The vitamin C and thiamin contents of quick frozen peas

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Summary

The effect of maturity, variety, post-vining delay and various stages in commercial processing, including cleaning, blanching, freezing and end-cooking, on the vitamin C and thiamin contents of quick frozen peas has been studied. As the peas matured, the vitamin C content decreased but there was no correlation between maturity and thiamin content. The vitamin C content of six varieties was approximately constant, but one variety had an unexpectedly low thiamin content. In most cases, post-vining delay had a detrimental effect on the vitamin C content whereas immature (but not mature) peas showed an increase in thiamin content. On average, frozen peas retained 80% of the original vitamin C content and 90% of the thiamin content. Cooking caused a further loss of vitamin C so that, at the point of consumption, the frozen peas retained approximately 55% of the fresh value for this nutrient.

Introduction

The nutrients examined in this evaluation of the critical points of the freezing process under factory conditions were vitamin C and thiamin; both vitamins are water soluble and can be lost by leaching, also, enzymic or chemical oxidation during processing may cause additional losses. Peas served with a meal can contribute at least one third and one tenth of the total daily requirement for vitamin C and thiamin, respectively, so any modification which could be made to commercial procedure to reduce nutrient loss would further help to improve the nutritional value of the national diet.

The main objective has been to study the effects of variety, maturity, post-vining delay and factory processing, including washing, blanching, cooling and freezing, on the vitamin levels. Although information about nutrient changes during the preservation of green peas has been reported (Lee, 1958; Lynch, Mitchell & Casimir, 1959), blanching has been the focal point; simulated laboratory conditions have often been used to investigate the effect of blanching and other points in the processing line have

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been neglected. The present study was carried out in a commercial factory during the
summer of 1972 and covered all aspects of freezing peas; the effect of cooking on the
vitamin C content of fresh and frozen peas was not studied at the same factory until
the summer of 1973.

Experimental and results

Analytical methods

(i) Vitamin C content. Duplicate 30 g samples of peas were ground with a small
quantity of sand and made up to volume with 3% metaphosphoric acid–acetic acid
solution. The extracts were centrifuged, in place of filtering, and assayed in duplicate by
the microfluorimetric method (AOAC, 1970). The fluorimetric method determines
vitamin C after a preliminary oxidation to dehydroascorbic acid and, therefore, is a
measure of the total vitamin C activity in the product, i.e. ascorbic acid + dehydroascorbic
acid.

(ii) Thiamin content. Duplicate 30 g samples of peas were assayed fluorimetrically
(AOAC, 1970) but, from preliminary investigations, the initial digestion with acid was
found to be unnecessary. The extracts were centrifuged to provide clear solutions for
the subsequent analyses in duplicate.

(iii) Solids content. Approximately 500 g samples of peas were minced and 10 g
sub-samples were dried at 80°C for 18–24 hr. The vitamin contents have been expressed
on a dry weight basis to overcome fluctuations in the moisture content of the peas. The
solids content of blanch water was determined in the same manner, taking duplicate
20 ml samples, to establish the state of cleanliness of the water.

Harvesting and processing procedure

The harvested pea plants were vined in the field and the shelled peas were transported
by lorry to the factory in bulk loads of 2–3 tons. The delay time between vining and
transfer to the hoppers for the first stage of the factory process varied but was seldom
more than 90 min. From the hoppers, the peas travelled through cold water washers
and then into a water blancher at 96–98°C for 1 min. On emerging from the blancher,
the peas were cooled with water sprays for 6 sec which was followed by air cooling.
Finally, the peas entered the freezing tunnel which operated at approximately –20°C.

Factors investigated

(1) Maturity. On 12 consecutive days, vines of the variety, Sparkle, were taken from
the same plot of ground to eliminate agricultural variation. On arrival at the factory,
the vines were podded in a miniature viner and the maturity of the peas was determined
in duplicate with a tenderometer. The vitamin content was determined immediately so
that the post-vining delay was zero. The results are summarized in Table 1 and show
that as the peas matured the tenderometer readings (TR) rose from 77·5 to 123·5. Over
the same period, the vitamin C content decreased from 222 to 119 mg/100 g dry weight although the moisture content of the peas only decreased from 81.3 to 75.7% with increasing maturity. No correlation between the thiamin content of 1.60–1.70 mg/100 g dry weight and maturity was observed.

(2) Post-vining delay. On two occasions, samples of the variety, Sparkle, were transported to the factory on the vine. Some of the vines were handpodded and the remainder were podded mechanically in the miniature viner. Tenderometer readings of the peas were recorded immediately and the remainder were kept in the laboratory and analysed for vitamin content at intervals during a delay time of 0–120 min. Commercially, vined samples were not investigated as it was difficult, in practice, to control the delay time.

The batches of immature (TR-90) and mature (TR-110) peas, subjected to handpodding and miniature vining, showed a progressive decrease in vitamin C content with time except for the handpodded immature sample which tended to remain constant (Table 2). The thiamin content of the same samples of peas showed no conclusive pattern in relation to delay time (Table 2) except for an indication that the level could increase in some circumstances.

(3) Various cultivars and the effect of blanching. Six varieties (Sparkle, Swift, Swan, Scout, Dark Skinned Perfection (DSP) and Puget) were analysed after commercial vining in the field with a delay time of 70–80 min and equivalent vines were brought to the factory for miniature vining to provide reference values with a delay time of zero. Ideally, the TR values for all varieties should have been the same but, in practice, the
TABLE 2. Effect of post-vining delay on the vitamin C and thiamin contents of handpodded and miniature vined peas (variety, Sparkle)

<table>
<thead>
<tr>
<th>Delay (min)</th>
<th>Handpodded Vitamin C (mg/100 g dry wt)</th>
<th>Handpodded Thiamin (mg/100 g dry wt)</th>
<th>Miniature vined Vitamin C (mg/100 g dry wt)</th>
<th>Miniature vined Thiamin (mg/100 g dry wt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 0</td>
<td>230.0</td>
<td>1.28</td>
<td>222.2</td>
<td>1.28</td>
</tr>
<tr>
<td>30</td>
<td>214.8</td>
<td>1.25</td>
<td>202.3</td>
<td>1.39</td>
</tr>
<tr>
<td>60</td>
<td>224.3</td>
<td>1.26</td>
<td>201.8</td>
<td>1.49</td>
</tr>
<tr>
<td>90</td>
<td>230.1</td>
<td>1.36</td>
<td>201.7</td>
<td>1.51</td>
</tr>
<tr>
<td>120</td>
<td>235.8</td>
<td>1.44</td>
<td>193.9</td>
<td>1.71</td>
</tr>
<tr>
<td>(b) 0</td>
<td>206.8</td>
<td>1.52</td>
<td>179.1</td>
<td>1.63</td>
</tr>
<tr>
<td>30</td>
<td>193.0</td>
<td>1.56</td>
<td>177.5</td>
<td>1.94</td>
</tr>
<tr>
<td>60</td>
<td>178.4</td>
<td>1.22</td>
<td>177.8</td>
<td>1.23</td>
</tr>
<tr>
<td>90</td>
<td>177.7</td>
<td>1.50</td>
<td>174.4</td>
<td>1.48</td>
</tr>
<tr>
<td>120</td>
<td>169.4</td>
<td>1.62</td>
<td>168.1</td>
<td>1.52</td>
</tr>
</tbody>
</table>

(a) Handpodded TR-90·5, miniature vined TR-89·5.
(b) Handpodded TR-110, miniature vined TR-100·5.

peas from the hoppers had TR values of 95–110 and the miniature vined samples recorded TR values of 90·5–96. Samples of the six varieties were also withdrawn from the air cooler after blanching for vitamin analyses.

The vitamin C content, based on the miniature vined samples with zero delay time, came within the range 154–170 mg/100 g dry weight for five varieties; the variety, Swift, contained 202 mg vitamin C/100 g dry weight. The corresponding values for the commercially vined samples were 125–160 mg vitamin C/100 g dry weight for five varieties and 181 mg vitamin C/100 g dry weight for Swift. The vitamin C content of the peas after blanching and air cooling has been expressed as a percentage of the amount present in the commercially vined peas (Table 3); retention values for four varieties came within the range 77–83%, the varieties Scout and Swan retaining 72% and 90% respectively.

Contrary to the findings for vitamin C, the thiamin content of the commercially vined samples was always slightly higher than the corresponding miniature vined peas (Table 3). Five of the varieties contained 1·51–1·71 mg thiamin/100 g dry weight prior to processing, Scout being the exception with 1·18 mg thiamin/100 g dry weight. The retention of thiamin at the air cooling stage after blanching was 91–99% for four varieties; retention values for Scout and Swift were 64% and 82%, respectively.

(4) Other processing variables. The intention was to study whether the state of cleanliness of the washing and blanching waters influence the level of retention of vitamin C and thiamin in peas during processing. Theoretically, four permutations are possible, viz.
**Vitamin C and thiamin of quick frozen peas**

Table 3. Comparison of the vitamin C and thiamin contents of six varieties of peas subjected to miniature vining, commercial vining and blanching. (Retention after blanching expressed as a percentage of the commercially vined values)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Sample</th>
<th>Content Vitamin C (mg/100 g dry wt)</th>
<th>Thiamin</th>
<th>Retention Vitamin C (%)</th>
<th>Thiamin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sparkle</td>
<td>Miniature vined</td>
<td>170.4</td>
<td>1.59</td>
<td>83.4</td>
<td>91.1</td>
</tr>
<tr>
<td></td>
<td>Commercially vined</td>
<td>125.4</td>
<td>1.69</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blanched</td>
<td>104.6</td>
<td>1.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swift</td>
<td>Miniature vined</td>
<td>201.8</td>
<td>1.36</td>
<td>76.7</td>
<td>82.2</td>
</tr>
<tr>
<td></td>
<td>Commercially vined</td>
<td>180.8</td>
<td>1.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blanched</td>
<td>138.6</td>
<td>1.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swan</td>
<td>Miniature vined</td>
<td>168.9</td>
<td>1.51</td>
<td>90.4</td>
<td>98.6</td>
</tr>
<tr>
<td></td>
<td>Commercially vined</td>
<td>138.8</td>
<td>1.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blanched</td>
<td>124.8</td>
<td>1.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scout</td>
<td>Miniature vined</td>
<td>154.1</td>
<td>0.58</td>
<td>72.3</td>
<td>63.6</td>
</tr>
<tr>
<td></td>
<td>Commercially vined</td>
<td>137.1</td>
<td>1.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blanched</td>
<td>99.1</td>
<td>0.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Puget</td>
<td>Miniature vined</td>
<td>155.4</td>
<td>1.49</td>
<td>80.4</td>
<td>98.6</td>
</tr>
<tr>
<td></td>
<td>Commercially vined</td>
<td>129.8</td>
<td>1.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blanched</td>
<td>104.4</td>
<td>1.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSP*</td>
<td>Miniature vined</td>
<td>164.4</td>
<td>1.63</td>
<td>80.6</td>
<td>92.4</td>
</tr>
<tr>
<td></td>
<td>Commercially vined</td>
<td>160.0</td>
<td>1.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blanched</td>
<td>120.0</td>
<td>1.58</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* DSP: Dark Skinned Perfection.

Clean wash/clean blanch, clean wash/dirty blanch, dirty wash/clean blanch and dirty wash/dirty blanch, but in the factory procedure for changing the processing water the situation of clean wash/dirty blanch did not arise. Samples of the variety, DSP, were withdrawn at six points on the processing line as indicated in Fig. 1 but the results in Table 4 record only four critical points. The delay time and TR values could not be kept constant for all the processing runs but in most cases were 90 min and TR-100, respectively, except that the clean wash/clean blanch combination was investigated with immature peas (TR-89.5). The samples of peas were collected from the processing line in aluminium sieves, so that excess water drained away, and were stored at 4°C in tied polythene bags. Samples taken after leaving the blancher, but before entering the air cooler, were chilled quickly by placing the bag in a mixture of solid CO₂, acetone and water. All samples were analysed on the day that they were taken and were stabilized in metaphosphoric acid within 2 hr of leaving the processing line. The 'dirtiness' of the water was assessed from the solids content, a sample of blanch water being withdrawn from the overflow pipe. Clean blanch water contained 0.2% solids
Table 4. Retention of vitamin C and thiamin after various stages of processing peas of variety, Dark Skinned Perfection

<table>
<thead>
<tr>
<th>Stage in processing</th>
<th>Clean wash/clean blanch</th>
<th>Dirty wash/clean blanch</th>
<th>Dirty wash/dirty blanch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retention (%)</td>
<td>Vitamin C</td>
<td>Thiamin</td>
<td>Vitamin C</td>
</tr>
<tr>
<td>Commercial vining</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Washing</td>
<td>97</td>
<td>100</td>
<td>95</td>
</tr>
<tr>
<td>Blanching</td>
<td>74</td>
<td>100</td>
<td>78</td>
</tr>
<tr>
<td>Freezing</td>
<td>75</td>
<td>91</td>
<td>78</td>
</tr>
</tbody>
</table>

which increased to approximately 2.0% solids when dirty and on the point of being discarded.

Individual analyses showed values ranging from 91 to 99% retention of vitamin C after the peas were washed but the average values were 94–97% retention showing that the condition of the washing water had little, or no, effect on retention; similarly, 94–100% retention of thiamin was observed at the same stage of processing, Table 4. When the peas emerged from the blancher, the vitamin C content was reduced to
average values of 74–78% retention with clean blanch water, and 82% for dirty blanch water; the subsequent stage of a 6 sec passage through water sprays, air cooling and freezing resulted in no further loss of vitamin C. The overall retention of thiamin after blanching, cooling and freezing was 90–92%. These results for the retention of vitamin C and thiamin in frozen DSP peas are in agreement with the values previously found for this variety, Table 3.

(5) Cooling losses. Only one trial was possible from the same batch of peas of variety, Puget, to examine the vitamin C content of fresh, frozen, fresh/cooked and frozen/cooked peas. To prepare the frozen/cooked samples, 8 oz of frozen peas were added to ½ pint of slightly salted boiling water and simmered for 3 min after returning to the boil. Fresh handpodded peas from the same field and of the same tenderometer reading were boiled under similar conditions to the same texture as the frozen cooked peas as assessed by a taste panel. In addition, further data on cooking losses only, with no allowance for the earlier reduction during commercial processing, were obtained by analysing the vitamin C content of frozen peas before and after cooking, following the same procedure described above. The overall level of vitamin C in the fresh/cooked peas and the frozen/cooked peas (Table 5) was similar despite the variation in cooking procedures, i.e.

\[
\begin{align*}
1.1 \text{ min to boil} & \quad + & \quad \text{freezing process} + 3.0 \text{ min to boil} \\
+ & \quad 6.3 \text{ min further boiling} & \quad 3.0 \text{ min further boiling} \\
& \quad (\text{Fresh peas}) & \quad (\text{Frozen peas})
\end{align*}
\]

**TABLE 5.** Effect of cooking on the vitamin C content of peas of variety, Puget

<table>
<thead>
<tr>
<th>Sample</th>
<th>I* (mg vitamin C/100 g dry wt)</th>
<th>II† (mg vitamin C/100 g dry wt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercially vined</td>
<td>123.2</td>
<td>99.8</td>
</tr>
<tr>
<td>Frozen</td>
<td>109.8</td>
<td>99.8</td>
</tr>
<tr>
<td>Frozen/cooked†</td>
<td>75.7</td>
<td>68.1</td>
</tr>
<tr>
<td>Handpodded</td>
<td>139.4</td>
<td>99.8</td>
</tr>
<tr>
<td>Handpodded/cooked§</td>
<td>76.9</td>
<td>99.8</td>
</tr>
</tbody>
</table>

* I: duplicate analysis of one trial.
† II: duplicate analysis of three trials.
‡ 3 min to return to the boil + 3 min simmering.
§ 1.1 min to return to the boil + 6.3 min simmering.

**Discussion**

The reduction in the vitamin C content of peas with increasing maturity which was found in the present investigation (Table 1) is in agreement with the previous work of
As peas mature, the skin/cotyledon ratio decreases but the content of vitamin C in the skin is twice that in the cotyledons which would account for the lower level of vitamin C in more mature peas (Todhunter & Sparling, 1938). No correlation between thiamin content and maturity has been found which is contrary to the reports of Clifcorn & Heberlein (1944) and Heinze, Hayden & Wade (1947) who observed that thiamin levels were affected by maturity. The percentage increase of total solids which was found with increasing maturity agrees favourably with the results of Lynch et al. (1959).

Two conclusions can be drawn from the study of the effect of delay on the vitamin C content of peas: ignoring differences in TR values and the method of podding, in three out of four cases the level of vitamin C in the peas showed a progressive decrease with time which is in agreement with Jenkins, Tressler & Fitzgerald (1938) who found a 14% loss after holding for 3 hr; the miniature vined peas had somewhat lower contents of vitamin C than the comparable handpodded samples (Table 2). Holdsworth (1970) has suggested that mechanical damage leads to loss of vitamin C because of increased enzymic oxidation by ascorbic acid oxidase; miniature vining is likely to inflict more damage to the peas than handpodding. Similarly, the investigations with different varieties of pea showed a large difference between the vitamin C content of miniature and corresponding commercially vined samples (Table 3) which could not be attributed entirely to the post-vining delay when analysing the latter; more severe bruising during commercial vining than with miniature vining is a probable explanation.

The effect of delay time on the thiamin content of peas was variable with increased and decreased levels being recorded, although it was the immature peas which tended to show the former characteristic (Table 2). Moyer & Tressler (1943) found no loss in thiamin during a 3 hr delay between vining and washing whereas Ingalls et al. (1950) observed an apparent increase which could not be attributed to changes in total solids. It is interesting to note that the thiamin content of the six varieties of peas was always higher in the commercially vined samples, with an unavoidable delay time of 70–80 min, than in the corresponding miniature vined samples with a delay time of zero (Table 3).

The microfluorimetric method of analysis, which measures the dehydroascorbic acid content in addition to the fully reduced ascorbic acid, was employed in the present investigation and may account for the range of values for the vitamin C content of six varieties of peas (Table 3) being close to the upper limit of previously reported figures (Mack & Tressler, 1936; Robertson & Sissons, 1966). However, Mapson (1961) has reported that the concentration of dehydroascorbic acid in fresh vegetable material is small. After blanching, the vitamin C retention ranged from 72–90% which indicates a possible difference in processing characteristics between varieties.

With the exception of the very low level in the variety, Scout, the thiamin contents of the other five varieties were in agreement with previously reported values (Clifcorn
Vitamin C and thiamin of quick frozen peas

In most cases, over 90% of the thiamin of commercially vined peas was retained after the blanching process. Although vitamin loss during processing can arise from chemical and enzymic oxidation, leaching is likely to be the major factor. A theory has been proposed that the leaching effect will be reduced if the processing water contains a proportion of soluble solids. Allen, Barker & Mapson (1943) reported that serial scalding in the same water minimized losses during blanching whereas Guerrant et al. (1947) found no improvement in vitamin C retention by repeatedly passing samples through the same blanch water. Lynch et al. (1959) showed that it was the immature peas which lost most vitamin C during blanching. The present study has shown that the state of the washing and blanching waters had little influence on the retention of vitamin C and thiamin (Table 4); although the average retention value for vitamin C was highest after dirty wash/dirty blanch treatment, the range of values obtained from replicate analyses of the different combinations overlapped and a significant claim cannot be made. After blanching, the peas were only in contact with water for 6 sec before being air cooled and frozen, and no further loss of vitamin content was found; Hard & Ross (1956), Mapson (1956) and Joslyn (1961) recorded losses of water soluble nutrients when water cooling was employed. Mapson (1956) and Cain (1967) found no evidence that nutrients were lost during the freezing process and this observation was confirmed in the present study. The overall retention of vitamin C in frozen peas (Table 4) is in agreement with the value of 75% recommended for good commercial practice in the freezing of vegetables by the International Institute of Refrigeration (1971) when it is remembered that the current analyses include the dehydroascorbic acid content which contribute approximately 2-3% to the vitamin C activity in peas. Losses of thiamin, regardless of the condition of the processing water, were small and confirmed previous findings which have been reviewed by Lee (1958).

The retention of vitamin C after the cooking of fresh and frozen peas is of interest (Table 5). The 55% retention when fresh peas are boiled approximates to the 80% retained after the commercial freezing process followed by a 25-30% reduction during the milder cooking treatment for the frozen peas. The retention of vitamin C when boiling frozen peas appears to be a constant factor; if the frozen product has a lower vitamin C content, the level of this nutrient will be correspondingly lower after cooking under standardized conditions. The percentage retention of vitamin C after cooking fresh and frozen peas in this investigation was of a higher order than that reported by Mapson (1956).

Conclusion

The vitamin C content and thiamin content of peas through all stages from vining to the frozen product have been followed under factory conditions. The situations where loss of vitamin C is most likely to occur have been pinpointed to mechanical damage
during vining, delay in holding the shelled peas before entering the production line, blanching, and end-cooking; post-blanching cooling with water was not employed in the factory studied but could provide an additional area for loss of vitamin C. Because of the reduced time needed to cook frozen peas compared with fresh peas, the vitamin C content of both at the point of consumption was similar. The overall loss of thiamin was relatively small during the freezing of peas and, under some conditions, increases in thiamin levels were observed which must be attributed to anabolic enzymic activity as opposed to the catabolic action of ascorbic acid oxidase.

Acknowledgments

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