INT. J. BIOL. BIOTECH., 2 (3): 511-515, 2005.

EXPLORING EXPORT POTENTIAL THROUGH SCIENTIFIC STORAGE OF CITRUS FRUITS AND USE OF GAMMA IRRADIATION TO OBTAIN SEEDLESS KINNO (*CITRUS RETICULATA* BLANCO)

Tahir Ali

Department of Commerce, Faculty of Business Administration and Commerce, University of Karachi, Karachi-75270, Pakistan

ABSTRACT

Agriculture is the lynchpin of Pakistan's economy and any improvement in this sector will lead to socio-economic development of the country. Besides major crops, Kinno mandarin has high demand in the international market. With almost stagnant production of citrus fruits for the last five years, insufficient and unscientific storage facilities and large number of seeds are some of the hot issues in this industry. Scientific storage i.e. proper adjustment of temperature, relative humidity, time duration etc. may help reduce the huge post-harvest losses in citrus fruits. In addition, Pakistani exporters have been facing the problem of large number of seeds in kinno mandarin. The Nuclear Institute for Agriculture and Biology (NIAB) claims that they have developed seedless kinno mutant through radiation. Overcoming these problems will open a new era in domestic and international marketing of citrus fruits in Pakistan.

Key-words: Citrus fruits, storage, gamma radiation, seedless kinno

INTRODUCTION

Citrus has a long history in the subcontinent region. In 1936 different varieties of citrus fruits were obtained from the leading citrus producing countries and were experimented in order to find out the most suitable varieties for cultivation in the region now included in Pakistan. At present around 34 % of the total orchard area in Pakistan and 60 % of the Punjab are reserved for citrus cultivation (Aslam, 1998) Citrus fruits contribute around 35 percent of the total fruit production of the country. The citrus industry in Pakistan has been facing two main problems for decades. These are high post-harvest losses, mainly due to insufficient and unscientific storage facilities and large number of seeds, especially in kinno mandarin.

The average annual production of citrus fruits in Pakistan has been, around 1.8 million tons for the last five years ending 2004. The peak picking season of citrus fruits in Pakistan generally starts from December throughout February. Harvested citrus is immediately transferred to all fruit markets of the country. It is manifest that rate of picking is much higher than that of consumption and therefore large quantity of citrus fruits require adequate storage. It is estimated that around 50 percent of the total production of citrus fruits requires proper storage during the peak season time. The storage facilities available in Pakistan for fresh fruits and vegetables are not only insufficient but most of them are technologically obsolete (i.e. factors like temperature, relative humidity, time duration are usually neglected). This results in high post-harvest losses of citrus fruits. Fruits and vegetables are highly perishable commodities. Their quality begins to deteriorate from the moment of harvest and continues throughout marketing process. It is estimated that up to 10 percent of the value of fresh fruits and vegetables is lost in the marketing process. This is due to improper storage and handling, spoilage, trimming to improve appearance, careless handling by shoppers and theft. (Richard *et al.*, 1990). Because of inadequate and unscientific storage facilities for fruits and vegetables, this percentage usually goes upto 40 to 45% in Pakistan.

The physical and nutritional characteristics of citrus fruits, especially kinno mandarin, produced in Pakistan are unique. Besides attractive appearance, large size and high percentage of juice, the proportion of vitamin C, minerals and other nutritional ingredients of Pakistani kinno mandarin are not only comparable but in many cases better than that of citrus produced in other parts of the world. However the biggest drawback in the kinno produced in Pakistan is the large number of seeds, which usually ranges from 20 to 24 per fruit. Efforts are underway to produce seedless kinno but commercialization of this still needs more attention.

Storage of citrus fruits

Storage has always been considered a key element of distribution strategy. Adequate storage facilities not only preserve product for future sale but also stabilizes prices by regulating demand and supply positions in the market. Production of most of the agricultural and horticultural products is seasonal, whilst consumption is throughout the year. Furthermore fruits, especially citrus, are more sensitive and perishable than many other agricultural products, therefore adequate scientific storage facilities are imperative. In the leading citrus producing countries (USA, Brazil,

China etc.) the bulk of citrus crop is transferred to packinghouse and processing units, concentrated juice, stored in large tanks is usually more readily available than fresh citrus fruits. However in the countries where major portion of domestic consumption and export of citrus fruits is in fresh state (like Spain, Mexico etc.) storage of citrus fruits, usually orange and grapefruit is done in a systematic and scientific manner. Keeping fruit in storage house may not fulfill effective storage function unless adequate technology is applied. Effective storage function demands adequate knowledge about some biological and technical aspects of scientific storage of fruits and vegetables.

Biological and chemical features

Fruits contain living tissues and are therefore usually considered as living organisms, even after picking. The respiration of these tissues generates heat, consumes oxygen and gives off carbon dioxide. During storage, some of the fruits and vegetables produce volatile substances, which may be harmful to other products. Furthermore, chemical and biological characteristics of fruits and vegetables usually vary from one another and consequently require different storage conditions like temperature, humidity etc. It is therefore usually advised that fruits having different biological characteristics should not be stored together under same conditions. For instance, apple gives off ethylene and other volatiles that may cause spotting in potatoes and tainting in other commodities. Table-1 indicates temperature required for storage of some selected fruits. However if two commodities, requiring different temperatures have to be stored at one place, it is safer to adjust the temperature and other conditions in accordance with the commodity requiring higher temperature. Adjustment of temperature in this way at least prevents low temperature injury losses. Such losses are generally caused by storing the fruit below freezing point which cools the tissues of fruits and creates Chilling - a metabolic disturbance. Usually lemon and lime, kinno and orange are stored at above 10, 5 and 2 to 3 degree centigrade respectively (Anon., 1997). As low temperature injuries affect the quality of fruit substantially, it is advised that fruits requiring different temperatures should not be stored at one place.

Humidity and length of storage

Humidity and temperature are interdependent factors. Lower humidity than the desirable level (Table 1) may lose moisture by evaporation, which affects the fruit considerably. In contrast a very high relative humidity may result in deposition of moisture on fruit, which usually activates the growth of some organisms, which makes the fruit moldy and / or rots substantially. In addition, duration of storage should also be considered which generally varies from one fruit to another (Table 1). Storage of fruits for more or less time period, than required affects the quality and health of fruit considerably.

Table 1. Temperatures, Relative Humidity and Time duration for storage of some selected fruits.

Fruits	Required Temperature (F)	Relative Humidity (%)	Length of Storage (Approx.)
Apple	30.32	85.95	As per variety
Apricots	31.32	85.90	1-2 Weeks
Grapes	31.32	85.90	4 Weeks
Peaches	31.32	85.90	2 Weeks
Pears	30.31	85.90	2-3 Weeks
Plumps	31.32	85.90	1-2 Weeks
Citrus	31.30	85.85	4 Weeks

Source: Citrus Fruits Ayub Agriculture Research Institute, Faisalabad, Pakistan

Furthermore citrus fruits can also be stored at room temperature, provided they are individually sealed in either a small plastic freezer bag or a plastic sandwich bag. The storage life of plastic-wrapped citrus fruits at room temperature is given in Table 2.

It can be noted that storage life of plastic wrapped different varieties of citrus fruits at room temperature ranges from 3 weeks to 3 months. More specifically, storage life of grapefruit and lemon through plastic wrapped technique is 2 to 3 months, whilst in case of mandarin and orange it would be 2 to 6 weeks respectively.

To conclude it can be said that suitable temperature, humidity and time constitute a desirable environment for storage of specific fruits. If one of these elements is changed, the whole environment may be disturbed and adjustments to other elements may be required accordingly. In order to store fruits in their desirable environment, most of the developed countries have chamber storage system. In this technique fruits are stored in sections (chambers) with respect to their storage environment i.e. desirable temperature, humidity and time duration.

Table 2. Storage life of plastic-wrapped citrus fruits at room temperature.

Type of fruit	Variety	Storage life of plastic - wrapped fruit at room temperature
Orange	Washington Navel Valencia	6 Weeks
Grapefruit	Marsh Seedless	2 Months
Lemon	Eureka Lisbon	2 to 3 Months
Mandarin	Early imperial Dancy Ellendate Emperor	3 to 4 Weeks
Lime	------	6 to 8 Weeks

Source : SARDI Horticulture-Postharvest <www.sardi storing citrus fruits and juice.

Seedless Kinno

Kinno mandarin was discovered by H.B Frost in 1815 at the Citrus Research Center, California, USA. This variety was developed through cross between King and Willow Leaf and was named kinno in 1935 (Ahmad and Hameedullah, 1995). The shape of fruit is oblate round with deep cadmium yellow orange color and medium to large in size (60 to 120 mm). It matures in January or February and remains available throughout March.

Kinno is usually considered the best variety of citrus fruits produced in Pakistan. The pulp of kinno contains an excellent sugar acid blend. It is a prolific variety which gives around 800 fruits per tree, along with lucrative return. The production of Kinno has revolutionized the citrus industry in Pakistan by suppressing the cultivation of sweet orange and other varieties of citrus. Kinno mandarin contributes more than 60 percent of the total citrus production in Pakistan. The only defect in this variety in Pakistan has been the large number of seeds, which usually ranges between 20 to 24. Research to produce seedless kinno mandarin has been conducted at the Nuclear Institute of Agriculture and Biology (NIAB) Faisalabad, Pakistan since 1984-85. Information obtained through personal interviews with Dr. Muhammad Jamil Qureshi, Chief Scientific Officer and Mr. Abdus Sattar, Senior Technical Officer at NIAB are summarized below:

Table 3. Physical quality characteristics of Kinno parent and its seedless mutants.

Crop Year	Fruit size* (mm)	Juice yield %	Seeds / Fruit	Peel thickness(mm)
Parent (mV-0)				
1987-88	65-80 (74.0)	47-50 (48.33)	18-27 (22.56)	2.3-2.5 (2.47)
1992-93	65-81 (70.4)	47-49 (47.8)	19-27 (23.0)	2.4-2.6 (2.5)
1996-97	63-83 (71.6)	48-50 (48.2)	19-28 (22.2)	2.4-2.6 (2.5)
Mutant (mV- 1)				
1987-88	63-79 (71.56)	45-47 (45.48)	3-7 (4.67)	3.0-3.5 (3.28)
1988-89	64-80 (68.55)	44-47 (45.25)	2-8 (4.78)	3.3-3.5 (3.39)
1989-90	60-82 (71.22)	45-47 (46.11)	3-7 (5.33)	3.2-3.5 (3.26)
Mutant (mV –2)				
1992-93	65-79 (71.790	45-48 (46.21)	3-7 (5.00)	3.1-3.4 (3.20)
1993-94	63-89 (70.780	45-47 (46.40)	3-7 (4.89)	3.3-3.5 (3.34)
1994-95	63-83 (71.560	45-47 (46.11)	2-8 (5.00)	3.1-3.5 (3.23)
Mutant (mV –3)				
1996-97	65-82 (72.78)	45-48 (45.99)	3-8 (5.11)	2.9-3.5 (3.18)
1997-98	67-80 (73.670	45-47 (45.84)	3-8 (5.00)	2.9-3.2 (3.03)
1998-99	63-80 (72.22)	45-47 (46.00)	3-8 (5.44)	3.0-3.4 (3.14)

Source : The Nucleus, Pakistan Atomic Energy Commission 37 (1-2), 2000 p.109

Three consecutive crops of kinno mandarin were taken as parent for this experiment (i.e. 1987-88, 1992-93 and 1996-97, each crop of kinno requires around 3 years to bear fruit) in which the number of seeds ranges from 18 to 28 per kinno. Besides various materials and methods* applied, the base of the study was bud mutation. Dormant buds on a scion (5 buds / 12.5 cm) of kinno were subjected to Gamma irradiation at a dose rate of 370 Gy/hr, using Gamma Cell 220 (60 Co, ϒ - Source) in air medium at 25 ± 2°C. Radiation doses of 20, 40, 60, 80, and 120 Gy were administered. In each dose lot, 100 scions were irradiated and grafted on rootstock. The results were very encouraging. Sparsely seeded mutant kinno was identified from the plants generated from the buds irradiated at 20 Gy of the Gamma irradiation. The number of seeds per fruit in the mutant kinno were significantly lower (2-8) than that of parent kinno (18-20) during three consecutive crops (Sattar *et al.*, 2000).

Table 3 indicates that the quality attributes of the mutant kinno are not affected significantly because of the induction of seedlessness in kinno mandarin. The size of the mutant kinno ranges from 63-83 mm, which is almost the same as that of parent kinno. Though the juice yield of parent kinno was substantially high (47-50%) than that of mutant kinno (44.2-48.0%), this was compensated by thicker peel of mutant kinno (2.90-3.50 mm) as compared with parent kinno (2.30-2.60 mm). It is an appreciable improvement because thick peel protects and ensures fruit integrity. This not only helps in attaining quality juice but also export in fresh form.

Table 4. Chemical characteristics of Kinno parant and its seedless mutant (range and mean values).

Crop Year	TSS %	Acidity %	Vitamin C mg/100 ml juice	TSS / Acid Ratio
		Parent (mVo)		
1987-88	10.5-11.2 (11.00)	0.58-0.62 (0.59)	17.2-20.7 (19.24)	17.5-19.20 (18.58)
1992-93	10.2-11.0 (10.74)	0.57-0.62 (0.59)	19.3-20.5 (20.07)	17.7-18.9 (18.17
1996-97	10.5-11.1 (10.75)	0.58-0.61 (0.59)	19.2-21.1 (20.05)	17.8-18.9 (18.36)
		Mutant (mV1)		
1987-88	9.8-10.5 (10.23)	0.61-0.63 (0.62)	19.6-22.6 (20.45)	16.1-16.9 (16.55)
1988-89	10.0-11.2 (10.50)	0.59-0.62 (0.61)	18.7-21.4 (19.85)	16.6-18.2 (17.24)
1989-90	10.5-11.2 (10.65)	0.60-0.63 (0.61)	18.6-22.5 (20.23)	17.0-18.7 (17.63)
		Mutant (mV2)		
1992-93	10.6-11.1 (10.69)	0.60-0.63 (0.62)	19.5-21.3 (20.19)	16.8-17.5 (17.21)
1993-94	10.2-10.8 (10.58)	0.59-0.62 (0.61)	19.0-21.1 (20.05)	16.4-18.0 (17.45)
1994-95	10.3-11.0 (10.66)	0.58-0.62 (0.60)	19.2-21.4 (19.59)	17.8-19.1 (17.78)
		Mutant (mV3)		
1996-97	10.3-10.9 (10.48)	0.58-0.63 (0.60)	18.4-20.5 (19.37)	16.8-18.1 (17.51)
1997-98	10.4-10.9 (10.47)	0.59-0.62 (0.60)	18.8-21.3 (19.89)	17.2-18.1 (17.45)
1998-99	10.4-10.7 (10.63)	0.57-0.62 (0.60)	18.6-21.4 (19.99)	17.3-18.2 (17.72)

Source: The Nucleus, Pakistan Atomic Energy Commission 37 (1-2), 2000 p.111

Chemical characteristics

Analyses of fruit juices of all genotypes were made to examine changes in TSS, acidity, vitamin C and TSS: acid ratio between the parent and seedless mutant kinno mandarin. [Table-4] Although there had been insignificant change in TSS contents of the juice, the acidity of juice varied considerably. Mutant kinno mandarin were more acidic than parent (on average 59% to 60% with the highest value of 62% in the first crop). TSS acid: ratio in parent kinno was considerably higher than that of mutant, but it will increase in the successive mutant kinno. Furthermore no significant change of vitamin C had been found over the cropping years and between the genotypes.(ranged from 17.20 to 22.60 mg/100ml juice).

During the survey at NIAB it was noted that though the results of the study are promising, it still requires another 5 to 7 years to commercialize the seedless variety of kinno mandarin in Pakistan.

CONCLUSION

Scientific storage is imperative for citrus fruits to avoid huge losses and effectively fulfill domestic and international demands. Organoleptic quality of fruit i.e. size, appearance, color and taste & flavor of juice did not change considerably between the parent kinno and its mutant during the experiment to obtain seedless kinno. Considering the promising results of induction of seedlessness in kinno mandarin at NIAB, special attention in this connection will help achieving far reaching benefits.

REFERENCE

Sattar,, A., W. A. Farooqi, M. Ahmad and M. J. Querashi (2000). Induction of Seedlessness in Kinno (*Citrus reticulata* Blanco) with gamma radiation. *The Nucleus, Pakistan Atomic Energy Commission, Nuclear Institute of Agriculture and Biology (NIAB), Faisalabad, Pakistan Issue* 37: 107.

Aslam, A. R. (1998). A Review on citriculture in Pakistan, *Citrus Fruits.* The United Nation Development Program, The Horticultural Foundation of Pakistan, 3.

Anonymous (1997). *Citrus Fruits - Post-harvest Technology*. Post-harvest Research Center, Ayub Agriculture Research Centre, Faisalabad, Pakistan

Richard, L., K., Josep and N. Uhl (1990). *Marketing of Agricultural Products*. Macmillan Publishing Company ed 7th, NY.

Anmed, N. and Hamedullah (1995). *Suggested Varieties of Citrus Fruits.* Agriculture Information Bureau, Government of Punjab, Lahore Pakistan.

(*Accepted for publication May 2005*)