juice was significantly and gradually decreased by microwaves over time and after 4 min 94% of initial β-carotene was destroyed. In fact, these values are not true since the visual observation indicates the occurrence of charring for mango juice which increased with time. One can also observe even after 1 min exposure time about 25% of β-carotene of mango juice was destroyed.

Table (3): Effect of various exposure times of microwaves on β-carotene contents of sliced sweet potatoes, sliced carrots and mango juice.

	Standard β-carotene		Sliced sweet potatoes		Sliced carrots		Mango juice	
Exposure time (min)	Concentration (mg%)	Retention (%)	Concentration (mg%)	Retention (%)	Concentration (mg%)	Retention (%)	Concentration (mg%)	Retention (%)
0	0.69^{a}	100	2.62^{a}	100	4.18^{a}	100	4.73^{a}	100
1	1.13^{b}	163	4.18^{b}	160	4.54^{b}	109	3.22^{b}	67.96
2	1.47^{c}	212	5.31^{c}	203	7.36^{c}	176	1.07^{c}	22.62
3	1.59^{d}	231	7.14^{d}	273	9.95^{d}	238	0.45^{d}	9.5
4	1.82^{e}	264	9.69^{e}	370	11.2^{e}	268	0.26^{e}	5.47
LSD value at level P= 0.01	0.02		0.03		0.28		0.03	

Values in a column followed by the same letter indicate non-significant (P=0.01) increase in β-carotene content.



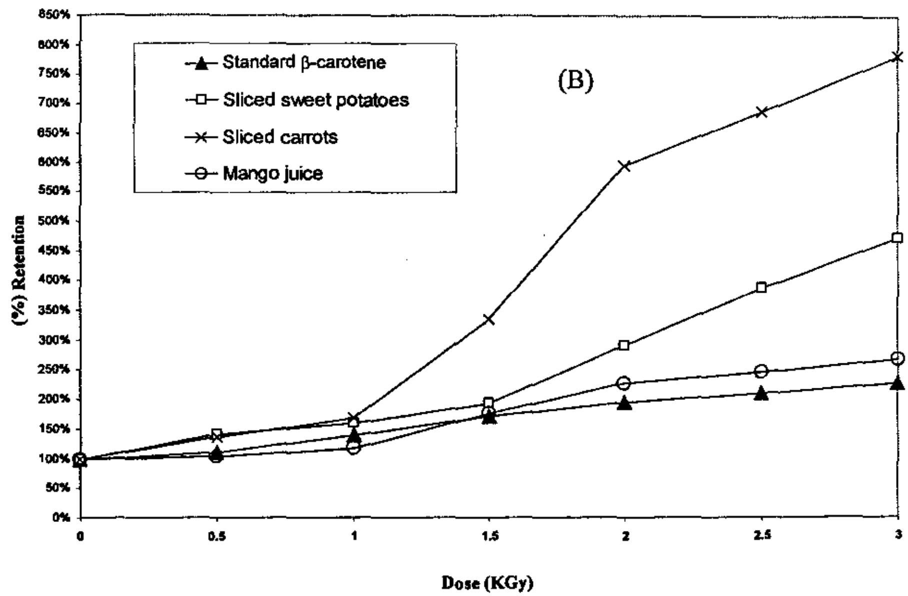


Fig. (2). Influence of microwaves (A) and γ-irradiation (B) on β-carotene content of sliced sweet potatoes, sliced carrots and mango juice.

Table (4): Changes in β-carotene contents of γ-irradiation sliced sweet potatoes, sliced carrots and mango juice.

Treatment Dose (kGy)	Standard β-carotene		Sliced sweet potatoes		Sliced carrots		Mango juice	
	Concentration (mg%)	Retention (%)	Concentration (mg%)	Retention (%)	Concentration (mg%)	Retention (%)	Concentration (mg%)	Retention (%)
0	0.18[a]	100	2.16[a]	100	4.56[a]	100	4.20[a]	100
0.5	0.20[b]	111	3.05[b]	141	6.21[b]	137	4.39[b]	104
1.0	0.25[c]	140	3.81[c]	160	7.66[c]	168	4.90[c]	117
1.5	0.31[d]	172	4.18[d]	194	10.08[d]	335	7.43[d]	177
2.0	0.35[e]	196	6.32[e]	292	15.36[e]	595	9.55[e]	227
2.5	0.38[f]	210	8.37[f]	387	21.75[f]	687	10.32[f]	246
3	0.39[g]	227	10.19[g]	471	24.93[g]	782	11.25[g]	268
LSD value at level P= 0.01	0.02		0.03		0.02		0.04	

Values in a column followed by the same letter indicate non-significant (P=0.01) increase in β-carotene content.

Influence of γ-irradation on β-carotene

a. Model system

Table 4 shows the changes of standard β-carotene content due to exposure to γ-irradiation using different doses 0.5, 1, 1.5, 2, 2.5 and 3KGy. The results show that standard β-carotene level was significantly and gradually increased by increasing the γ-irradiation doses. At the end of the experiment, the β-carotene content was increased to be about 2.27 fold as times as the level at the start of the experiment.

b. Food system

Table (4) and Figure (2B) show the effect of γ-irradiation on β-carotene contents of sliced sweet potatoes and sliced carrots and mango juice. The results demonstrate that the amount of β-carotene in sweet potatoes was significantly and gradually increased by increasing the γ-irradiation dose. The amount of β-carotene of sliced sweet potatoes after dosing at 3KGy was about 2.27 times as high as that at the start of the experiment. The data demonstrate that the level of β-carotene in sliced carrots was also significantly and gradually increased when the irradiation doses increased from 0.5 to 3KGy. The level of retinol equivalent after dosing at 3KGy was about 5.4 times as great as the start of the experiment. It is of interest to note that the content of retinol equivalent of different γ-irradiated foods at the end of the experiment was in the decreasing order : sliced carrots > sliced sweet potatoes > mango juice > standard β-carotene.

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دراسة مقارنة لثبات فيتامين C والكاروتينات فى شرائح بعض الخضراوات وعصائر الفاكهة المعرضة للميكروويف وأشعة جاما

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تهدف هذه الدراسة إلى تقدير كلا من فيتامين C فى عــصائر الجوافــه والليمــون والبرتقال والكاروتينات فى شرائح الجزر وشرائح البطاطا وعصير المانجو. تم إســتخدام طريقتان طبيعيتان وهما الميكروويف وأشعة جاما للحفاظ على فيتامين C والكاروتينــات فى العينات سالفة الذكر وقد عرضت العينات لجرعات مختلفة من أشعة جاما وهى ٠,٥، ١، ١,٥، ٢، ٢,٥، ٣ كيلوجراي ، بينما عرضت فى فرن الميكروويف لمدد مختلفة وهى ١، ٢، ٣، ٤ دقائق على مستوى طاقة منخفض.

ودلت النتائج على حدوث تغيرات فى كميات فيتــامينC والكاروتينــات باســتخدام الطريقتين سالفتى الذكر وهذا التغير يعتمد على ظروف كل معاملة وبصفة عامة تبين أن طريقة أشعة جاما كانت أفضل للحفاظ على مستويات فيتامين C والكاروتينــات مقارنــة بطريقة الميكروويف.

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