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Textural and Compositional Changes of *Asparagus* Spears During Storage at 1°C and Subsequent Senescence at 25°C

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Abstract: We held *Asparagus* (*Asparagus officinalis* L.) spears at 1°C for up to 7 and 14 days and then transferred to 25°C to examine the textural and compositional changes that occurred during low temperature storage and subsequent senescence. The preliminary objective of the study was to determine the influence of storage time on the shelf life and edible quality of *Asparagus* spears when they are transferred to a little bit high temperature to simulate retail display in the super market. A general increase in the amount of fiber of the spears along with the increase of storage time was observed. The toughness determined as the value of breaking force was higher in the bottom portion than in the top portion. The fiber content of the spears increased more when they were transferred to 25°C and the increase was maximum in the spears stored for 14 days at 1°C. There was a gradual loss in sugar content throughout the storage period and the trend of declines were more or less similar for sucrose, glucose and fructose although sucrose was found only in very low concentrations both in the top and bottom portions. The sugar loss was higher in the spears stored for 14 days. Organic acid content also decreased with the increase of storage time. Moreover, the spears stored for 7 days at 1°C remained edible up to 4 days after transferring to 25°C but those stored for 14 days remained only for 2 days which suggested to avoid long time low temperature storage of *Asparagus* before exporting or simulating retail sale.

Keywords: *Asparagus officinalis*, organic acids, storage, sugars, texture

Introduction

Asparagus spears are metabolically very active and significant changes occur in its structure and chemical composition during handling and storage, which greatly affect its edible qualities (Lill, 1980; King *et al*., 1988). Texture is intimately associated with the structural make up of *Asparagus* spears whether fresh or stored (Van Buren, 1979; Lipton, 1990), and variations in texture have a great deal to do with acceptability. During handling and storage, the changes in chemical composition like sugar and organic acid content first signal the initial stages of deterioration limiting postharvest life. Because the *Asparagus* spears obtain the sugars required for its growth from the crown and storage roots (Rabe, 1984) but this source of sugars is lost after harvest, even though the spears still require metabolic substrate to provide energy and structural components for maintaining tissue integrity.

Asparagus production is now available from many parts of the world and the market for green *Asparagus* is also expanding. But to achieve a satisfactory marketting, spears must remain in good condition for up to certain period and have at least some days shelf life after storage to simulate retail display. Lill *et al*. (1990) reported that stored *Asparagus* had a shorter shelf life after a simulated transit period than freshly cut spears and advised not to store *Asparagus* before exporting. Rapid deterioration after storage has been the major problem limiting export and retail display or sale in the super market. A better understanding of the processes of deterioration is therefore needed before significant progress can be made in achieving good shelf life after long term storage. Although much research have been done to extend the shelf life of *Asparagus*, there are very few reports regarding the changes that occur during low temperature storage and subsequent senescence to simulate retail display in the super market. Considering the above facts we studied the textural and compositional changes of *Asparagus* spears during low temperature storage and subsequent senescence to have a thorough knowledge of the nature and extent of changes taking place between the time of harvest and the time of consumer utilization.

Materials and Methods

Plant material and storage: Green *Asparagus* spears (*Asparagus officinalis* L. cv. Welcome) harvested from a commercial crop in Miki-cho, Ikenobe, Kagawa, Japan were obtained directly from a packing house. The cultivar 'Welcome' was selected due to its adaption to moderate cooler condition and availabilty throughout the country. Spears were hand harvested and trimmed to approximately 25 cm length. The spears which were straight, undamaged, with closed bracts and with no obvious signs of disease were put in plastic bags and held at 1°C for 7 and 14 days. Afterwards they were transferred to 25°C to simulate retail display. At harvest (0 day), 7th and 14th day and subsequent 24 h intervals the spears were weighed and breaking force in creep meter were measured. For sugar and organic acid measurement spears were frozen at -30°C after the designated time. Mold appeared on the spears on the 5th day and 3rd day after transferring to 25°C for 7 and 14 days storage respectively, and consequently, they were discarded.

Texture measurement: Texture was measured rheologically based on the measurement of resistant to pressure or shearing. Breaking force to indicate the fiber content in spears was determined with a creep meter YAMADEN RHEONER RE-3305 equipped with a software Ver. 2.0 for automatic analysis. The thickness of the blade was 0.04 mm and it sheared at the rate of 1 mm per second with a pressure of 20 kg. Spears were cut into two equal pieces and breaking force readings were made separately in the mid point of top and bottom portions of the spears.

Determination of sucrose, glucose and fructose contents by high performance liquid chromatography(HPLC): About 7.5 g of *Asparagus* sample (for each portion) was mixed with 1 g sea sand and homogenized in a cooled mortar and pestle. Twenty five ml of distilled water was added to the homogenate and centrifuged at 11000 x g for 10 min. The mixture was filtered through a cellulose nitrate membrane filter (0.45 µm pore size). Soluble sugars were analyzed by HPLC using a stainless steel column (10.7 mm ID x 30 cm) packed with silica gel (gel pack C610). The mobile phase (filtered water) was pumped through the column at a flow rate of 1.0 ml/min. The pressure was adjusted to 14-15 kg/cm² and the temperature to 60°C. ARI monitor (Hitachi L-3300) was used. Sucrose, glucose and fructose were identified by their retention times and were quantified according to standards.

Determination of organic acids by High Performance Liquid Chromatography (HPLC): About 5 g of *Asparagus* sample (for each portion) was mixed with 1 g sea sand and homogenized in a cooled mortar and pestle. Ten ml of distilled water was added to the homogenate and centrifuged at 11000 x g for 10 min. The mixture was filtered through a cellulose nitrate membrane filter (0.45 μm pore size). Organic acids were analyzed by HPLC using a stainless steel column (10.7 mm ID x 30 cm) packed with silica gel (gel pack GL-C610H-S). The mobile phase was 0.1% phosphoric acid adjusted to the flow rate of 0.5 ml/min. The pressure was adjusted to 15-19 kgf/cm² and the column temperature was ambient. The ultraviolet detector was set at 210 nm. ARI monitor (Hitachi L-3300) was used. Citric, malic and oxalic acids were identified by their retention times and were quantified according to standards.

Statistics: A randomized complete block design was adopted with three replications. The level of significance was calculated from the F value of ANOVA.

Results

Weight loss: The percent weight loss of *Asparagus* spears during storage is presented in Fig. 1. The weight losses were especially pronounced after transferring the spears at 25°C and it was maximum in case of 14 days stored sample. During storage at 1°C, however, the spears lost weight slowly for upto 7 and 14 days than those of 25°C.

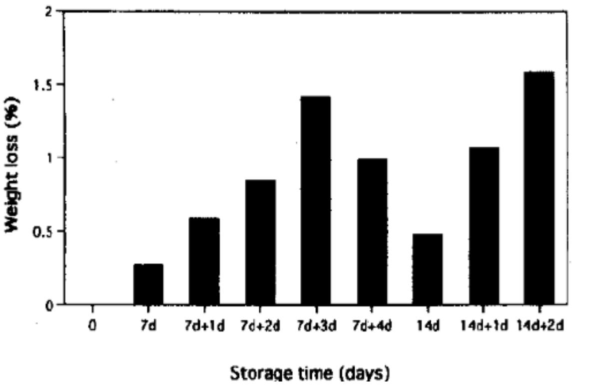

Fig. 1: Weight loss (%) of *Asparagus* spears during storage at 1°C for 7 and 14 days and subsequent transfer at 25°C. Weight loss was measured together for all spears

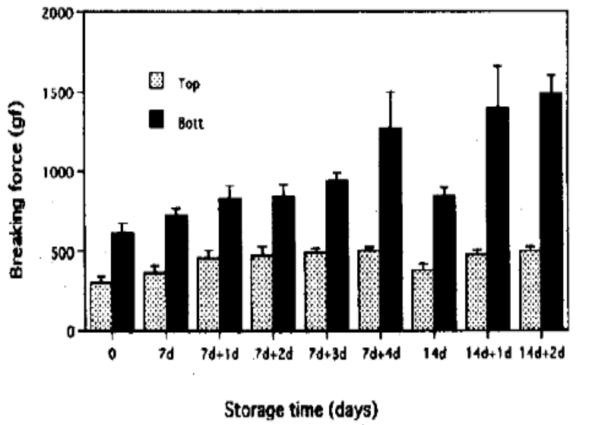

Fig. 2: Changes in breaking force to shear *Asparagus* spears in a tenderometer (YAMADEN RHEONER 3305) during storage at 1°C for 7 and 14 days and subsequent transfer at 25°C. Vertical bars ndicate SE

Textural changes: A general increase in fiber content of spears was observed at all storage conditions but the greatest increase was found after transferring to 25°C (Fig. 2). In the top portion of spears the breaking force was lesser and the rate of increase was slower than in the bottom portion. The rate of increase in fiber content remained more or less constant at 1°C both in the top and botom portions, but it increased when transferred to 25°C and the rate of increase was higher in bottom portion.

Changes in sugar content: Fig. 3 shows the changes in soluble sugar content in the top and bottom portions of *Asparagus* spears during storage. There was a gradual loss in sugar content throughout the storage period and the pattern of declines were more or less similar for sucrose, glucose and fructose although sucrose was found only in a very low concentrations both in the top and bottom portions. The decline was slightly higher in the top portion of the spears than that in the bottom portion. The sugar loss was higher in the spears stored for 14 days, especially when they were transferred at 25°C. Among the three sugars, the level of fructose always remained higher than that of glucose and sucrose, in the top as well as bottom portions.

Changes in organic acid content: Malic and citric acid concentrations remained almost constant at 1°C for both 7 and 14 days but decreased when transferred to 25°C (Fig. 4). The rate of decrease was higher in the spears stored for 14 days. Oxalic acid content followed more or less the same pattern but it was found in very low quantity. In the top portion malic acid content was lower than the bottom portion and the rate of decrease was also slow. On the other hand citric and oxalic acid content were higher in the top portion than the bottom portion and the rate of decrease was more pronounced.

Discussion

Stored *Asparagus* had a shorter shelf life and significant changes occurred in its structure and chemical composition affecting its edible qualities. The principal changes that we observed include weight loss, fiber content, soluble sugar content and organic acid content. *Asparagus* spears stored at 1°C lost weight slowly for up to 7 and 14 days but the weight loss was pronounced after transferring the spears to 25°C. The large weight loss from spears stored for 14 days is considered to be due to moisture loss and loss in reducing substances. Maintaining higher humidity in the store can minimize the weight loss to some extent but for long term storage before exporting or retail display it is not effective. Since fibrousness of *Asparagus* is the most important factor determining edible quality, any change in the fiber content due to storage conditions is of interest. We measured the fiber content rheologically based on the measurement of resistant (breaking force) to shearing considering that the increase in breaking force was related to the progressive lignification of the vascular elements as shown by Bisson *et al.* (1926). It was found (Fig. 2) that during the storage period represented in this experiment, the fiber content increased gradually with time after transferring the spears to 25°C. The increase in fiber content might be due to the higher activity of the enzymes involved in lignification enhancing lignification of the spears in both fiber ring and vascular bundles (Hennion *et al.*, 1992). In the top portion of spears the breaking force was lesser and the rate of increase was slower than in the bottom portion. It might be due to the heterogeneity of the tissues in top and bottom portions (Lill *et al.*, 1990).

Large changes in composition also occurred over the storage period. Soluble sugars decline substantially during the storage period (Fig. 3). This decline was more in top than in bottom portions. The sugar loss was higher in the spears stored for 14 days, especially when they were transferred to 25°C. Among the three sugars the level of fructose always remained higher than that of glucose and sucrose, in the top as well as bottom portions. The loss of sugar during storage is probably due to its transformation to cell wall material, mainly lignin and other structural substances. Organic acids were also found to decrease

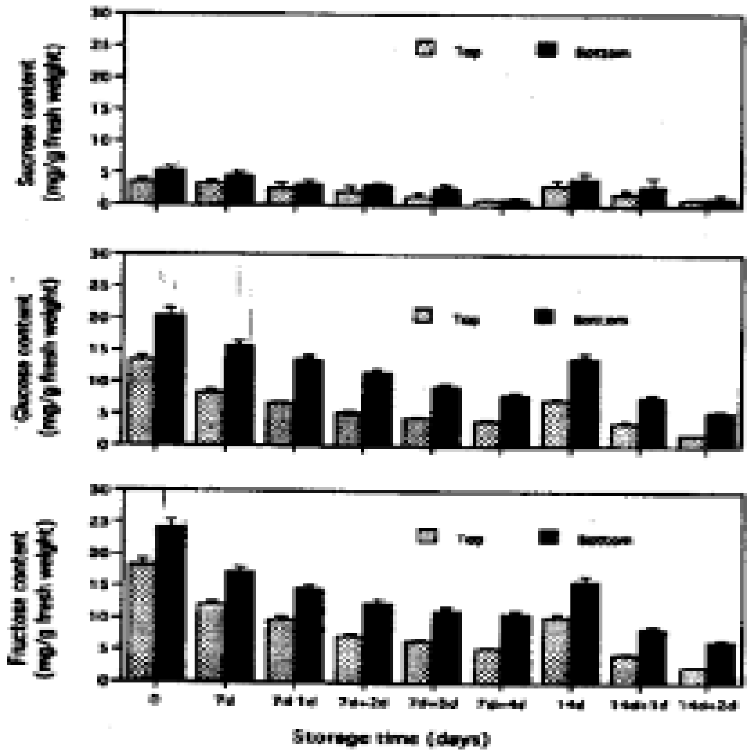

Fig. 3: Changes in sugar content in the top and bottom portions of *Asparagus* spears during storage at 1°C for 7 and 14 days and subssequent transfer at 25°C. Vertical bars indicate SE

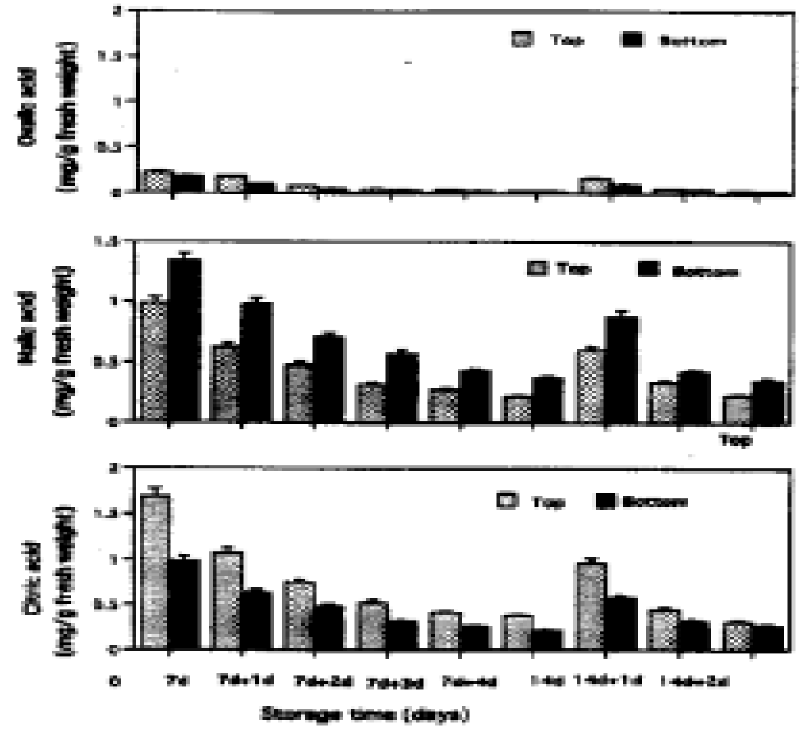

Fig. 4: Changes in organic acid content in the top and bottom portions of *Asparagus* spears during storage at 1°C for 7 and 14 days and subsequent transfer at 25°C. Vertical bars indicate SE

during the storage period (Fig. 4). In the top portion malic acid content was lower than the bottom portion and the rate of decrease was also slow . On the other hand citric and oxalic acid content were higher in the top portion than the bottom, and the rate of decrease was more pronounced. The changes in organic acid content might be due to the changes in metabolism in response of substrate depletion.

It appears from our results that stored *Asparagus* had a shorter shelf life after transferring it to high temperature, 25°C. There is progressive deterioration as shown in the reduction of sugars and organic acids, and increase in fiber content. Therefore, it is desirable that the product should reach the consumer in the shortest possible time and if possible *Asparagus* should not be stored for long time before exporting or simulating retail sale.

Acknowledgments

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