Jerusalem Artichoke

Stanley J. Kays
The University of Georgia, Department of Horticulture
Athens, Georgia

Scientific Name and Introduction: *Helianthus tuberosus* L., the Jerusalem artichoke, is a perennial of the Asteraceae family (Compositae) that is grown as an annual. The tops die in the early Winter at which time the tubers are harvested. There are many cultivars and the cultivar selected depends upon the production location. Commercial production in the U.S. is limited and found mostly in the northeast and north central States and California. In the deep south, soilborne diseases largely prevent commercial production (McCarter and Kays, 1984).

Interest in the crop has stemmed from the fact that the storage form of carbon in the Jerusalem artichoke is inulin, a straight chain fructan that is poorly digested by humans. Inulin can be used as a bulking agent in foods when sugar is replaced with an artificial sweetener. The volume previously occupied by sugar is replaced by the low calorie inulin, allowing the total caloric content of the processed product to be greatly reduced. With little reformulation, inulin, though not sweet, functions similar to sugar, ie., browning reactions, aroma synthesis, textural properties, in many foods. Likewise, inulin, whether ingested as Jerusalem artichoke tubers or as a bulking agent, is a dietary fiber and confers a number of health advantages, eg., lowers blood cholesterol level; promotes *Bifido* bacteria in the large intestine; reduces blood sugar level, low density lipoproteins, and triglycerides; and is beneficial to help in preventing certain heart diseases (Varlamova et al., 1996).

Quality Characteristics and Criteria: Tuber size and shape are critical quality attributes and are strongly modulated by cultivar and production conditions. Many clones have an irregular tuber surface topography due to branching, an undesirable trait.

Horticultural Maturity Indices: The tubers are harvested in the late Fall, generally after the first frost. In production areas where harvest can be accomplished throughout Winter (see below), the crop can be field-stored and harvested as needed. Elsewhere, harvest is followed by cold storage.

Grades, Sizes, and Packaging: There are no existing standard grades. Generally larger tubers with smooth surfaces are preferred. Polyethylene bags are the typical package, though precise recommendations are not established. Package physical parameters vary with storage temperature, product volume, and other factors.

Pre-cooling Conditions: Generally pre-cooling is not required, though placing the tubers under favorable low temperature conditions as soon as possible after harvest is recommended.

Storage Options: The three primary storage options are refrigerated storage, common storage in root cellars, and *in situ* field storage. In common storage in root cellars, champs or pits, cooling is obtained from the natural low temperatures of the outdoor air and/or soil (Shoemaker, 1927). In the first two options (refrigerated and common storage), tubers are harvested in the Fall and placed in storage. With field storage, however, tubers are left in the ground and harvested as needed. Cold storage is highly effective, but costly. Regardless, refrigerated storage is routinely used for seed and fresh market tubers, especially in situations where field storage is not a viable alternative. Root cellars, champs, and pits are used when the tubers must be harvested in the Fall, prior to the ground freezing or other adverse conditions occurring, and refrigeration is not available or prohibitively expense.

The selection of *in situ* field storage is dependant upon several factors. Location is the primary determinant in the potential success of *in situ* field storage. Field storage is a viable option in northern hemisphere production areas where cold soil temperatures prevail throughout the Winter, but freezing of the soil surface is uncommon. Sandy, well-drained soils are preferred because they allow harvest throughout the Winter. Locations that do not meet these criteria generally require the use of refrigerated or some form of common storage.

Optimum Storage Conditions: Tubers can be stored for 6 to 12 mo at 0 to 2 °C (32 to 34 °F) and 90 to 95% RH. Some cultivars are much more susceptible to storage losses than others (Steinbauer, 1932). Tubers shrivel readily at low RH and are more likely to decay.

Controlled Atmosphere (CA) Considerations: The benefit of CA storage has not been adequately assessed. Storage of tubers in 22.5% CO_2 + 20% O_2, significantly retarded the rate of inulin degradation, apparently through an effect on enzyme activity (Denny et al., 1944).

Retail Outlet Display Considerations: Water loss accounts for the majority of postharvest losses during retail sales. Product should be displayed in refrigerated display cases and when not packaged, under high RH conditions such as that afforded by mist systems.

Chilling Sensitivity: Tubers can withstand low temperatures without damage, but freeze at -2.2 °C (28 °F) (Whiteman, 1957). Freezing at -10 °C (14 °F), whether in the field or storage, causes rapid deterioration, but nonlethal freezing at -5 °C (23 °F) causes little damage. As with most fleshy plant products, temperature at which freezing damage occurs and extent of damage varies with cultivar, season, preconditioning, rate of freezing, and other factors (Kays, 1997).

Ethylene Production and Sensitivity: Tubers are not sensitive to ethylene.

Respiration Rates:

Temperature	mg CO_2 kg^{-1} h^{-1}	Rate of dry mater loss (g kg^{-1} day^{-1})
0 °C	10.2	0.162
5 °C	12.3	0.201
10 °C	19.4	0.317
20 °C	49.5	0.801

To get mL kg^{-1} h^{-1}, divide the mg kg^{-1} h^{-1} rate by 2.0 at 0 °C (32 °F), 1.9 at 10 °C (50 °F), and 1.8 at 20 °C (68 °F). To calculate heat production, multiply mg kg^{-1} h^{-1} by 220 to get BTU per ton per day or by 61 to get kcal per metric ton per day. Data are from Peiris et al. (1997).

Physiological Disorders: Storage losses are due primarily to desiccation, rotting, sprouting, freezing, and inulin degradation. Desiccation remains a significant storage problem even though losses can be fairly easily circumvented with proper storage conditions. Storage at high RH is essential (Shoemaker, 1927; Steinbauer, 1932) because tubers lack of a corky surface layer similar to that found on potatoes to reduce water loss, and have a thin, easily damaged surface that permits rapid water loss. While beneficial for some produce (Kays, 1997), γ-irradiation greatly accelerates inulin degradation (Salunkhe, 1959) and is of little storage value.

Postharvest Pathology: Storage rots are a serious problem (Barloy, 1988; McCarter and Kays, 1984); higher storage temperatures result in greater loss. Approximately 20 organisms causing storage rots have been isolated from Jerusalem artichoke tubers. The organisms most frequently isolated were *Botrytis cinerea* Pers. and *Rhizopus stolonifer* (Ehrenb.: Fr.) Vuill., though *R. stolonifer* and *Sclerotinia sclerotiorum* (Lib.) de Bary are the most serious organisms causing rots at low storage temperatures. *Sclerotium rolfsii* Sacc. and *Erwinia carotovora* spp. *carotovora* (Jones) Bergey et al., in contrast, are not significant pathogens at temperatures below 20 °C (68 °F). Storage rots are controlled by storage at 0 to 2 °C (32 to 34 °F), removal of diseased tubers, minimizing mechanical damage, and proper RH control.

Quarantine Issues: None.

Special Considerations: During storage, tubers undergo significant alterations in carbohydrate chemistry which, depending upon the intended use, can have a pronounced effect on quality. Inulin is not one compound, but a series of molecules of varying chain length that begin to depolymerize during storage (Jefford and Edelman, 1963; Schorr-Galindo and Guiraud, 1997), whether harvested or left *in situ*. The degree of polymerization is critical for uses such as fat replacement or high fructose syrups. With the former, as the chain length decreases, the ability of inulin to mimic a lipid diminishes. Likewise, with progressive depolymerization, the ratio of fructose:glucose decreases and upon hydrolysis yields a progressively less pure fructose syrup. For example, during Winter storage the fructose:glucose ratio decreases from 11 to 3 (Schorr-Galindo and Guiraud, 1997). Thus, syrups derived from stored tubers contain a lot more glucose.

References:

Barloy, J. 1988. Jerusalem artichoke tuber diseases during storage. In: Topinambour (Jerusalem artichoke). Proc. Wkshp., Comm. Eur. Communities. G. Grassi and G. Gosse (eds) Madrid. pp. 145-149.

Denny, F.E., N.C. Thornton and E.M. Schroeder. 1944. The effect of carbon dioxide upon the changes in the sugar content of certain vegetables in cold storage. Cont. Boyce Thompson Inst. 13:295-311.

Jefford, T.G. and J. Edelman. 1963. The metabolism of fructose polymers in plants. II. Effect of temperature on the carbohydrate changes and morphology of stored tubers of *Helianthus tuberosus* L. J. Exp. Bot. 14:56-62.

Kays, S.J. 1997. Postharvest Physiology of Perishable Plant Products. Exon Press, Athens GA, 532 pp.

McCarter, S.M. and S.J. Kays. 1984. Diseases limiting production of Jerusalem artichokes in Georgia. Plant Dis. 64:299-302.

Peiris, K.J.S., J.L. Mallon, and S.J. Kays. 1997. Respiratory rate and vital heat of some specialty vegetables at various storage temperatures. HortTechnology 7:46-48.

Salunkhe, D.K. 1959. Physiological and biochemical effects of gamma radiation on tubers of Jerusalem artichoke. Bot. Gaz. 120:180-183.

Schorr-Galindo, S. and J.P. Guiraud. 1997. Sugar potential of different Jerusalem artichoke cultivars according to harvest. Biores. Tech. 60:15-20.

Shoemaker, D.N. 1927. The Jerusalem artichoke as a crop plant. USDA Tech. Bull. No. 33, 32 pp.

Steinbauer, C.E. 1932. Effects of temperature and humidity upon length of rest period of tubers of Jerusalem artichoke (*Helianthus tuberosus*). Proc. Amer. Soc. Hort. Sci. 29:403-408.

Varlamova, C., E. Partskhaladze, V. Oldhamovsky, and E. Danilova. 1996. Potential uses of Jerusalem artichoke tuber concentrates as food additives and prophylactics. In: 6th Symp. Inulin, Carbohydrate Res. Found., The Hague, The Netherlands, pp. 141-144.

Whiteman, T.M. 1957. Freezing points of fruits and vegetables. USDA Mkt. Res. Rpt. No. 196, 32 pp.