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Vitamin C Content of Ready-To-Drink Orange Juice in Different Storage Conditions

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Abstract

The vitamin C contents of ready-to-drink orange juices in doy pack, tetra wedge and plastic bottle stored at room (31 - 32^{0}C) and refrigerated (4 - 5^{0}C) temperatures for a month were determined using the dichloroindophenol titration procedure. All the orange juice samples stored at room temperature showed higher vitamin C lost (1.45 - 4.09 mg/100ml) compared to orange juice samples stored inside the refrigerator (1.18 - 2.91 mg/100ml). The differences in the amounts of vitamin C lost in the orange juice samples stored at different temperatures were insignificant. At room temperature storage, higher amount of vitamin C was lost in the doy pack orange juice sample (4.09 mg/100ml), followed by juice sample in plastic bottle (2.35 mg/100ml) and in tetra wedge (1.45 mg/100ml). At refrigeration, the amounts of vitamin C lost in orange juice sample were as follows, doy pack (2.91 mg/100ml) > tetra wedge (1.18 mg/100ml) > plastic bottle (0.99 mg/100ml). The amounts of vitamin C lost in refrigerated orange juice samples contained in tetra wedge and plastic bottle were not significantly different. The use of container with thick inner layer, and lesser head-space oxygen content and storage at cool temperature are recommended for retention of vitamin C in ready-to-drink orange juice.

Keywords: *Vitamin C; Orange juice; Micronutrient; Plastic bottle; Refrigerator*

Introduction

The National Nutrition food consumption survey conducted in 2013 showed low consumption of vitamin C among Filipinos. The adult average daily per capita intake of vitamin C was noted to decrease from 46.7 mg in 1993 to 44.7 mg in 2008. The diminishing intake was attributed to factors such as high food prices and lack of food supply due to seasonality of sources. Vitamin C is white, crystalline, odorless water soluble compound that is acidic, has reducing properties and naturally occurred in plants but not in humans. Therefore, humans acquire this vitamin from consuming plant sources. The primary functions of vitamin C is to act as coenzymes in energy metabolism and in reactions that build and maintain body tissues like bones, muscles, collagen and red blood cells. It also helps enhance iron absorption, fight infections and combat diseases caused by free radicals by operating as an active antioxidant. Rich sources of Vitamin C are fruits, specifically citrus fruits, kiwi, guava, strawberries, grapefruits and vegetables such as the green leafy, green peppers, asparagus and broccoli. Vitamin C deficiency results to bleeding gums, easy bruising, poor wound healing, slow recovery from infection, fatigue and depression. The Philippine recommended vitamin C intake for female and male adults is 60 and 70 mg/day, respectively [1].

Ready to drink fruit juices are significant source of vitamin C commonly available in the market, nowadays. Fruit juices are liquid naturally contained in fruit or vegetable tissues. Codex Alimentarius defines juice as "unfermented but fermentable juice, intended for direct consumption, obtained by the mechanical process from sound, ripe fruits, preserved exclusively by physical means. The juice may be turbid or clear. The juice may have been concentrated and later reconstituted with water suitable for the purpose of maintaining the essential composition and quality factors of the juice. The addition of sugars or acids can be permitted but must be endorsed in the individual standard." [2]. All citrus juices are abundant in vitamin C, containing twice as much as the recommended daily allowance per eight-ounce glass.

Vitamin C is an essential micronutrient, however, the Vitamin C naturally present in fruit juices is highly labile. It is readily deactivated upon exposure to air, light, heat and is further lost at different rates depending on the condition of storage [3]. Hence, the need to monitor the quality of commercially processed fruit juices.

Determining the Vitamin C in commercially available fruit juices and the amount lost under different storage conditions are of great importance to consumer in order to maximize the benefit of Vitamin C in the food items they are consuming. Moreover, these convenient commercial juices come in different flavours, brands and nutrient rich claims. Since the common ready to drink orange juice brands are claiming their products to be rich in Vitamin C, it is essential to validate its value and or claim as a source of vitamin C for consumer information and protection.

In this study, the effects of different storage conditions and packaging materials on the amount of vitamin C present in the commercially available fruit juices were determined. Specifically, the study aimed to compare the amount of vitamin c of the commercially available fruit juices in various packaging conditions (doy pack, tetra wedge and plastic bottle) and stored at room and refrigerated temperatures.

Materials and Methods

One brand of orange fruit juice samples contained in three different packaging materials namely the doy-pack (240 ml), tetra wedge (235 ml) and plastic bottle (355 ml) were purchased in local supermarket in Los Baños, Laguna, Philippines. The selected samples have close manufacturing date (within the same week) and similar orange juice components. The orange juice samples contained in the different packaging materials were stored at room (31 - 32^{0}C) and refrigeration (4 - 5^{0}C) temperatures for four weeks. Amount of Vitamin C in the samples were measured each week on the fifth day. All tests were done in triplicates.

The dichloroindophenol titrimetric (DCPIP) method was used to determine the amount of vitamin C in each sample of orange juice [4].

The data were expressed as mean ± SD. Readings within a group were compared using the one-way ANOVA analysis and readings between groups were compared using the Independent sample test. Statistical analysis was performed using SPSS (Version 22). A level of $p < 0.05$ was considered to be significant.

Results and Discussion

The reduction in the values of vitamin C in ready-to-drink orange juices in tetra wedge, doy pack and plastic bottle stored at room and refrigeration temperatures for a month are presented in Tables 1, 2 and 3.

Orange juice in tetra wedge	Vitamin C Content (mmg/100ml)	
	Room Temperature	Refrigerated
Week 1	$10.52 \pm 0.41^{a}_{a}$	$10.52 \pm 0.41^{a}_{a}$
Week 2	$9.62 \pm 0.32^{a}_{ab}$	$10.52 \pm 0.31^{a}_{ab}$
Week 3	$9.07 \pm 0.41^{a}_{bc}$	$10.25 \pm 0.31^{a}_{abc}$
Week 4	$9.07 \pm 0.16^{a}_{bc}$	$9.34 \pm 0.57^{a}_{abc}$

Table 1: *Vitamin C content of orange juice in tetra wedge stored at different temperature for one month.*

**Values are expressed as mean ± standard deviation.*

***Superscript with the same letter in each row is not significantly different based on Least Significant Difference (LSD) test at 5% level of significance.*

****Subscript with the same letter in each column is not significantly different based on Least Significant Difference (LSD) test at 5% level of significance*

The vitamin C content of orange juice in tetra wedge stored at room temperature was lost at a faster rate as compared with the sample stored at refrigeration temperature. The difference in the vitamin C content lost in the juice packed tetra wedge and stored in room and refrigerated temperatures was not significantly different. Significant lost in vitamin C was noted after three-week storage at room temperature but the amount of vitamin C lost at refrigeration temperature after weeks of storage was not significantly different.

Similarly, as shown in [Table 2], the vitamin C content of orange juice in doy pack stored at room temperature was reduced at a faster rate as compared with the sample stored at refrigeration temperature however the difference was noted to be insignificant. After 3 and 4 weeks of storage at room and refrigeration temperatures, a significant reduction in vitamin C was noted in the orange juice samples contained in doy pack.

Orange juice in doy pack	**Vitamin C Content (mg/100ml)**	
	Room Temperature	Refrigerated
Week 1	$15.06 \pm 0.32^{a}_{a}$	$15.06 \pm 0.32^{a}_{a}$
Week 2	$13.51 \pm 0.57^{a}_{ab}$	$13.10 \pm 0.83^{a}_{ab}$
Week 3	$12.52 \pm 0.94^{a}_{bc}$	$13.33 \pm 0.28^{a}_{bc}$
Week 4	$10.97 \pm 0.68^{a}_{c}$	$12.15 \pm 0.32^{a}_{c}$

Table 2: *Vitamin C content of orange juice in doy pack stored at different temperatures for one month.*

**Values are expressed as mean ± standard deviation.*
***Superscript with the same letter in each row is not significantly different based on Least Significant Difference (LSD) test at 5% level of significance.*
****Subscript with the same letter in each column is not significantly different based on Least Significant Difference (LSD) test at 5% level of significance*

It can be seen in [Table 3] that the difference in the vitamin C content of the plastic bottled juice stored at room and refrigerated for a month was also not significant. On the other hand, significant differences in the reduction of vitamin C during the fourth week of storage were noted in the plastic bottled juice samples stored in two different temperature conditions. The decrease in vitamin C content of sample stored at room temperature was significantly different at fourth week unlike the refrigerated samples which showed no significant decrease after a month of storage.

Orange juice in plastic bottle	**Vitamin C Content (mg/100ml)**	
	Room Temperature	Refrigerated
Week 1	$29.02 \pm 0.78^{a}_{a}$	$29.02 \pm 0.78^{a}_{a}$
Week 2	$28.30 \pm 0.00^{a}_{ab}$	$29.02 \pm 0.32^{a}_{ab}$
Week 3	$27.58 \pm 0 .83^{a}_{abc}$	$28.39 \pm 0.16^{a}_{abc}$
Week 4	$26.67 \pm 0.28^{a}_{c}$	$28.03 \pm 0.27^{a}_{abc}$

Table 3: *Vitamin C content of orange juice in plastic bottle stored at different temperatures for one month.*

**Values are expressed as mean ± standard deviation.*
***Superscript with the same letter in each row is not significantly different based on Least Significant Difference (LSD) test at 5% level of significance.*
****Subscript with the same letter in each column is not significantly different based on Least Significant Difference (LSD) test at 5% level of significance*

As seen in all the results of all the three packaging condition and storage temperature conditions, the amount of vitamin C present in all the juices decreased gradually (Tables 1, 2 and 3). But also, the results differ for the different storage condition. After a month of storage, greater amounts of vitamin C were retained in all the refrigerated samples with different packaging than those samples stored at room temperature. Difference between the retained vitamin C amounts was not significant.

All the orange juice samples stored at room temperature showed higher vitamin C lost (1.45 - 4.09 mg/100ml) compared to orange juice samples stored inside the refrigerator (1.18 - 2.91 mg/100ml).

Packaging	Week 1	Week 4 (Room)	Week 4 (Ref)
Doy Pack	15.06 ± 0.32	10.97 ± 0.69	12.15 ± 0.32
Tetra Wedge	10.52 ± 0.41	9.07 ± 0.16	9.34 ± 0.57
Bottled	29.02 ± 0.78	26.67 ± 0.28	28.03 ± 0.27

Table 4: *Comparison of lost vitamin C (mg/100ml) among orange juices stored in different conditions.*

At room temperature storage, higher amount of vitamin C was lost in the doy pack orange juice sample (4.09 mg/100ml), followed by juice sample in plastic bottle (2.35 mg/100ml) and least in tetra wedge (1.45 mg/100ml). At refrigeration, the amounts of vitamin C lost in orange juice sample were as follows, doy pack (2.91 mg/100ml) > tetra wedge (1.18 mg/100ml) > plastic bottle (0.99 mg/100ml).

The vitamin C of all samples decreased during storage. However, higher retention of vitamin C was observed at refrigeration temperature than at ambient temperature. This is consistent with studies that report that the vitamin C content of stored produce degrades steadily upon prolong storage at ambient temperature due to its labile nature and high sensitivity to oxygen [3,5-10].

The inability of the packaging materials to act as effective barrier against light, oxygen, temperature and other environmental factors further result to reduction of vitamin C content [11]. And in this case, the factors are the storage temperatures, presence and exposure to oxygen and light. According to Polydera [8], the rapid decrease may also be attributed to the immediate reaction of vitamin C with the dissolved oxygen. On the other hand, Burdurly [12] stated that anaerobic degradation, commonly observed in thermally stored juices, may also contribute to loss of vitamin C.

Likewise, in the study of Padayatty [9] it was observed that temperature affects vitamin C content. Since vitamin C is the least stable nutrient by far, its diminution is usually used as a basis to estimate the overall nutrient retention of food products. Moreover, it is highly sensitive to oxidation during storage hence its lost may be used as an indicator of extent of loss of other nutrients and other antioxidant activities [13-15].

In terms of the effect of packaging material on the vitamin C content, the ability to resist heat, exposure to light and oxygen are the factors that will possible determine vitamin C retention in food products. The general material structure for doy pack is CPP (cast polypropylene)/ PET (polyethylene terephthalate)/ LDPE (low density polyethylene). This material provides the doy pack with properties such as moisture proof and oxygen isolation. On the other hand, tetra wedge is made out of paperboard, polyethylene and aluminum foil. Paperboard is the main material the cartons. It provides stability and strength to the packaging. Polyethylene protects product against outside moisture and enables the paperboard to stick to the aluminum foil. Aluminum foil protects against oxygen and light to maintain the nutritional value and flavors of the food in the package in ambient temperatures. Lastly, the plastic bottles called polyethylene terephthalate are made of thermoplastic polymer that can be either opaque or transparent, depending on the exact material composition. Factors, such as transparency, gloss, shatter resistance, thickness and pressure resistance, are also carefully monitored as it affects the nutrient values of the product [16-19]. In both storage temperature conditions, the loss of vitamin C was greater in doy pack probably due to hot pack filling process and lesser heat resistance from outside environment as compared with tetra wedge which had a plastic/ aluminum foil/ paperboard laminated carton that provided layers of protection against light, heat and oxygen thus resulting to lesser vitamin C lost [18,20,]. Although plastic bottles have undergone cold filling process, its transparent feature and monolayer structure provided little protection against light, heat and oxygen that may have caused much reduction in vitamin C content as shown in the results of this study.

Summary and Conclusion

One-month storage at room and refrigerated temperatures resulted in the loss of vitamin C in ready to drink orange juice samples packed in different containers. Lesser loss in vitamin C was noted in the refrigerated samples than the samples stored at room temperature. The hot filling process of orange juice in doy pack sample and its lesser capacity to resist heat from outside environment may have contributed to much loss in vitamin C as compared with orange juice samples in plastic bottles and tetra wedge. Plastic bottling of orange juice undergoes cold filling process and this may have resulted to lesser reduction in vitamin C despite its monolayer structure that offers the least protection against light, heat and oxygen as compared to doy pack and tetra wedge. The least reduction in vitamin C of tetra wedge packed orange juice may be attributed to the multi structural layer consisting of plastic, aluminum foil and paperboard laminated carton that served as a barrier against exposure to light, heat and oxygen from the environment.

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