Effects of Conventional Storage Methods on the Ascorbic Acid Content of Summer Vegetables.

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ABSTRACT

The study aimed to determine the effect of common storage practices adopted at the domestic level on the ascorbic acid content of 12 summer vegetables. Five common techniques namely storage at room temperature, refrigeration, drying, freezing without blanching and blanching prior to freezing were applied. Results showed that almost all the vegetables were good sources of vitamin C. However, significant losses were observed during storage at room temperature (25% - 55.5%), refrigeration (11%-33.3%), freezing without blanching (12.5% - 61.5%), and freezing after blanching (38.8 – 66.6%). Data indicated sun drying being the most vulnerable method as far the percent losses in the Vitamin C levels in the sampled vegetables (66.6% - 87%) suggesting it to be the most inappropriate method at noncommercial level. The current study also confirmed the inevitable losses of Vitamin C in all the storage methods being evident from statistically significant lower values in the stored vegetables as compared to fresh vegetables. The present study thus emphasized the importance of nutrition education for the home makers to minimize nutritional losses and conserve the nutrients at the domestic level.

Keywords: ***Summer vegetables, vitamin C, domestic storage practices, Vitamin C losses, conservation of nutrients.***

INTRODUCTION:

Vegetables constitute an integral component of human diet with a high content of certain minerals, vitamins, fiber and phytonutrients. They provide not only textural and colour variety to the meals but also add complementary nutrients such as dietary fibre, and certain vitamins and minerals. Vegetables are estimated to provide 30% of the vitamin C, 20% of the vitamin A (as carotenes), and 10% of the thiamine and iron of the average UK diet (Household Food Consumption and Expenditure, 1985, HMSO). Vegetables are most easily available and economical way of receiving vitamin C from the diet particularly by the vulnerable groups (ICN, 1999).

Fresh vegetables available to the consumer have typically spent a period of 3-7 days in retail distribution and storage before consumption (Bushway et al., 1989). Although the transportation and storage is made at lower temperatures (i.e. refrigerated), but the traditional greengrocer and market trader and many householders continue to transport and store vegetables at ambient temperatures. Thus, fresh vegetables are exposed to a variety of conditions which can the quality characteristics and nutrient content before in-home cooking and consumption (Perrin and Gaye, 1986; Shewfelt, 1990). Changes can occur can also occur during the freezing particularly during blanching which is necessary to inactivate natural enzymes (Lathrop and Leung, 1980, Guenes and Bayindirli, 1993). It is probable that the nutrient content of the fresh vegetable will at some time during retail distribution and storage be equal to that of the frozen vegetable and will continue to fall to below that of frozen thereafter (Ottaway, 1993).

Ascorbic acid (vitamin C) is the micronutrient most readily associated with vegetables (and fruit). Vitamin C content varies considerably between different vegetables; being higher for leafy vegetables and lower for roots and seeds (Henry and Chapman, 2002). Therefore, the level of vitamin C is not an indicator of quality per se, but, since the vitamin is vulnerable to chemical and enzymatic oxidation, and is highly water soluble, it can be considered as a sensitive and appropriate marker for monitoring the quality changes that may occur during storage, transportation and processing(Giannakourov and Taoukis 2003, Henry and Chapman, 2002) .

A large varieties of vegetables are grown in numerous eco-systems across Pakistan from dry zone to wet zone, low elevation to high elevation, rain fed to irrigated, and low input to very high input systems such as plastic houses (Kokhar, K.M. 2013). Despite huge increase in the production from 6454.2 in 200-03 to 8478.8 thousand tons in 2011-12 from 2002-2003 to 2011-12 (Economic Survey of Pakistan, 2012) per capita vegetable

intake is still low and post harvest losses are estimated to be 25-50% (Fruit, Vegetables and Condiments Statistics of Pakistan, 2013.

The impacts of globalization, recent increase in the price indices of the food commodities and large number of the employed home makers resulted in a shift in food patterns and food systems in the developing countries like Pakistan (FAO Nutrition Papers, 2004). Nutritional security of the stored food products needs to be taken in to serious consideration. A lot of work done stressed on various processing methods and quality of the products but no attention has been given to home preservation procedures and their subsequent effects on the nutritional quality of vegetables. The present study is an attempt to determine the effects of various storage procedures on the vitamin C content of summer vegetables.

METHODOLOGY

The experiment was conducted at the Food Technology lab, Department of Food and Nutrition Sciences, College of Home Economics, University of Peshawar, Pakistan, during the months of May and July 2013.

Sampling

Around 12 (twelve) commonly available summer vegetables were purchased from the local market in the most fresh available form in Peshawar.

Sample Treatments:

The well graded vegetables were washed thoroughly using clean water to remove foreign matter and dust. Vegetables were sorted, trimmed, and diced or cut as for cooking fresh. For blanching one gallon of water per half kg of prepared vegetables was boiled and vegetables were lowered into this water in a wire basket. This blanching was done for 2 – 5 minutes with closed lid and after removing these vegetables were immediately cooled in cold water, drained thoroughly, and wrapped in polythene bag. Both blanched and un blanched vegetables were stored for 10-15 days at freezing at -18ºC. For drying purpose diced vegetables were spread on plastic mat, covered with fine muslin cloth and dried under sunshine for 15 days. For refrigeration purpose vegetables were wrapped in polythene bag and stored at 3-7ºC for 07 days. For storage at room temperature vegetables were not sliced and diced rather kept in a basket for 3-5 days. For analysis vegetables were sliced and finely homogenized in blender.

Analysis of Sampled Vegetables for Vitamin C

The volumetric dye reduction method also called as titrimetric method (AOAC. 1998) was employed as it is a speedy, rapid, and an inexpensive method. Ground and homogenized samples were titrated through Whatman No 42 filter paper and were extracted with 0.4% oxalic acid solution and the volume was made to 200 ml. Of this 10 ml in a pipette was titrated against the standard 2, 6 dichorophenol indophenols solution till rose pink colour end point. Vitamin C content was calculated using the following formula.

$$\text{Ascorbic Acid}\,\frac{\text{mg}}{100}\,\text{g 0f sample} = \frac{\text{TR}\times\text{DF}\times\text{D}}{\text{V}\times\text{A}}$$

TR = titration reading
DF = Dye factor
D = Dilution of slurry
V = volume of the sample
A = Aliquot taken from diluted slurry

STATISTICAL ANALYSIS

The analyses for all the storage treatments were performed in triplicates therefore Mean, standard deviations were computed using IBM SPSS, version 20. Test of significance were performed for LSD ≤0.05 level at 95% degree of confidence to test the significance of variance among the treatments against the Vitamin C levels in fresh vegetables.

RESULTS

Results of the current study revealed large variations in the vitamin C content of selected vegetables (Table-1). Vitamin C content of fresh vegetables ranged from 7 mg / 100g to 248 mg / 100g the highest amount being estimated in capsicum and green chillies (248 mg / 100g green chilies 240 mg/100 gm) followed by bitter gourd 80mg/100 gm and tomatoes 20mg/100 gm, summer squash (18mg / 100gm), zucchini and cucumber (13 mg / 100 gm each) okra and green chilies (12 mg / 100gm), onion (9mg/100gm) potatoes (9 mg / 100gm) , potatoes (9mg/100gm) and brinjals (8mg / 100gm).

Table 1: Vitamin C Content of Fresh Vegetables

S.No	Vegetables (N=12)	Botanical Names	Vitamin C (mg/100gm)
1	Green chilli	*Capsicum Annuum*	240± 2.15
2	Capsicum	*Capsicum Annuum*	248 ±4.01
3	Tomatoes	*Solanum Lycopersicum*	20 ±3.05
4	Bitter gourd	*Momordica Charantia*	80 ±2.05
5	Zucchini squash	*Cucurbita Pepo*	13 ±2.11
6	Okra	*Abelmoschus Esculentus*	12 ±1.56
7	Onion	*Allium Cepa*	7 ±2.8
8	Potato	*Solanum Tuberosum*	9 ±1.98
9	Bottle gourd	*Lagenaria Siceraria*	10±1.30
10	Brinjal	*Solanum Melongena*	8 ±.98
11	Cucumber/garden cucumber	*Cucumis Sativus*	13±2.36
12	Summer squash	*Citrulus Fistulosus*	18±2.57

Table 2: Effect of Storage at Room Temperature on the Vitamin C Content

Vegetables (N=12)	Vitamin C(mg/100gm)	Percent losses	P level*
Green Chillies	160.8±3.23	33%	0.048
Capsicum	168.08±2.14	33.3%	0.040
Tomato	11±2.81	45%	0.026
Bitter gourd	56±2.12	42.8%	0.003
Zucchini	7±4.02	46.1%	0.046
Okra	8±3.01	33.3%	0.043
Onion	7±2.11	36.3%	0.037
Potato	6±2.51	33.3%	0.020
Bottle gourd	6±2.44	40%	0.042
Brinjal	6±2.11	25%	0.047
Cucumber	10±2.16	23%	0.049
Summer squash	8±2.31	55.5%	0.007

*significance at P≤0.05

Table – 3 Effect of Refrigeration on the vitamin Content of Vegetables

Vegetables (N=12)	**Vitamin C(mg/100gm)**	**Percent losses**	**P level**
Green Chilies	213.4± 1.23	11.6%	0.056
Capsicum	206.83± 2.66	16.6%	0.034
Tomato	17± 2.05	30.8%	0.013
Bitter gourd	70.7±2.0	21%	0.052
Zucchini	9 ±2.36	30.8%	0.025
Okra	8±4.12	33.3%	0.013
Onion	6± 3.00	27.7%	0.056
Potato	7 ±2.89	22.2%	0.047
Bottle gourd	7± 2.08	20%	0.038
Brinjal	7±1.55	12.5%	0.048
Cucumber	11± 1.69	15.03%	0.040
Summer squash	16±3.06	15.03%	0.037

*significance at P≤0.05

Results of the effect of refrigeration showed (Table-3) that highest percent losses occurred in okra (33.3%) followed by zucchini and tomatoes (30%) onion (27.7%) potatoes (22.2%) bitter gourds (21%) bottle gourd(loki) (20%) green chilies and capsicum (16.6%) cucumber and summer squash (15.03) and brinjals (12.5%) respectively when compared with fresh vegetables as controls. The sampled vegetables were freeze without blanching for 15 days and when analyzed for vitamin C content and percent vitamin C losses showed that (Table – 4) greater percent losses of vitamin C occurred in zucchini at (61.5%) followed by cucumber (46.1%) summer squash (44.4%) green chilies (41.6%) tomatoes (35%) bottle gourd(loki) (30%) bitter gourd (28%), capsicum (27.7%0 onion (27.2%) okra (25%) and brinjals (12.5%) respectively.

Table – 4: Effect of Freezing (without blanching) on vitamin C content of vegetable

Vegetable **(N=12)**	Vitamin C (mg/100g)	Percent losses	P level
Zucchini	08±2.354	61.5%	0.000
Cuccmber	07±2.63	44.4	0.001
Potatoes	5±2.13	44.3	0.001
Summer squash	10±2.39	41.6	0.001
Green chilies	156±2.48	35	0.001
Tomato	13±2.57	30	0.012

Bottle gourd	07±2.98	28	0.007
Bitter gourd	57.84±2.46	27.7	0.018
Capsicum	179.30±3.17	27.2	0.039
Onion	07±2.17	25	0.047
Okra	09±2.00	12.5	0.024
Brinjals	4.45±2.41	44.4	0.008

*significance at P≤0.05.

Blanching vegetables before freezing is a common practice being done to deactivate enzymatic activities and their subsequent changes in vegetable and food products. Vegetables of the current study (Table - 5) were blanched (2-7minutes) cooled and freezer in the lab freezer for 15 days. The samples were then analyzed for percent ascorbic acid losses. Estimated results showed highest percent losses occurred in green chilies (66.6%) followed by brinjals (62.5%) potatoes (55.5%) tomatoes (55%) okra (50%) zucchini (46%) onions (45.4%) capsicum (44.4%) bottle gourd(loki) (40%) summer squash (38.8%) and bitter gourds (28.5%) respectively.

Table- 5: Vitamin C Content and Percent Losses in Frozen Vegetables (Blanched)

Vegetables (N=12)	**Vitamin C mg/100mg**	**Percent loss**	**P level**
Green chilies	80.16±25.01	66.6	0.000
Brinjals	3±4.05	62.5	0.000
Potatoes	4±3.25	55.5	0.000
Tomatoes	6±3.09	55.5	0.000
Okra	7±3.05	50	0.000
Zucchini	6±3.56	46.1	0.001
Onion	10±2.89	45.4	0.001
Capsicum	137.88±2.59	44.4	0.001
Bottle gourd(loki)	6±3.25	40	0.001
Summer squash	5±5.05	38.8	0.008
Bitter gourds	49.28±2.15	38.4	0.012
Cucumber	9.39±3.31	28.5	0.003

*significance at P≤0.05.

Sun drying is a common domestic preservative method adopted in the northern region of Pakistan. Upon drying the (Table-6) data should highest percent losses of vitamin C occurred in brinjal (87.5%) followed by okra (83.3%) onion (81.8%) bottle gourd(loki) (80%) capsicum (77%) zucchini (76.9%) tomatoes and chilies (75% each) summer squash (72.2%) bitter gourd (71.4%) and potatoes (66.6%)respectively. The data indicated highly significant losses of vitamin C in almost all of the methods due to storage methods

Table 6: Vitamin C Content and Percent Losses in Sun Dried Vegetables

Vegetables (N=12)	Vitamin C mg/100mg	Percent losses	P level
Brinjals	01±4.23	87.5	0.000
Okra	02±4.91	83.5	0.001
Onion	02±2.36	81.3	0.000
Bottle gourd	02±5.21	80	0.000
Capsicum	57.04±2.98	77	0.000
Zucchini	03±2.23	76.9	0.000
Green chilies	60±2.56	75	0.000
Tomatoes	05±2.24	75	0.012
Summer squash	05±5.21	72.2	0.010
Biter gourd	22.88±4.62	71.4	0.001
Potatoes	03±5.40	66.6	0.002

*significance at P≤0.05

The overall percent losses of vitamin C indicated drying as the vulnerable method for the retention of vitamin C in stored vegetables, blanching vegetables prior to freezing may be a good method for the preservation of quality parameters and deactivation of enzymatic reaction but caused conspicuous losses of vitamin C losses in almost all (range 28.5% - 66.6%) the vegetables as compared to freezing without blanching (range 12.5- 61.5%). Storing vegetables at room temperature also counted appreciable percentage of vitamin C losses (range 25.0 – 55.5%) but the duration of the storage as only three days. Method that caused comparatively lesser percentage of vitamin C losses in the sample vegetables was storing in the refrigerator (12.5% - 33.3%). Vegetables that were most affected were zucchini tomatoes summer squash bottle gourd (loki) okra and capsicum as compared to other vegetables.

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DISCUSSION

To the land lords, it is the returns that guide their investments in real estate not the nature of the tenants. The present study assessed the effect of various storage methods on the vitamin C content of summer vegetables. By using fresh vegetables as the control or reference five storage procedures namely storage at room temperature refrigeration freezing without blanching, freezing with blanching and sun drying were used. As evident from the data fresh vegetables contained the highest vitamin C. losses in the ascorbic acid occurred in storage at room temperature are in line with the Lee and kader (2000) who stated temperature management after harvest as the most important factor to maintain vitamin C of fruits and vegetables. Storage at room temperature in the present study showed appreciable losses ranging from 23% - 46%. Refrigeration of vegetables on the other hand caused comparatively lesser losses as compared to other methods ranging from 15.03% - 33.8%. These results coincide with the work of Shashikala and Sehgal (1996) who observed markedly greater reduction in the ascorbic acid concentration in leafy vegetables in the refrigerator. Greater losses occurred during freezing (range 12.5 – 61.5%) in this present study. Giannakourod and Taoukis (2002) found similar

results while working on the systematic kinetics of ascorbic acid loss in green vegetables in freezing storage. They found that depending upon the type of plant tissues significant losses in vitamin C occurred during freezing. Substantial losses in the ascorbic acid concentration occurred during freezing preceded by blanching procedure. These losses ranged from 28.5 – 66.6%. Upon comparison with freezing without blanching approximately 25% more losses occurred coinciding with the findings of Igwemmar(2013) and Gupta et al (2008) who proposed about 25% of vitamin C losses in vegetables due to blanching. Lee and kader (2000) also found that blanching reduces the vitamin C content of horticultural products during processing and frozen storage. The results of Yadav and Sehgal (1997) also showed estimated 55.3 – 65.9% losses of vitamin C in green leafy vegetables after blanching.

This decrease in the vitamin C may be attributed to the oxidation of ascorbic acid. Comparing the results of this present study refrigeration storage and freezing without blanching exhibited higher vitamin C content of the frozen vegetable than that of storing at refrigerator temperature. This can be explained by the phenomena of negative correlation between the supply of oxygen and oxidation of ascorbic acid. Similar results were reported by Jany et al (2005) while working on winter vegetables. Comparison of all the storage methods of the present study revealed that refrigeration storage was the best method of storing vegetables. This method however has a serious disadvantage i.e. vegetables can be stored for shorter period of time of approximately not more than a week.

Jany et al (2008) and Bender (1966) reported losses in the organoleptic characteristics of winter vegetable and proposed that processing and preparation of foods bring about losses in nutrients and the extent of these losses depends upon the type of techniques in storage time. The high significant losses in the sun dried vegetables (66.6 – 87%) in agreement with Ejoh (2005) for leafy vegetables. Singh et al (2001) demonstrated similar close values for vitamin C in some Indian vegetables. Oshodi (1992) also proposed that vitamin C level in vegetables is temperature dependent. These losses may be justified by the principle that vitamin is hydro soluble and thermo sensitive based on this principle Machlin (1984) found 50% decline in vitamin C during heat treatment. Garrote et al (1988) and Somogyi (1990) attributed the loss of vitamin C to tissue disruption which is caused by peeling, cutting, slicing and high temperature. In the present study vitamin C losses were greater and significant for all vegetables after blanching and freezing. Results of Clydesdale et al (1991) and Selman (1994) suggested this loss to cutting washing blanching and cooling which cause the vitamin to leach out during these operations. Fennema (1981), Howard et al (1999) and Wu et al (1992) proposed that vegetables are highly susceptible to water heat blanching and cooling techniques. Some vegetables need to be blanched without water.

CONCLUSIONS

The study based on the findings above made the following conclusions:that premium storage conditions at domestic level are requisite to preserve vitamin C in vegetables. Some losses in vitamin C are inevitable; however, handling and storing raw vegetables under appropriate conditions, inactivation of oxidative enzymes and reduction in the temperature fluctuation will minimize these hidden losses. This is crucial from the consumers' perspective when improper handling and storage tend to reduce the nutritional benefits of vegetables.

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