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**KINETICS OF COLOR CHANGE
AND ASCORBIC ACID LOSS
IN SELECTED FROZEN FRUITS
AND VEGETABLES**

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EXPERIMENTAL METHODS

Samples :

- Broccoli and Spinach were cut in small pieces, washed, steam blanched (98 °C 1.5 min), cooled in a ice/water bath and placed in heat-sealable bags with N₂
- Strawberries were washed in water, cut in small pieces and placed in heat-sealable bags with N₂
- Lemons were squeezed and placed in heat-sealable bags with N₂

Freezing Method

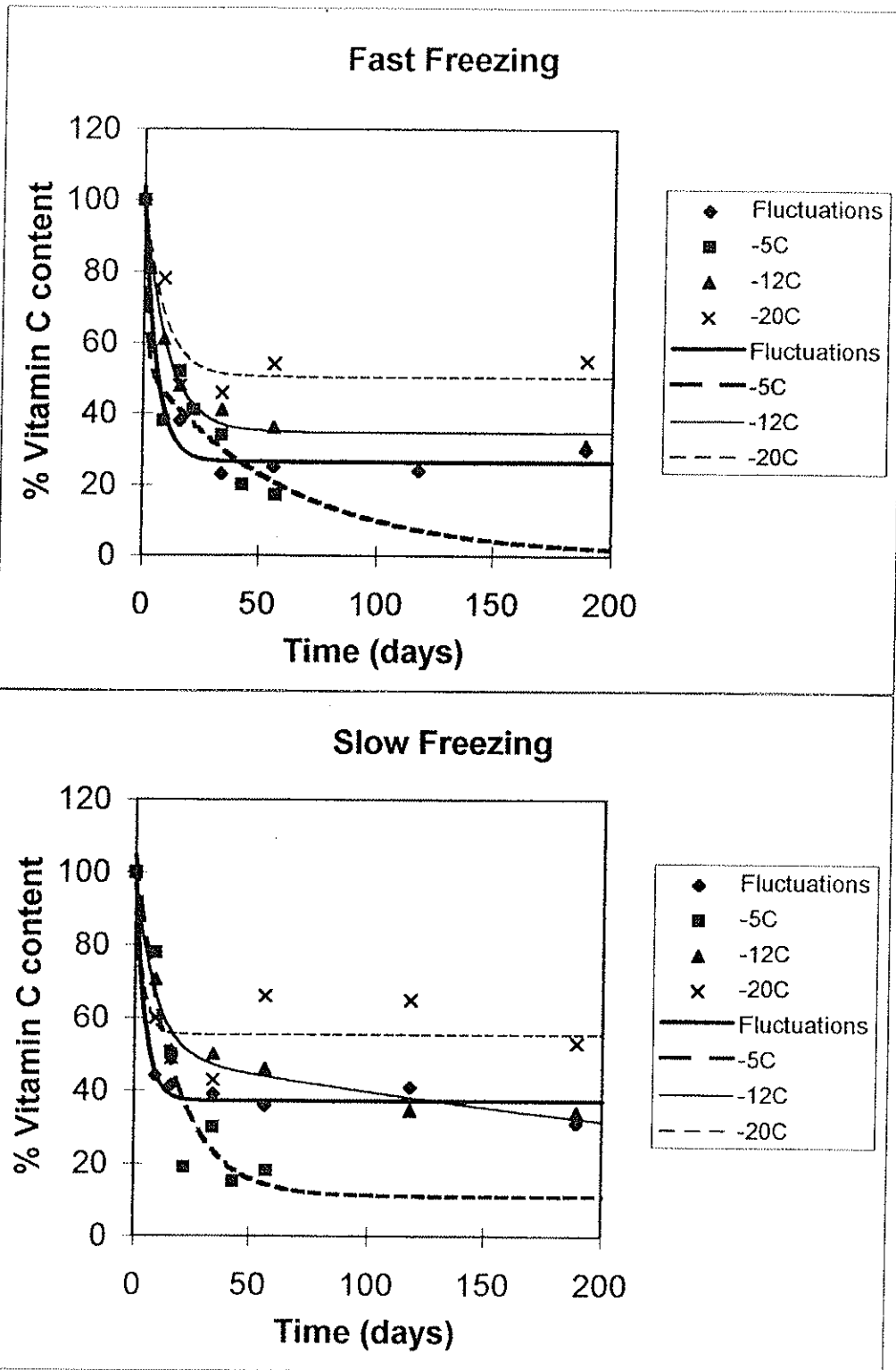
- fast freezing using an air-blast freezer (T=-69 °C, air velocity of 60 m.min⁻¹, t=2 h)
- slow freezing in a cold room at -20 °C with circulating air (t=24 h)

After freezing, the samples were transferred to different chest freezers at the desired temperatures (-5 °C, -12 °C, -20 °C). The samples treated by a fluctuated temperature were moved from the -5 °C freezer to the -20 °C freezer every 48 h.

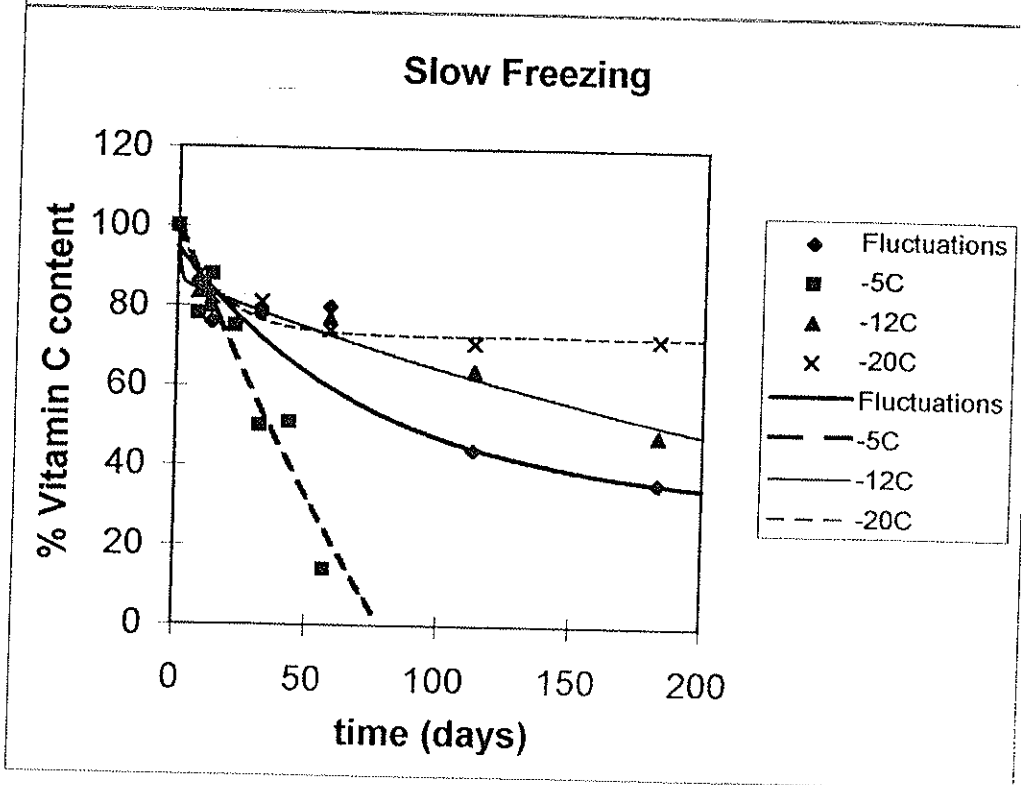
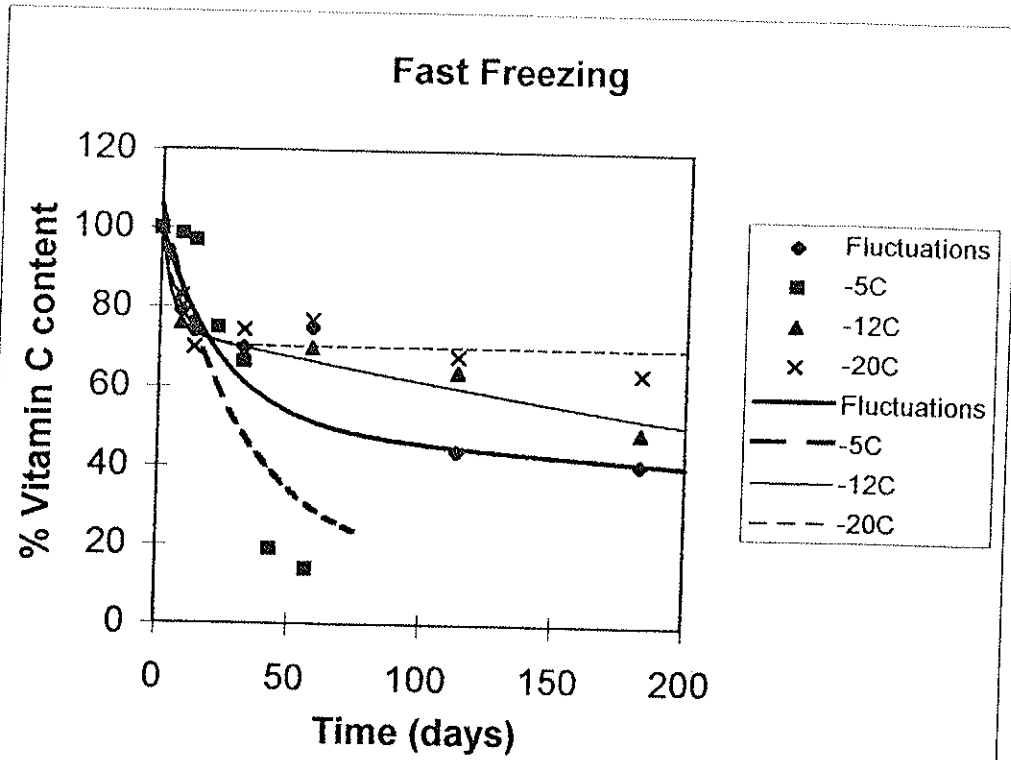
Thawing Methods

- Water immersion at 0 °C (in a ice/water bath) for 1.5 h

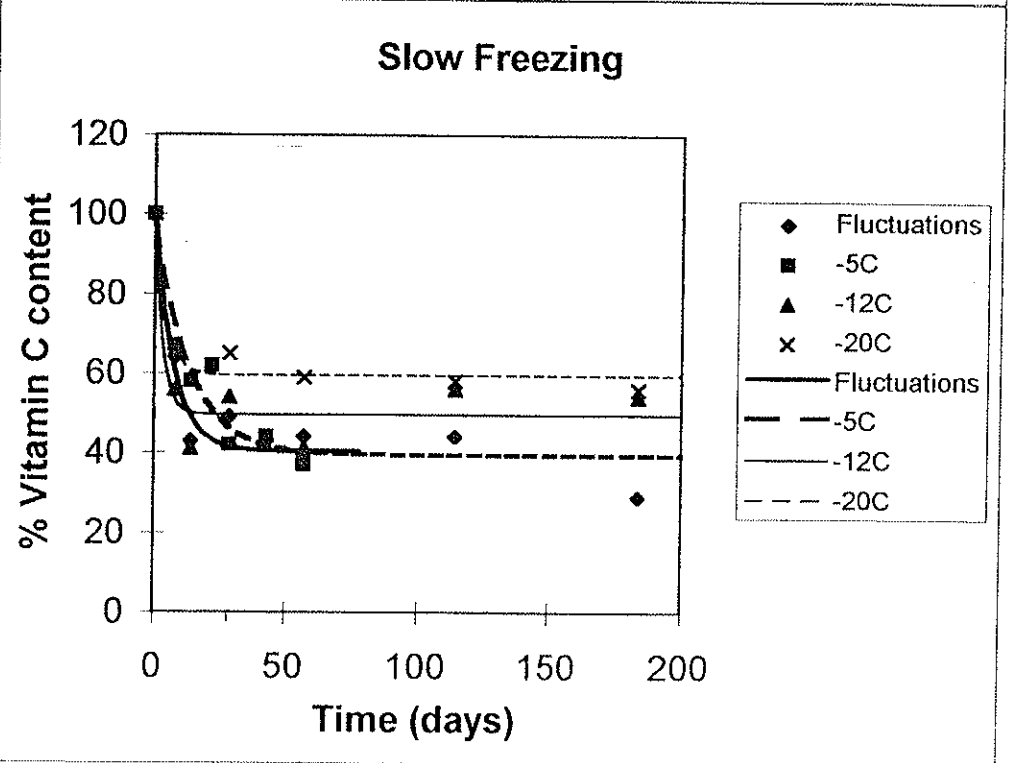
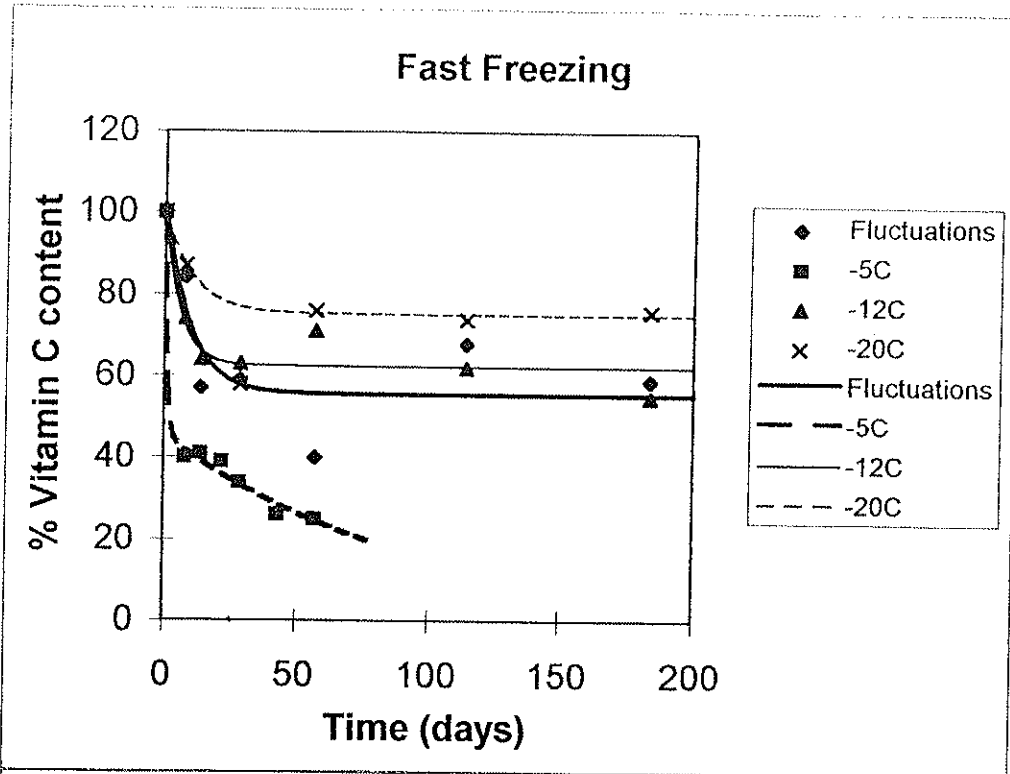
AA loss over time for Spinach



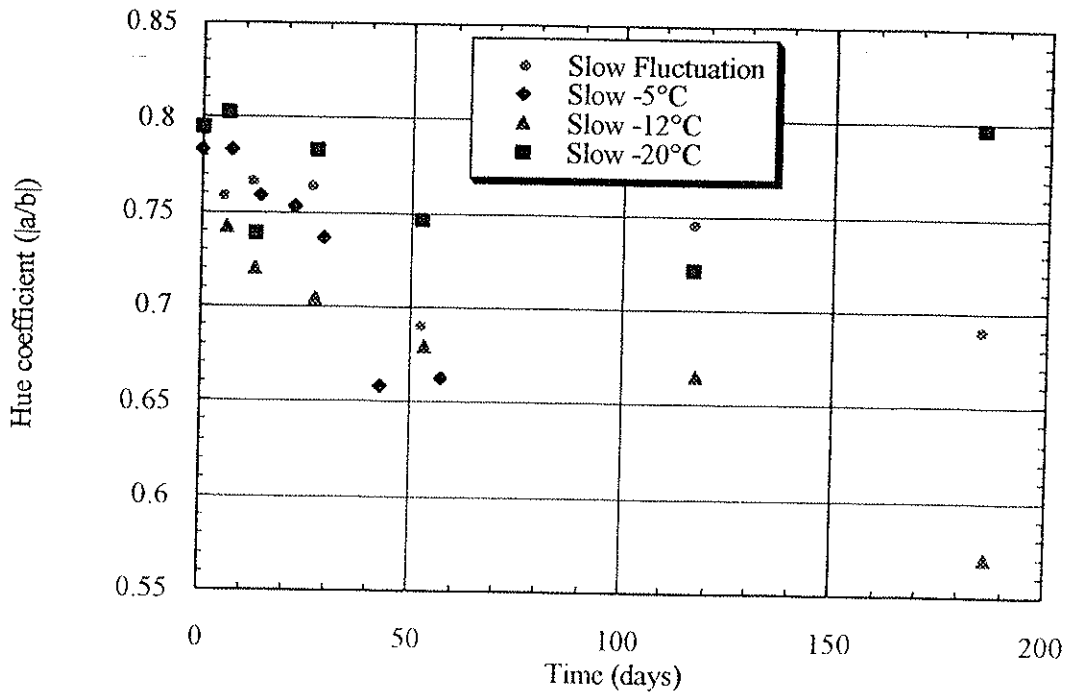
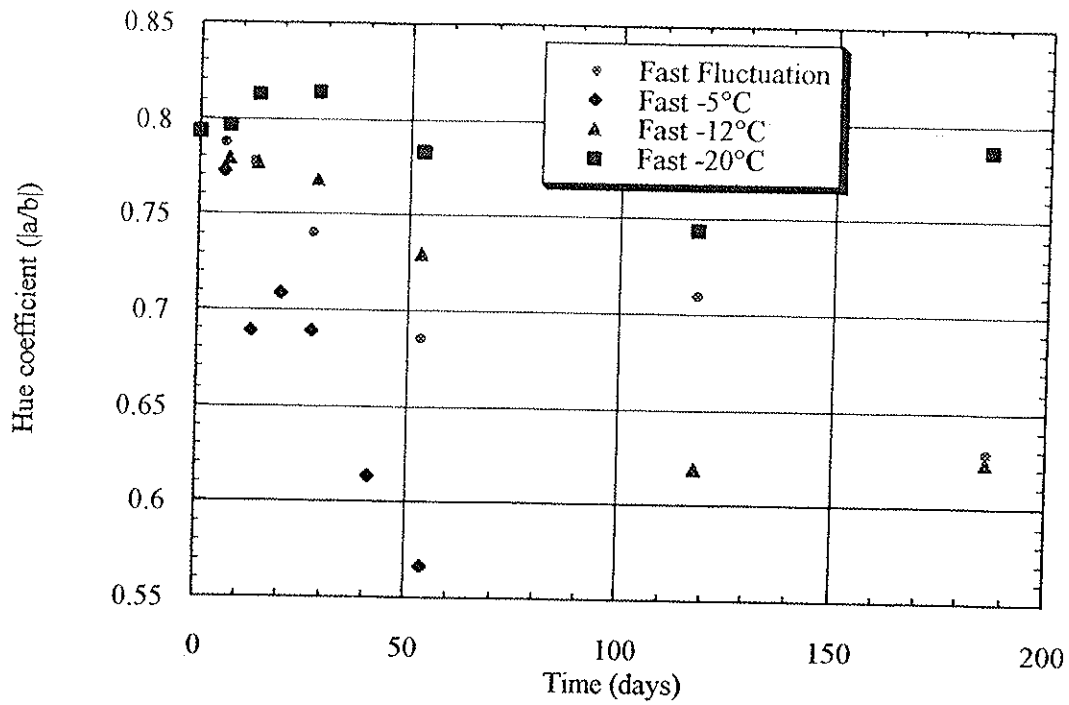
AA loss over time for Lemon Juice



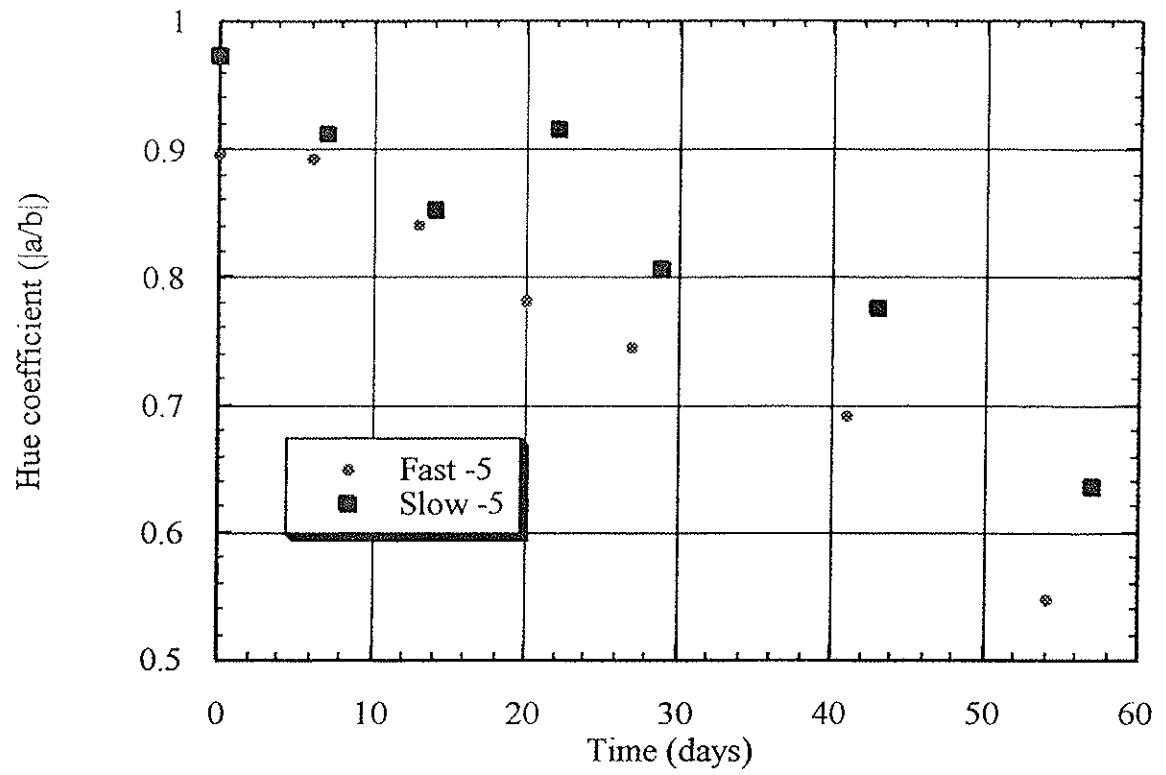
AA loss over time for Strawberries



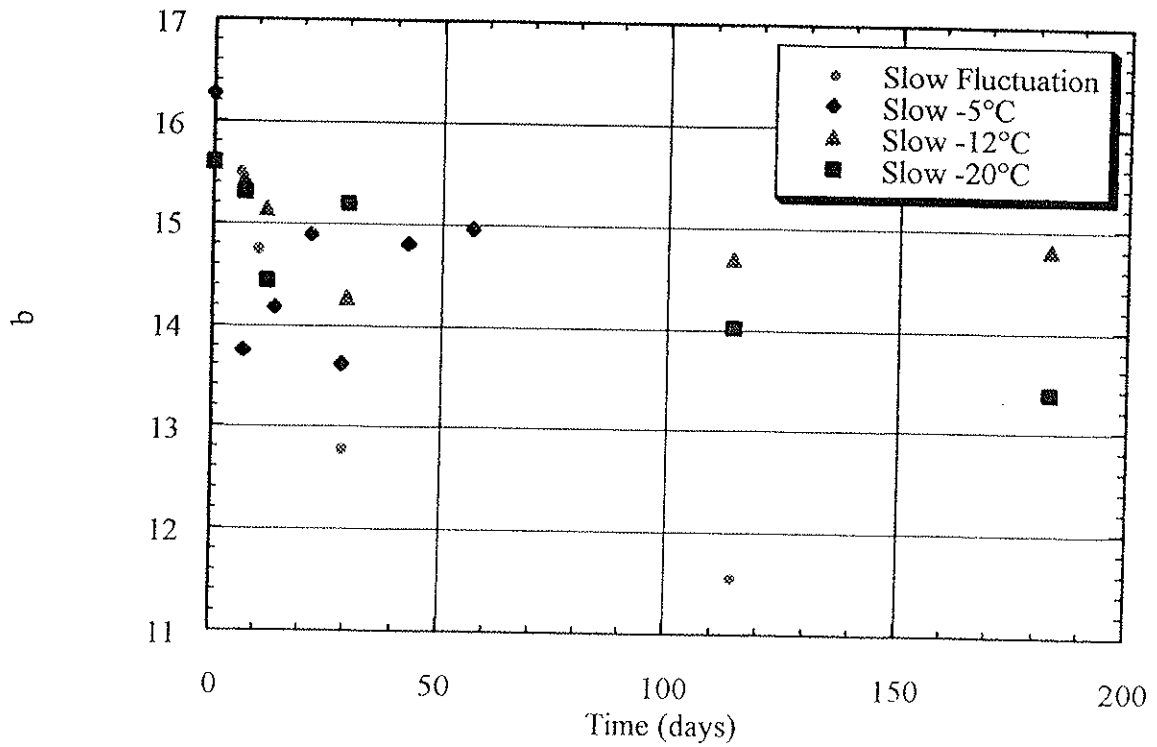
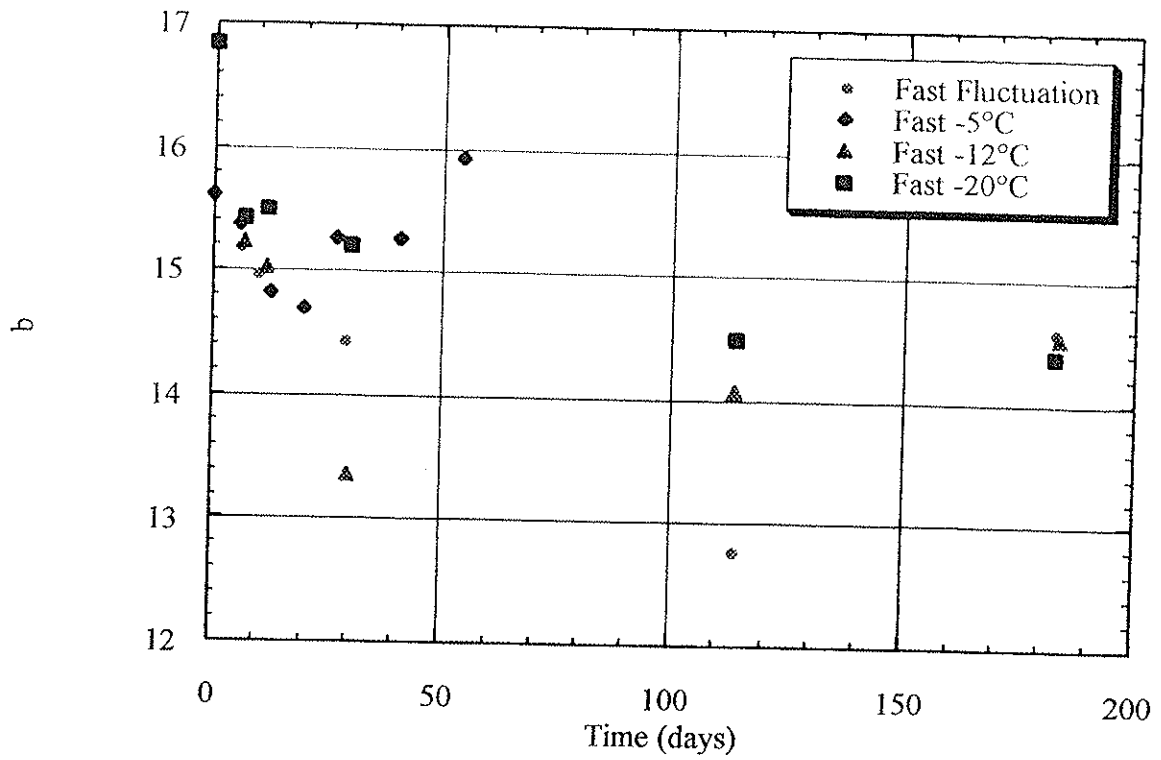
Variation of the Hue Coefficient over time for Broccoli



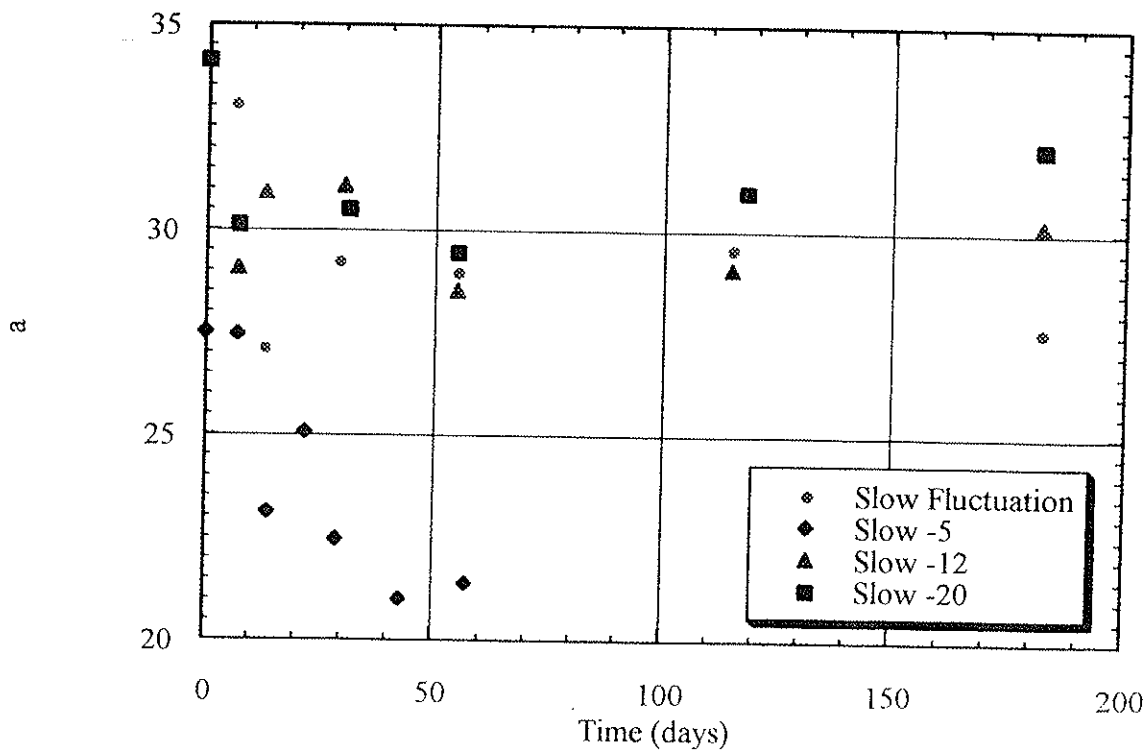
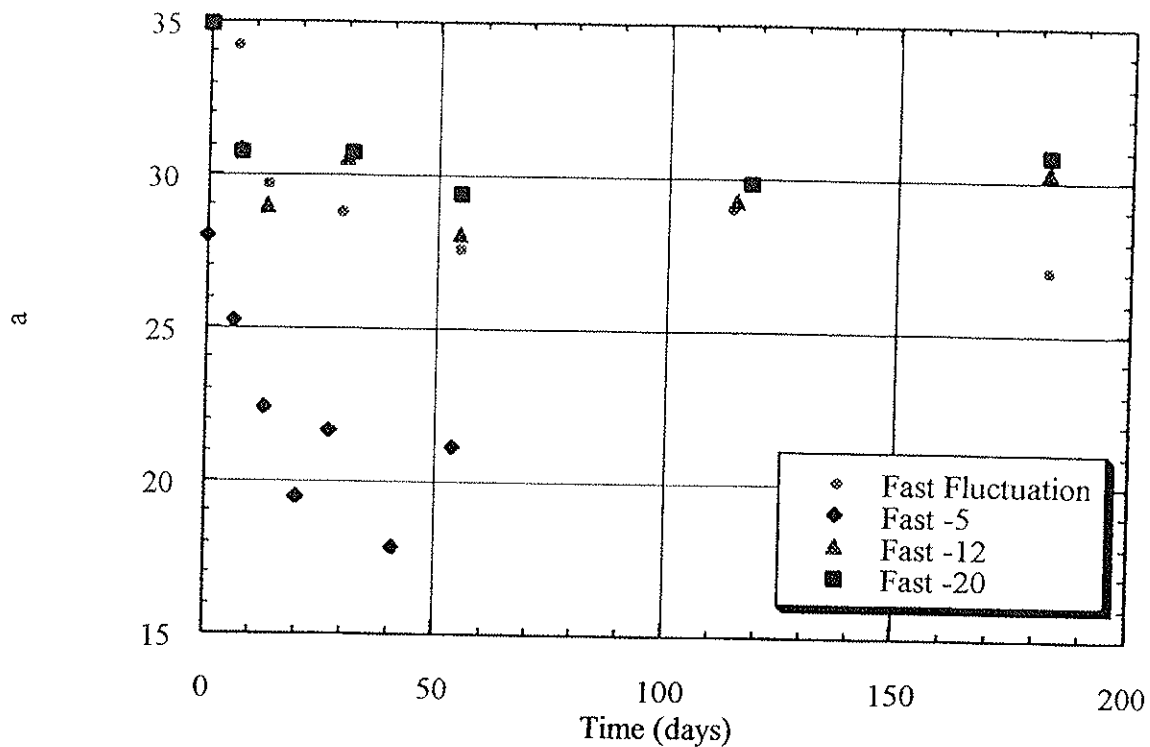
Variation of the Hue Coefficient over time for Spinach



Variation of the Hue Coefficient vs. time for Lemon Juice



Variation of the Hue Coefficient vs. time for Strawberries



RESULTS AND DISCUSSION

Vitamin C loss :

- At -5°C , for the lemon juice and vegetables studied, the amount of AA left after 2 months is small (0-20%). For strawberries, the amount is around 40%.
- If $T < -5^{\circ}\text{C}$, there is a rapid decrease in the AA content during the 1st month of storage. The amount usually stays constant afterwards at a level depending on the samples and the freezing method.
- Experiments done at fluctuating temperatures between -5°C and -20°C are generally equivalent to the experiments done at -12°C (constant storage temperature).
- The kinetic of the AA loss generally follows a mono or a two-exponential decay.
- Freezing and frozen storage produce alterations of membranes by ice crystal growth and an increase of solute concentration that leads to textural changes in fruits and vegetables. Due to the freezing and storing processes, an alteration in the arrangement of the components in a food can lead to changes in the sensory, physical and chemical characteristics of the entire food system.

Kinetics of Color Change :

Vegetables :

For the *broccoli*, the color changes are more significant at $T > -20^{\circ}\text{C}$. The rate of change is proportional to the temperature. At -5°C , the color changes are very important and rapid, but do not depend on the freezing method. For *spinach* : No significant differences on the color changes are seen between slow and fast freezing.

Generally, a relationship between time of storage and percentage of chlorophyll conversion to pheophytin is available in the literature.

Fruits :

For the *lemon juice* : the color changes depend on both the time and the temperature of storage. At -5°C , a fast color change is observed in less than 40 days. Working at lower temperatures, the values are constant even after 6 to 8 months, this being independent of the freezing method. For *strawberries* : if the temperature is cold enough, almost no color changes are observed (less than 25%) even after 8 months of storage. At -5°C , the change is very fast (about 50% in 2 months of storage).

CONCLUSION

This study was to present the influence of different parameters (storage temperature, freezing process and storage time) on the loss of color and vitamin C content in four different fruits and vegetables. It has been shown that the higher the temperature, the greater the loss. The method of freezing (slow or fast) has also an importance in the change of quality. But, the storage time seems to be more important. After one or two months of storage, depending on the product and the storage temperature, the loss of quality may be large enough to alter the overall quality of the product ; after this time, the quality does not seem to vary. This study can then be used to design a better freezing process in order to achieve an optimal quality of the product after thawing.

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