The Stability of Vitamin C in some Vegetables Exposed to Different Heat Treatment during Cooking served in some Restaurants

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Abstract
Customer demand for healthy food has increased rapidly so many efforts have been made to improve the quality of food. Vitamins are organic compounds found in natural foods especially vegetables. Vitamin C considered the most important water soluble antioxidant. It is a typical heat sensitive nutrient. It exposed to different heat treatment during cooking served in restaurants. The aim of this study to assess the chemical composition and the stability of vitamin C of four different vegetables tomato, zucchini, green beans and artichoke exposed to various heat treatments during frying, roasting and boiling. The result showed that fresh tomato contained the highest moisture (93.61%) followed zucchini (93.7%). Mean ash and protein significantly decreased with heat treatments, while carbohydrate significantly increased. Fat content was affected by heat treatment as it decreased except in fried samples where they contained the highest fat percentage. Also, Vitamin C decrease with heat treatment. Therefore, the study recommended to increase consumption of fresh vegetables.

Keywords: Stability of Vitamin C; Vegetables and Heat Treatment.

Introduction
Customers are becoming increasingly concerned about healthy food such as food rich in vitamins (Fatimah et al. 2011). Healthy food is a critical restaurants selection attribute (Worsfold, 2006). Thus, in cooking stage restaurants chefs are challenged by an urgency to produce and serve food with less lose of vitamins (Sanlier et al. 2010). In order to ensure that restaurant chefs need to recognize the chemical composition and stability of vitamins expose to different heat treatment to minimize this lose (Namkung et al. 2011). Vitamins are organic compounds accruing in natural food especially in vegetables (webb and lang, 2010). Vitamins are needed for maintenance of skin, bones, teeth, hair and help the body to absorb calcium and phosphorous. (Bender, 2009). Also, vitamins are involved in blood clotting, normal functioning of nervous system and needed for metabolism of macro molecules (Chatterjea and Shinde, 2012).

Vitamin C is a six carbon lactones which is synthesized from glucose by many animals (Rao, 2007). Also referred to as ascorbic acid or acrobat belongs to the water soluble vitamin. It is an essential micronutrient required for normal metabolic function of the body, it lowers blood pressure, a marker of inflammation and possibly a predictor of heart disease (Block et al., 2004).
It is widely used in the treatment of certain diseases such as scurvy, common cold, anemia and even infertility (Hyson, 2005) when there is insufficient vitamin C in the diet humans suffer from the potentially lethal deficiency disease scurvy (Hyson, 2005). Vitamin C, vitamin E and beta carotene are the most widely studied dietary antioxidants vitamin C is considered the most important water soluble antioxidant in extracellular fluids. It has been cited as being capable of regenerating vitamin E and has been found to prevent tissue damage. (Sies, 2012). Vegetables considered sources of vitamins C their contribution as a group estimated at 91% of vitamin C such as tomatoes, potatoes, beans, zucchini and artichoke (Eisa, 2010 and wargovich, 2008).

**Literature review**

Vitamin C is a typically heat sensitive nutrient (Sagay et al., 2008). Cooking and heat treatments losses of vitamin C depend on the degree of heating, leaching into the cooking medium, surface area exposed to water, presence of transition metals and any other factors that facilitate oxidation (Gayathri et al., 2004).

Nursal and yucecan (2000) observed changes in loosing vitamin C in frozen spinach, peas, green beans and okra commercially cooked in different stew pans with and without thawing. Frozen peas were the vegetables found to be the least affected (3.5% loss) and frozen green beans the most affected 19.6 % loss) by thawing at room temperature. While cooking (boiled for 5 min. then simmered for 30 min.) spinach, peas, green beans and okra without thawing resulted in 46.5%, 25.2% and 21.6% vitamin C loss boiling them in pan resulted in 58.5%, 36.0%, 42.1% and 28.2% vitamin C loss respectively. It was found that thawing before cooking caused more vitamin C loss, thus using only small amount of water is advantageous. Golaszewska and zalewski (2011) concluded that the best quality of potatoes was achieved by using dry methods where losses of vitamin C were 8-17%, whereas wet methods induced higher losses of vitamin C (20-40%). Gliszczynska et al. (2006) observed vitamin C loss in broccoli from blanching when was blanched packed and treated (100°C for 30 min.) a 75% decrease in total vitamin C was noted. Turkmen et al. (2005) found that blanching reduced the level of vitamin C in chive leaves by 29%. Also, reported 47.51% losses of vitamin C in parsley leaves affected by blanching. Alvi et al. (2003) subjected vegetables for vitamin C content in raw cooked and peeled-cooked forms. The loss of vitamin C in cooking raw brinjal was 61.45% and in cooking peeled was 97.19%. The percentage losses of vitamin C for the same two parameters for bitter gourd were 53.42% and 89.75% respectively. The aim of this study to asses the chemical composition including moisture, ash, fat, protein and carbohydrate and the stability of V. c in some vegetables exposed to various heat treatment during cooking in restaurants.
Material and methods

1- Sample
A total of 100 samples were collected from different restaurant consisted of four types of vegetables tomato, zucchini, green beans and artichoke. Divided to three samples each of them half kilograms cut into cubes (2x2x2cm.) for three treatment methods were including boiling, frying, roasting until cooked for 5-15 min. according to the types of vegetables.

2- Treatment
2.1 Boiled sample
Each type of vegetable were cooked in boiling water by minimal amount of water and kept on the flame until cooked at the boiling point of water 100 degree.

2.2 Fries sample
Each vegetables were fried in corn oil at 80℃ when the oil temperature reaches 180℃frying of the sample was done from both sides until be cooking.

2.3 Roasted sample
Each type of vegetables were cooked in the oven at temperature 210℃. The samples were placed in a roasting pan in the oven until being cooked.

2.4 Fresh sample
Five samples of each type of vegetables were obtained representing the control samples.

2. Chemical composition
3.1 Determination of moisture, ash, protein, fat and digestible carbohydrate contend it was carried out according to AOAC (2003).

3.2 Determination of vitamin C according to leskova et al. (2006).

Results
The data in table (1) showed the proximate composition of tomato at different heat treatments. Mean moisture content in fresh tomato was 93.61% that increased by 0.52% with boiling to reach 94.1% and decreased in frying and roasting by 0.88% and 1.14% respectively. For ash and protein they were content in tomato 0.71% and 1.19% respectively. They decreased with boiling, frying and roasting to (0.67%, 0.94%), (0.64%, 0.68) and (0.56%, 0.91%) respectively.

There was a significance decrease in protein content in frying tomato, which decreases to reach 0.68% from 1.3% in fresh tomato.

Fat content in fresh sample was 0.25%, it decreased in boiled and roasted samples by 13% and 74% while fat content increased by 247.80% in fried sample to reach 0.80%.
Carbohydrate content in fresh sample was 5.45%, which increased with frying and roasting 16.60% and 38.60% while it decreased in boiled sample by 0.80%.

Proximate composition are shown in table (2). The results indicated that moisture content of fresh sample was 95.37% increased in boiled and roasted samples by 0.58% and 0.82% to reach 96.23% and 95.37% respectively. While it decreased with fried, samples by 8.5% to reach 89.50%. Ash content of fresh sample was 0.78% which decreased with different heat treatments except in frying, it increased to reach 0.81%.

Protein content of fresh sample was 2.23% which decreased with different treatments, while fat content of fresh zucchini 0.38% which decreased with boiling and roasting 39.5% and 56.4% while increased in fried sample by 339% to reach 2.38%. Generally there were significance differences in ash, fat and carbohydrate content of zucchini at different heat treatments.

Data in table (3) showed the proximate composition of artichoke at different heat treatment. Moisture content of fresh sample was 86.18% that decreased with different heat treatment expect in boiled sample the moisture content increased by 1.3% to reach 85.29%. For ash content fresh sample was 1.5% this ratio decreased with different heat treatments boiling and roasting (0.94%, 0.81%) and increased with frying to reach 1.36%. There was a significance increase in the carbohydrate content in artichoke with different heat treatments. While there was significance decrease in the protein content with heat treatments.

Table (4), illustrated the content of moisture, ash, protein, fat and carbohydrate in green beans at different heat treatment. Moisture content of fresh sample was 89.86% and decreased with boiling, roasted and frying by 0.60%, 8.00%, and 13.67% to reach 88.19%, 83.46%, and 78.38% respectively. Ash content of fresh sample was 0.83%. This percentage increased with boiling and frying by 1.30%, and 16.86%. While it decreased with roasting by 6.10% to reach 0.88%, 0.95% and 0.99% respectively. Protein content of fresh sample was 1.09% and increased in roasted sample by 6.82% to reach 1.34% while it decreased in other heat treatments.

Generally there was significant increase in carbohydrate and fat content in fried samples compared to fresh samples as they increased by 116.6% and 167% to reach 19.33% and 1.99% respectively.

Table (5) represented vitamin C content of different types of vegetables at different heat treatments.

Generally there was a highly significant decrease in vitamin C content in boiled zucchini, fried and roasted tomato as they were 1.62 mg/100g, 0.61 mg/100g, 0.2 mg/100g respectively. While there were significance decreases in fried artichoke and green beans.
### Table 1: proximate composition of tomato at different heat treatments

<table>
<thead>
<tr>
<th>Tomato</th>
<th>Moisture %</th>
<th>Ash %</th>
<th>Protein %</th>
<th>Fat %</th>
<th>Carbohydrate %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>% Change</td>
<td>%</td>
<td>% Change</td>
<td>%</td>
</tr>
<tr>
<td>Fresh</td>
<td>93.6</td>
<td>0.71</td>
<td>1.39</td>
<td>0.25</td>
<td>5.45</td>
</tr>
<tr>
<td>Boiling</td>
<td>94.1</td>
<td>0.67</td>
<td>-5.64%</td>
<td>0.94</td>
<td>-21%</td>
</tr>
<tr>
<td>Frying</td>
<td>93.7</td>
<td>-0.88%</td>
<td>0.64</td>
<td>-7%</td>
<td>0.68*</td>
</tr>
<tr>
<td>Roasting</td>
<td>94.5</td>
<td>-1.14%</td>
<td>0.56</td>
<td>-15.20%</td>
<td>0.91</td>
</tr>
</tbody>
</table>

* Significant at P<0.05  ** Highly Significant at P<0.01.

### Table 2: proximate composition of zucchini at different heat treatments

<table>
<thead>
<tr>
<th>Zucchini</th>
<th>Moisture %</th>
<th>Ash %</th>
<th>Protein %</th>
<th>Fat %</th>
<th>Carbohydrate %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>% Change</td>
<td>%</td>
<td>% Change</td>
<td>%</td>
</tr>
<tr>
<td>Fresh</td>
<td>95.7</td>
<td>0.7</td>
<td>2.23*</td>
<td>0.38</td>
<td>3.9</td>
</tr>
<tr>
<td>Boiling</td>
<td>96.2</td>
<td>-8.50%</td>
<td>0.7</td>
<td>-1.26%</td>
<td>0.61</td>
</tr>
<tr>
<td>Frying</td>
<td>89.5</td>
<td>-8.50%</td>
<td>0.8</td>
<td>15.18%</td>
<td>0.84</td>
</tr>
<tr>
<td>Roasting</td>
<td>95.3</td>
<td>0.2</td>
<td>-24%</td>
<td>0.68</td>
<td>-47.10%</td>
</tr>
</tbody>
</table>

* Significant at P<0.05  ** Highly Significant at P<0.01.
Table 3: proximate composition of artichoke at different heat treatments

<table>
<thead>
<tr>
<th>Artichoke</th>
<th>Moisture %</th>
<th>Ash %</th>
<th>Protein %</th>
<th>Fat %</th>
<th>Carbohydrate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh</td>
<td>86.1%</td>
<td>1.5%</td>
<td>3.41%</td>
<td>0.3%</td>
<td>8.3%</td>
</tr>
<tr>
<td>Boiling</td>
<td>85.2%</td>
<td>0.9%</td>
<td>-14.54%</td>
<td>2.01%</td>
<td>4.01%</td>
</tr>
<tr>
<td>Frying</td>
<td>79.7%</td>
<td>1.3%</td>
<td>11.82%</td>
<td>2.94%</td>
<td>16.93%</td>
</tr>
<tr>
<td>Roasting</td>
<td>75.9%</td>
<td>0.8%</td>
<td>-35.50%</td>
<td>2.86%</td>
<td>17.89%</td>
</tr>
</tbody>
</table>

* Significant at P<0.05.  ** Highly Significant at P<0.0

Table 4: proximate composition of green beans at different heat treatments

<table>
<thead>
<tr>
<th>Green beans</th>
<th>Moisture %</th>
<th>Ash %</th>
<th>Protein %</th>
<th>Fat %</th>
<th>Carbohydrate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh</td>
<td>88.8%</td>
<td>0.8%</td>
<td>1.09%</td>
<td>0.1%</td>
<td>8.45</td>
</tr>
<tr>
<td>Boiling</td>
<td>88.1%</td>
<td>0.8%</td>
<td>-22.42%</td>
<td>0.09%</td>
<td>9.06</td>
</tr>
<tr>
<td>Frying</td>
<td>78.3%</td>
<td>0.9%</td>
<td>16.86%</td>
<td>0.85%</td>
<td>116.62%</td>
</tr>
</tbody>
</table>

* Significant at P<0.05.  ** Highly Significant at P<0.0
Table 5: Vitamin C content of different vegetables at different heat treatments

<table>
<thead>
<tr>
<th></th>
<th>Fresh</th>
<th>Boiling</th>
<th>Fried</th>
<th>Roasting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mg/100 g</td>
<td>% Change</td>
<td>Mg/100 g</td>
<td>% Change</td>
</tr>
<tr>
<td>Tomato</td>
<td>12.79</td>
<td>5.2</td>
<td>72.60%</td>
<td>0.61**</td>
</tr>
<tr>
<td>Zucchini</td>
<td>11.2</td>
<td>1.82</td>
<td>85.71%</td>
<td>8.2</td>
</tr>
<tr>
<td>Artichoke</td>
<td>7.4</td>
<td>5.2</td>
<td>16.20%</td>
<td>2.4*</td>
</tr>
<tr>
<td>Green beans</td>
<td>3.79</td>
<td>2.1</td>
<td>44.60%</td>
<td>1.2*</td>
</tr>
</tbody>
</table>

* Significant at P<0.05. ** Highly Significant at P<0.01.

Discussion of results
Moisture, ash, protein, fat and carbohydrate of tomato at different heat treatments are showed in table (1). Moisture content of fresh tomato was 93.61 % this result was in agreement with (Davis and Hobson, 2009). Who reported that the moisture content of fresh tomato ranged between92.5 % to 95 %. Also, showed the ash, protein, fat and carbohydrate content as they were 0.71 %, 1.39 %, 0.18 % and 4.29 % respectively, similar results were obtained by (Sahlin et al. 2004), who reported that fresh tomato contained 0.68 % ash, 1.27% protein, 0.18 % fat and 4.29 % carbohydrate. Also, indicated in table (1) the effect of boiling, roasting and frying on proximate composition, there were significance difference in fat and carbohydrate between fresh and tomato exposed to different heat treatments. Moisture content in fresh tomato was 93.16 % increased in boiled sample by 0.52 % to reach 94.1 % while it decreased in frying and roasting by 0.88 % and 1.14 %, fat content decreased by boiling and roasting by 13.14 % and 73.9 %. These results are in agreement with Manzie et al. (2004), they reported that cooking process results loss of moisture and other nutrients due
to interaction among constituents, solubility in cooking medium and thermal degradation.

Table (2) represent the chemical composition of zucchini different heat treatment. Fresh zucchini contained 95.7 % moisture, 2.23 % protein, 0.38 % fat, 0.78 % ash and 3.96 % carbohydrate, These results are in agreement with British standards (2005) which reported that fresh zucchini contained 94.79 % moisture, 1.21 protein, 0.32 % fat, 0.58 % ash and 3.11 % carbohydrate.

Data presented in table (3), illustrated the chemical composition of artichoke at different heat treatments boiling, roasting and frying. Fresh artichoke contained 86.10 % moisture, 3.41 % protein, 1.53 % ash which are in agreement with Rangana, (2005) who reported 84.9 % moisture, 3.27 % protein, and 1.13 % ash. While result for fat and carbohydrate were 0.3 % fat, 8.3 % for carbohydrates and this disagree with Monterio, 2009 who reported 0.15 % fat, and 10.13 % carbohydrate. This difference in results may result from the difference climate and way of cultivation.

The data in table (4) indicated that fresh green beans contained 88.86 % moisture, 1.09 % protein, 0.1 % fat, 0.83 % ash and 8.45 % carbohydrate. This result in agreement with Deming et al., (2004) who reported that fresh green beans contained 90.32 % moisture, 1.83 % protein, 0.22 % ash, and 0.66 % carbohydrate.

Vitamin C content of different vegetables at different heat treatments are shown in table (5). The results indicated that vitamin C in boiled artichoke, green beans and zucchini decreased by 16.20 %, 44.60 % and 85.71 % respectively. Byers and perry, (2006) found that vitamin C is highly water-soluble, so cooking in water may cause greater losers by leaching into surrounding water than by other methods such as steaming. Sahlin et al. (2004) stated that roasting had a greater effect on losing vitamin C compared with boiling and frying. It is observed in the present study that roasted tomato had a great loss of V.C (98.43%). Similarly, Klauiet al. (2010) explained that reduction of vitamin C during treatments in tomato loss about 58% of vitamin C. As in this results vitamin C decreased by 72.5% in boiling, by 95.2% in frying and by 98.4% in roasting.

While Yuan et al. (2009) reported that steaming have no significant effect on vitamin C content. Overall, Francisco et al. (2010), that heat treatment influences retention of vitamin C in vegetables due to its high solubility in water and low stability with heat.

Conclusions
- Fried vegetables contained the highest fat content than fresh, boiled and roasted.
- Fresh vegetables contained the highest vitamin content as it decreased with thermal treatment. The higher vitamin value obtained in roasted samples comparing to boiled and fried samples.
- The analysis of the chemical composition of fresh and processed vegetables revealed that cooking affects both bioactive compounds and antioxidant activity of vegetables.
- Boiled vegetables contained the lowest vitamin content.
- Moisture content of vegetables decreased with heat treatment frying and roasting, while boiled vegetables contained the highest moisture content.
- Ash and protein percentage decreased with heat treatment, while carbohydrate significantly increased.

**Recommendations**

From the previous conclusions we can suggest the following recommendations:

- Paying special attention to deficiency of vitamins C in vegetables exposed to different heat treatment by reducing time of heat
- Provide chefs with nutrition information about vitamin C to avoid loosing it during cooking.
- Increase preparing dishes with fresh vegetables which contain the higher levels of vitamin C

**References**


بالملخص العربي

ثبات فيتامين C في بعض الخضروات التي تقدم في المطاعم أثناء تعرضها لمعاملات حرارية مختلفة خلال عملية الطهي

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تزداد في الآونة الأخيرة طلب العملاء للغذاء الصحي وقد بذلت جهود عديدة لتحسين جودة الغذاء، وتعد الفيتامينات مركبات غذائية توجد بشكل طبيعي في الغذاء. يعتبر فيتامين C أحد أهم الفيتامينات التي تذوب في الماء ويتأثر بحساسيته للحرارة حيث يتأثر بدرجة الحرارة التي يتعرض لها أثناء عملية الطهي. هدف تلك الدراسة تقييم التركيب الكيميائي وثبات فيتامين C في أربع أنواع مختلفة من الخضروات وهي الطماطم، الكوسا، الفاصوليا الخضراء والخرشوف أثناء تعرضهم لمعاملات حرارية مختلفة خلال عملية القلي، عملية التحمير وعملية السلق. وأظهرت النتائج أن الطماطم الطازجة تحتوي على أعلى نسبة رطوبة (61.07%)، بينما الكوسا (3.07%) وتزايد محتوى الخضروات بالدهون أثناء عملية القلي وانخفاض مستوى فيتامين C أثناء المعاملة الحرارية خاصة عملية السلق. وأوصت الدراسة بزيادة استهلاك الخضروات الطازجة لمنع فقد فيتامين C أثناء المعاملة الحرارية.

الكلمات الدالة: ثبات فيتامين C، الخضروات، المعاملة الحرارية