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Emerging vistas in post harvest paradigm of guava

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Abstract

Guava (*Psidium guajava* L.), a common man's fruit commonly called the "apple of the tropics" is cultivated or grown wild throughout the tropical and subtropical regions of the world. India's output of guava increased from 10.15 lakh tonnes in 1989-90 to 16.85 lakh tonnes in 2004–05. The area rose from 1.03 lakh ha. to 1.62 lakh ha. with a yield of 11.10 t ha^{-1}. Guava is one of the richest sources of vitamin C (200 to 400 mg per 100g fresh weight) and some cultivars are also rich in vitamin A. Guava fruit consists of about 20% peel, 50% fleshy portion, and 30% seed core. It contains 74-87 % moisture, 13-26% dry matter, 0.8-1.5% proteins, 0.4-0.7% fat, and 0.5-1.0 % ash. It is one of favourite fruit, which can be utilized for processing however selection of guava varieties for processing depends on several factors such as content of pulp, seeds, sugars, acids, pectin, and tannins in the fruit. The guava fruit can be consumed fresh; processed into a semiproduct in the form of puree, clarified juice, or concentrate and frozen or aseptically stored; or processed continuously to the final products, which include nectar, syrup, jam, jelly, fruit bar, cheese, chutney, ketchup, wine, dried fruit and powder, as well as canned guavas. Among them, guava nectar is more important than the others in the quantity of production and the popularity among consumers. The fruits of *Sardar* variety yield high-grade pectin with higher jelly units than the fruits from other varieties. Juice obtained from fresh fruits or from pulp can be used in the manufacture of clear guava nectar, clear guava juice blend, clear guava jelly, or guava powder.

Key words: *Guava, processing, juice, nectar, vitamin A*

Introduction

Guava (*Psidium guajava* L.), an important member of the Myrtaceae family, is believed to have originated in Central America and the southern part of Mexico. The Spanish explorers took the guava to the Philippines, and the Portuguese disseminated it from the Philippines to India (Nakasone and Paull, 1998). It now grows throughout the tropics and sub-tropics in the world in almost all habitats as one of the most widely utilized fruits. It is considered as common man's fruit and is rightly called the "apple of the tropics". Guava is particularly rich in vitamin C and pectin (Menzel, 1985). India produces 1.68 million tonnes of guava from an area of about 1.62 lakh hectares with a productivity of 11.1 metric tonnes per ha. in a year 2004-5 (Indian Horticultural Database-2005).

Harvesting and postharvest handling

Guava fruits are borne on current growth and can be produced throughout the year by adjusting the bahar treatment in different parts of the same orchard. However, three flowering seasons in guava are June-July, October-November and January-February. Of these, June-July flowering is commonly followed.

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Maturity and quality indices

Colour is a good indicator of ripeness stage in guava; size and shape may also be important in some markets. Guava fruits are picked at mature-green stage (colour change from dark- to light-green). The fruits are picked at the firm yellow to half-ripe (softer) stage for long-distance transport or at the fully ripe (yellow and soft) stage for local markets. Guava fruit takes about 110-150 days from the date of flowering to reach maturity. Several physico-chemical changes take place during development of guava fruit. The fruit weight and volume increases moderately up to the first 50 days, rapidly up to 100 days, and very slowly thereafter. The colour of the fruit remains green up to maturity. Chlorophyll degradation starts just before it reaches maturity. The softening of guava fruit progresses after about 115 days from anthesis. The fruit detachment force and fruit deformation force decline during maturation (Paul and Goo, 1983). Sugar content of guava fruit increases during development. Among the sugars, fructose increases rapidly, while glucose content increases slowly. Pectin content of guava increases during ripening and declines rapidly in overripe fruit (Luh, 1967). Acidity decreases while ascorbic acid content increases during development of guava fruit (El-Zorkani, 1968). Firm, yellow to half-yellow,

mature fruits should be harvested manually by hand. Fruits for export are harvested mature green (Brown and Wills, 1992). The use of shallow wooden boxes (crates) or corrugated cartons protects the fruits from external hazards. For long-distance transport, it is better to harvest firm, slightly under-ripe fruits.

Chemical Composition

Guava fruit consists of about 20% peel, 50% fleshy portion, and 30% seed core. The physicochemical characteristics of guava fruit change significantly with maturity. Guavas contain 74-87% moisture, 13-26% dry matter, 0.8-1.5% proteins, 0.4-0.7% fat, and 0.5-1.0 % ash (Wilson, 1980). The composition of guava varies significantly with variety, stage of maturity, and season (Singh, 1988). Carbohydrates are the principal constituents of guava. Sugars constitute about 6-11% of the fresh weight of guava (Singh *et al.*, 1990). Chan and Kwok (1975) reported that fructose, glucose, and sucrose are present in proportions of 59%, 36%, and 5%, respectively. The fruits are an excellent source of vitamin C (Dhillon *et al.*, 1987). They also contain appreciable quantities of niacin, thiamin, riboflavin, carotene, calcium, iron, phosphorus and dietary fiber. In general, guava fruit contains more citric acid than ascorbic acid. Malic acid and glycolic acid are the other two major organic acids (Wilson *et al.*, 1982). A wide variation in ascorbic acid content of guava fruits has been reported depending on the variety, season, location, maturity, and horticultural practices (Singh, 1988). Red-fleshed guavas contained more ascorbic acid than white-fleshed ones (Kumar and Hoda, 1974). Guava fruits ripened during the winter season contained more ascorbic acid (325 mg/100 g) than those ripened during the rainy season (140 mg/l00 g) (Singh, 1988; Mitra *et al.*, 1984). Ahire (1989) reported 286 and 122 mg of ascorbic acid per 100 g in flesh and seed core, respectively. Dried guava fruits and guava powder are rich in ascorbic acid (about 4%). Guava fruits are a rich source of pectin. The total pectin content of guava fruit is in the range 0.5-1.8% and its concentration is influenced by a number of factors such as variety, maturity and cropping season. The quality of pectin is measured by its ability to form a gel and is measured in terms of jelly units. Dingra *et al.* (1983) observed that winter-season guava fruits contained higher amounts of pectin with more jelly units than rainy-season guava fruits. Half-ripe fruits yield more jelly units than unripe ones.

Among the varieties studied by Dhingra *et al.* (1983), the fruits of Sardar variety yielded high-grade pectin with higher jelly units than the fruits from other varieties. The methoxyl content of purified guava pectin is relatively low (55%). Hydrolyzed guava pectin contained 72% D-galacturonic acid, 12% D-galactose, and 4% L-arabinose .The fruits contain citric, malic, glycolic, tartaric, and lactic acids. Of these, the first two are the predominant ones.

The flavor is the most distinguishing characteristic of guava fruits. The flavour of guava has been attributed to the presence of several volatile constituents, which include hydrocarbons, alcohols, and carbonyls. Steven *et al.*, (1970) identified 22 compounds, of which methyl benzoate, hexanol, p-phenyl ethyl acetate, methyl cinnamate, and cinnamyl acetate play predominant roles in the flavour and odour of guava fruit. Wilson and Shaw (1978) noted that cinnamyl acetate has the most guava like aroma. Guava fruits contain significant amount of polyphenols which decreases with the maturity of guava fruit. The decrease in astringency with ripening of guava is associated with increased polymerization of leucoanthocyanidins. The pigments in guava fruit include chlorophyll, carotene, xanthophyll, and lycopene. The pink flesh color found in some varieties of guava has been attributed to the presence of lycopene. Nakasone *et al.*,(1967) reported 4.8-6.9 mg/100g lycopene in guava fruits. The chlorophyll content of guava fruit is in the range of 0.2-1.6 mg/100 g, while carotene and xanthophyll contents vary from 0.1 to 0.9 and from 0.01-to 0.17 mg/100g, respectively (Jagtiani *et al.*, 1988).

Storage

Guava is a climacteric fruit (Akamine and Goo, 1979). Its shelf-life at room temperature is few days (Tandon *et al.*, 1989). The peak in CO_2 and ethylene production occurs about 5-6 days after harvest. Storage at 0°C causes chilling injury to the pulp. A temperature of 8-10°C is considered to be the optimum storage temperature for mature-green and partially-ripe guavas for 2-3 weeks at Optimum Relative Humidity of 90-95 % (Vazquez-ochoa and Cotinas-Leon, 1990).

Rates of Ethylene Production and Response

Rates of respiration and ethylene production depend upon cultivar and maturity/ripeness stage. Ethylene production at 20°C ranges from 1 to 20 $\mu l\ kg^{-1}\ hr^{-1}$. Ethylene at 100 ppm for 1-2 days can accelerate ripening of mature-green guavas to full-yellow stage at 15-20°C and 90-95% relative humidity. This treatment results in more uniform ripening, which is more important for guavas destined for processing.

Responses to Modified and Controlled Atmospheric storage

Scanty research on guava indicates that 2-5% oxygen levels may delay ripening of mature-green and partially ripe guavas kept at 10°C. Tolerance to elevated carbon dioxide levels has not been determined. Guava fruits packed in 300-gauge poly packs can be stored at room temperature for 10 days (Khedkar *et al.*, 1982). Singh, *et al.* (1984) reported that prepackaging of guava in 200-gauge polyethylene bags with 0.25-0.50% ventilation proved better than wax coating. Varietal differences in shelf life of guava fruits have been reported (Singh *et al.*, 1990). The shelf-life of guava fruits stored at 18 ± 2°C and 80-85% relative humidity ranged from 6 days in Allahabad Safeda to 9 days in Chittidar and Sardar cultivars. Adsule and Tandon (1983) reported that guava fruits stored in 600-gauge low density polyethylene (LOPE) bags at ambient temperature (18-23°C)

exhibited better organoleptic score and marketability up to 10 days than those stored in open atmosphere. Dhoot *et al.* (1984) reported that the shelf life of Sardar guava was prolonged up to 12 days when treated with 150 ppm naphthalene acetic acid (NAA) and stored in polyethylene bags having 0.05% vents.

Pretreatments

Preharvest spray of 1 % Ca $(NO_3)_2$ + 100 ppm NAA was found to maintain guava fruits in marketable conditions for 6 days, as opposed to 3 days for untreated fruits (Singh, 1988). Amen (1987) observed that guava fruits of cultivar Baladi dipped in 2% Ca Cl_2 solution with or without 2.5% corn flour could be stored in polyethylene bags at ambient temperature for up to 12 days. Preharvest application of 2.5 ppm or postharvest application of 2.5-5.0 ppm morphactin (a chlorflurenol methyl ester) reduced the postharvest weight loss, retained chlorophyll, increased soluble sugars, and extended the shelf life of guava fruits (Gupta and Mukherjee, 1980). Mudahar and Bhatia (1987) blanched guava fruits in boiling water for 4 min and filled into glass jars. The fruits were covered with steeping syrup containing 30% sugar, 0.4% acidity, and 400 ppm SO_2 in 1:1 proportion. The fruits were found to be acceptable after 4 months of storage at room temperature.

Storage Diseases

Anthracnose, canker, and rots are the most common postharvest diseases of guava (Wills *et al.*, 1983; Ramaswamy *et al.*, 1984; Snowdon, 1990). The rots of stored guava include those caused by *Phomopsis destructum*, *Guignardia psidi*, *Phytophthora citricola*, *P. nicotianae* var. *parasitica*, *Rhizopus stolonifer*, *Botryodiplodia theobromae*, *Curvularia tuberculata*, *Cylindrocladium scoparium* Morgan, *Fusarium solani*, *Macrophoma allahabadensis* and *Carticium rolfsii* (Adisa, 1985; Kapoor, 1983; Ullasa and Rawal, 1985; Lim and Razau, 1986).

Processing

Guava fruits are mainly consumed fresh. They are also into a semi product in the form of puree, clarified juice, or concentrate and frozen or aseptically stored; or processed continuously all the way to the final products, which include guava nectar, guava syrup, guava jam, guava jelly, guava bar, guava cheese, guava chutney, and guava powder, as well as canned guavas. Among them, guava nectar is far more important than the others in the quantity of production and the popularity among consumers.

Fresh-cut Guava Wedges

The shelf life of fresh-cut guava fruit is limited by the occurrence of softening, discoloration, and microbial growth. However, fresh-cut guava wedges can be washed with ozone-injected water to reduce the microbial load and stored at 5°C for 5 days with acceptable quality (Hsieh, 2000, Mattiuz *et al.*, 2003, Chan, 2004).

Osmotic dehydration

Osmotic dehydration of guava under different pulse vacuum conditions was reported by Panades *et al.*, (2003). Guava slices were osmotically dehydrated in different sweeteners and subsequently cabinet dehydrated to a final moisture content of 25%. Guava slices treated with sucrose: glucose (7:3) mixture with added potassium metabisulphite and ascorbic acid showed best results in terms of total fungal count during storage period. The guava slices prepared with sucrose :glucose (7:3) solutions showed highest overall acceptability with regard to its organoleptic quality.

Guava Puree

Guava fruits are usually macerated into puree first and then further processed to nectars, nectar blends, clarified juice, concentrates, powder, juice bar, beverages, syrup, ice cream topping, jams, jellies and more. For preparation of guava puree, fully mature, washed fruits are cut or sliced and fed into a pulper. The pulper removes seeds and fibrous material and forces the remainder of the product through a perforated stainless steel screen (CFTRI, 1990).Guava puree is preserved by (a) freezing to -29°C and storing at -18°C (frozen guava puree); (b) canning (canned guava puree); (c) aseptic packaging; or (d) dehydration. The deaeration of aseptically packaged guava puree helped in retention of ascorbic acid during storage up to 6 months (Chan, Jr. and Cavaletto, 1986).

Slightly over-ripened guava fruit, are macerated and finished by a rotor crusher, a paddle pulper, and a paddle finisher, all lined up in sequence. The screen on the pulper removes the seeds and the fibrous fragments of skin tissue. The residual stone cells may be ground by passing the finished pulp through a mill as it improves the mouthfeel (Jagtiani *et al.*, 1988). The type of centrifuge and the operation condition being used vary among factories. After flash heating and cooling in a scraped surface heat exchanger system, the puree can be filled into a presterilized, low-oxygen-permeability, laminated bag under aseptic conditions (Chan and Cavaletto, 1982). Brat-P *et al.*,(2002) prepared guava purees by flash vacuum-expansion.

Clarified Guava Juice

Guava juice is obtained either from fresh fruits or from pulp. Clarified guava juice can be used in the manufacture of clear guava nectar, clear guava juice blend, clear guava jelly, or guava powder. It is basically transparent and slightly colored pink, yellow, or white, depending on the cultivar. For extraction of juice, fruits are cut into small pieces, cooked by adding 250 ml of water and 0.2 g of citric acid per kilogram of fruit pieces, and stirred constantly. The cooked mass is strained through muslin cloth and the juice is collected. The recovery of juice may be increased to 70% by treatment with pectic enzyme (CFTRI, 1990). The fruit are macerated and treated with a commercial pectic enzyme preparation. The pulp is then passed through a hydraulic-plate-pack press to obtain the cloudy juice, normally over 80% in the yield. The cloudy juice is quickly heated in a plate heat exchanger for enzyme inactivation and then clarified by flowing through a plate or membrane

microfilter. Finally, the clarified juice is packed and stored, following procedures similar to those for guava puree, or concentrated.. Guava juice is further processed and utilized in the form of concentrate, beverage, jelly, powder, and other products. Gagrani *et al.* (1987) prepared a whey beverage using 25% guava fruit juice. The beverage had good flavor and contained 0.5% acidity and 20% TSS. Storage stability of guava juice has been studied by several workers (Gagrani, *et al.*, 1987; Shah *et al.*, 1975). There is significant loss of vitamin C during storage of guava juice.

Guava Concentrate

Guava juice can be concentrated to four to five times its original TSS content at 50-55°C under vacuum (Aurora *et al.*, 1990). During juice concentration, there is increase in TSS, acidity, sugars, pectin, and ascorbic acid, due to loss of water. The colour of the juice changes to brown due to browning reaction (Sandhu and Bhatia, 1985). Guava juice concentrate has been found to be suitable for drying into guava juice powder and ready-to-serve beverage. It may be advantageous to concentrate guava puree or clarified guava juice for long-term storage or for overseas shipments. Guava puree is usually subjected to an enzyme-depectinization pretreatment to reduce the viscosity before a concentration process starts. A depectinized puree can be concentrated to 34° Brix and remains flowable in an evaporator (Brekke and Myers, 1978). Clarified guava juice can even be concentrated up to 66° Brix (Muralikrishna *et al.*, 1968). For preserving good flavor and color quality, guava concentrates should be packed in low oxygen permeability packages and stored in frozen form.

Guava RTS

Pandey and Singh (1999) standardized recipes for commercial preparation of guava RTS beverage. The varietal suitability and storage stability were examined. The recipe containing 10% pulp and 11% TSS (total soluble solids) with 0.25% acidity was found most ideal. The RTS beverage prepared from cv. Sardar (L-49) was better than that from cv. Allahabad Safeda, Apple Colour and Sangam. Storage stability of the product was found 4 months at ambient temperature.

Guava Squash

Squash prepared from four guava cultivars were evaluated upto six month under ambient condition by Pandey and Singh (1998). Studies indicated that recipe containing 25 per cent pulp and 45 per cent total soluble solids with 1.0 per cent acidity was found most ideal. The squash prepared from Sardar (L-49) had a significantly higher organoleptic score than that from the cultivars (Allahabad Safeda, Apple Colour and Sangam). Storage stability of product was 6 months at ambient temperature.

Guava Nectar

Guava nectar is prepared by blending guava pulp or puree and 14-15° Brix syrup and is preserved by freezing at -18°C or by canning. Kalra and Tandon (1984) prepared guava nectar containing 15% pulp, 14% soluble solids, and 0.25% acidity. The nectar was fortified with 100mg/100 g vitamin C and stored in glass bottles. Guava nectar may be diluted to prepare ready-to-serve beverage. Jain and Borkar (1966) prepared good-quality ready-to-serve bottled beverages by dilution of guava nectar with four times its volume of water. The beverage can also be prepared from fresh or preserved pulp using 1 kg of sugar, 6 liters of water and 20 g of citric acid per kilogram of pulp. Guava puree, clarified guava juice, or guava concentrate can be blended with water, sucrose, citric acid, and other flavor additives to formulate cloudy nectar or clear nectar. The former type of nectar is more popular than the latter in most countries. A small amount of carboxymethyl cellulose, approximately 0.05% wt, may be added to improve the cloud stability. For example, typical guava nectar on the market in Taiwan is of the cloudy type, about 25% juice content, at pH 3.8, and contains about 11°Brix of sugar and 0.2 g/100 ml of titratable acids (Chen *et al.*, 1994).

The pectinesterase in guava is more heat-resistant than peroxidase, and, therefore, should be taken to be the target instead (Garces, 1969). *D* and *z* values for pectinesterase in different cultivars vary in a wide range though. the *D* 96°C and *z* values in pink-fleshed 'Allahabad' cultivar grown in India are 0.592 min and 16.6°C (Nath and Ranganna, 1983), whereas the *D* 90°C and *z* values in white-fleshed 'Pear' cultivar grown in Taiwan are 0.054 min and 8.9°C (Chen and Wu, 1991). The minimum shelf life for canned guava nectar in common storage conditions is 6 months. During the ambient storage of processed white-fleshed cloudy guava nectar, nonenzymatic browning plays an important role in the deterioration in quality. Ascorbic acid and tannins are involved in the discoloration (Chen *et al.*, 1994). The reduction in pH by the addition of citric acid in the formulation of nectar may reduce the browning rate effectively (Chen and Wu, 1993). Aradhita-*et al*, 1995 found that guava hybrids, are more suitable for the preparation of "nectar", in comparison to commercially established cultivars, Allahabad Safeda, Banarsi Surkha and L-49.

Guava Juice Blends and Nectar Blends

Guava puree or clarified guava juice can be blended with deflavored apple or grape juice to make guava juice blends and sold in the category of 100% juice. Guava puree may also be blended with sugar, water, and orange juice, grapefruit juice, or passion fruit juice to make nectar blends with different compositions that suit the tastes of different consumers. The processing procedures are similar to that for guava nectar. Shukla *et al.*(2003) developed beverages using fruit juice/pulp, separated milk and reconstituted skim milk. Shukla *et al.* (2004) prepared fruit beverages using whey and buttermilk by blending guava, juice/pulp (10.0, 20.0, 30.0, and 40.0%) Organoleptic evaluation of the beverages showed that guava pulp of up to 10.0%, respectively, could be used with both whey and buttermilk

Carbonated Beverages

The clarified guava juice can be converted to a sugar syrup base containing 40% guava juice at 40° Brix and 1% acidity. After dosing 50 ml of this syrup into a glass bottle (200 ml capacity) filled with chilled, 4–6 °C, carbonated water at 80 psi (5.6 kg/cm 2) pressure of carbon dioxide gas, the bottle is sealed and pasteurized at 60 °C. The carbonated guava beverage can be stored for 3 months at room temperature maintaining acceptable color, flavor, and overall quality (Khurdiya *et al.*, 1996).

Canned Guava

Canned guavas may frequently be seen on the market in some countries including India, Pakistan and Indonesia. They are usually packed in syrup in the form of wholes, halves, shells, or slices. The firm, ripe guava fruit are lye-peeled by immersing in 2.5% boiling sodium hydroxide solution for 15 sec, rinsing with water, and then dipping in 0.5% citric acid solution to neutralize the residual alkalinity. The fruit is cut into quarters and cored to obtain the shells. The shells are dipped in 2% calcium chloride solution for 1 h to firm the texture, rinsed, and then placed into cans. The 45% sugar syrup that contains 0.25% citric acid as the acidifying agent is then hot-filled at 88°C to cover the shells and to reduce the headspace to less than 1 cm. The filled cans are heated in a steam exhauster, sealed soon after their center temperatures reach 79°C, processed in boiling water for 25 min, cooled in a water bath to 40 °C, and then air-dried. Guava can be preserved by canning as halves or quarters, with or without seed core (shells) by another procedure also. Fully ripe fruits are peeled with a knife and cut into halves or quarters. For canning of shells, the seed core is scooped with a spoon-shaped knife. The halves, quarters, or shells are immersed in 1-2% brine solution for about 5 min. They are then removed, drained, and canned in syrup of 40° Brix containing 0.25% citric acid. The cans are exhausted at 82-100°C for 7-10 min or until the temperature in the center of the can reaches at least 74°C. The cans are then sealed, sterilized in boiling water for 20-25 min, and then cooled to room temperature (Lal *et al.*, 1986). Siddappa (1982) reported that Allahabad seedless white guavas were more suitable for canning as halves.

Dehydrated Guava

Guava pieces or slices (halves or quarters) are dehydrated by air-drying, osmotic dehydration, or osmovac dehydration (Campbell and Campbell, 1983). In air-drying methods, guava slices are blanched in boiling water for 4 min, sulfured in a sulfur box for 20 min, and dried at 71°C for about 15 h or until the final moisture content is reduced to 6-7%. Air-drying may be done in a flow dehydrator, in a solar hut, or in the sun. Chemical blanching with 0.1% KMS + 2.0% $CaCl_2$ at 100°C for 3 min or sulfiting with 1% KMS for 5 min or fumigation with sulfur at 2 g/kg fruit pieces for 4 h avoids browning of slices. Khurdiya and Roy (1974) dried guava quarters in a cabinet drier at 60 ± 5°C for 18 h or until the final moisture content was less than 3%. Osmotic dehydration is used to prepare glazed guava slices. The guava slices are heated in an equal weight of 70° Brix syrup containing 0.1% KMS at 90°C for 3 min. After cooling, they are allowed to soak overnight. The slices are drained, spread out on glycerine-coated drying trays, and dried at 80°C for 1 h and then at 65-70°C for 7-8 h . In osmovac dehydration, the guava slices are submerged in 70° Brix syrup for 5-6 h. They are then dried under vacuum until a final moisture content of 2% is attained.

Powder

Dehydrated guava slices are pulverized to obtain guava fruit powder. Guavas are quartered and seed core is removed. The shells are blanched for 2 min and air-dried at 54°C for 10-12 h. The dried guavas are then powdered and packed (CFTRI, 1990). Khurdiya and Roy (1974) reported preparation of guava powder by drying guava slices at 60+-5° C in a cross-flow cabinet drier. The storage of guava powder for 6 months resulted in significant decrease in ascorbic acid and SO_2 levels, with a slight increase in moisture content. Guava fruit powder can be used for preparation of guava juice, ready-to-serve guava beverage, milk shake or *shrikhand.* A milk shake was prepared by mixing 1.5 g of guava powder and 16 g of sugar with 100 ml of milk (Ahire, 1989). The product was found to have good color, aroma, and taste. Guava powder was mixed with *shrikhand* at a 10% level to obtain guava *shrikhand (Perukhand).* The produce was found to have good acceptability (Ahire, 1989).

Intermediate-Moisture Fruit

Guava can be preserved as an intermediate-moisture fruit (IMF). Pretreatments such as blanching in plain water improved the acceptability of IMF (Ahire, 1989). Addition of 1.5% citric acid in steeping water was found to give proper sugar-acid taste to the final product. The storage of IMF in 200-gauge polyethylene bags did not produce any deteriorative changes in flavor or acceptability up to 3 months. Jayaraman *et al.*(1974) prepared an intermediate-moisture guava by an immersion equilibration procedure using a soak solution containing glycerol, sucrose, water, and potassium sorbate. The product was acceptable up to 4 months at 0° C and up to 3 months at room temperature.

Pulp

The pulp can be stored in good condition under refrigeration up to 2-3 months in glass or PVC containers with added SO_2 (500-1000 ppm) (Tandon and Kalra, 1984). Lower concentrations of SO_2 (500 ppm) are required for storage of guava pulp at room temperature for short periods (up to 60 days) (Tandon *et al.*, 1983). During storage of guava pulp in PVC containers at room temperature there was increase in sugars, and decrease in vitamin e, tannins, and free S02 levels . Nila *et al.* (1987) prepared fruit yoghurt by blending plain yoghurt with guava pulp. Guava syrup can be diluted to make ready- to-serve guava beverage (Ambadan, 1973). The guava beverage can be preserved for 2- 7 months using 50-ppm sorbic acid as a preservative

(Kalra *et al.*, 1987).Bons and Dhawan(2003) preserved Guava pulp in food grade plastic jars by addition of potassium metabisulphite (KMS) and potassium sorbate (PS) at 0.07 and 0.1% either alone or in combination with heating. Results showed that guava RTS beverage prepared from pulp treated with KMS 0.07% and stored at freezing temperature obtained maximum sensory scores, followed by pulp with KMS 0.1% stored at low temperature.

Jam

Guava Jam is made by combining 45 parts of guava puree or pulp with 55 parts sugar. Dry pectin or pectin solution may be added to the pulp if needed and the mixture is thoroughly mixed while heating. Sugar is added while stirring. The mixture is heated until the Brix reaches 65°. The jam is filled, capped, and cooled as in the case of jelly.

Cheese

Firm ripe guava fruits are washed, cut into thin slices, and boiled with an equal quantity of water. The softened pulp is screened through net cloth and to every kilogram of pulp are added 1.25-1.50 kg of sugar, 2.2-3.3 g of citric acid, and 56 g of butter. The mixture is cooked to a thick paste. Small quantities of permitted red color and common salt may be added toward the end to improve the appearance of the final product. The hot cheese is allowed to set by spreading on a greasy tray. After cooling, it is cut into small pieces of suitable size. The pieces are wrapped *in* moisture-proof paper or polyethylene sheets (Lal *et al.*, 1986). The cheese can be stored at 4°C up to 120 days without loss of organoleptic properties (Singh *et al.*, 1983). Guava cheese prepared from Allahabad Safeda, Banarasi Surkha, and Lucknow-49 contained 1.241.55% pectin and 14.6-41.5 mg/100 g ascorbic acid (Singh *et al.*, 1983). The contents of pectin and ascorbic acid decreased during storage. This decrease was less during storage at low temperature .

Guava bar with highly acceptable texture can be made by hot air drying of clarified guava juice added with maltodextrin, sucrose, soluble starch, wheat flour, pectin, and antibrowning agent such as potassium metabisulfite (Vijayanand and Narasimham, 1998; Vijayanand *et al.*, 2000).

Toffee

Guava toffee is prepared by concentrating the pulp to about one-third of its original volume and mixing with sugar, fat, and acid. To every kilogram of guava pulp, 1.5 kg of sugar and 125 g of butter or ghee are added and the mixture is heated to obtain a thick mass. To this, 2 g of citric acid, a teaspoonful salt, and edible color are added. The product is spread in fat-smeared trays to about 0.6 cm thickness. After cooling, it is cut into small pieces of attractive shapes and sizes. The pieces are wrapped in butter paper and stored in clean, dry glass containers (Parpia, 1967). Guava toffee has good organoleptic properties and is comparable to chocolate. Chauhan and Sharma (1997) prepared fruit toffees by pulping and blending Fresh guava with soya slurry in different proportions. Sensory evaluation showed that the maximum soya slurry which could be added without compromising acceptability was 20-30% (depending on the fruit used).

Jelly

Fresh, slightly under ripe guavas with plenty of pulp and fewer seeds are used for preparation of jelly. The juice is extracted and allowed to settle overnight in a tall vessel. The clear juice is siphoned off and tested for pectin content. The juice is mixed with sugar (0.75 kg/kg of pectin-rich juice or 0.5 kg/kg of low-pectin juice) and boiled in a shallow vessel. Boiling is continued until the temperature reaches 105°C or until it gives a "sheet test." The hot jelly is poured into sterilized bottles or glass jars. These bottles are sealed and stored in a cool dry place (Lal *et al.*, 1986). Guava jelly has an attractive purplish-red color, pleasant taste, and aroma. It can be prepared from guava pulp by dilution with water or whey in 1:1.5 proportion (100). The peel and seed core, discarded during canning of guava, can also be used for preparation of guava jelly. The pink-fleshed variety Beaumont gave jelly of better quality than white-fleshed or other red-fleshed varieties (Ramanjaneya, 1983).

Wine

Two types of wines can be prepared from guava fruit: guava juice wine (GJW) and guava pulp wine (GPW). The treatment of pulp with pectinase increases the final yield of wine (Bardiya *et al.*, 1974). Guava pulp wine is prepared in the same way as guava juice wine. When the Brix reading reaches 10°, the pomace is removed and more sugar is added (10%) to the fermenting materials and the mixture is allowed to ferment further (Bardiya *et al.*, 1974).The cultivars Apple Colour, Allahabad Safeda, Banarsi Surkha, Lucknow-49 and Seedless were assessed for chemical composition of juice, wine and brandy and for recovery of brandy from wine. Highest wine alcohol content (5.81%) was obtained from Allahabad Safeda. The recovery of alcohol (74.2%) in brandy from wine was highest with Lucknow-49 (Dhawan *et al.*, 1983). Ananta and Shukla (2004) prepared Low-alcoholic beverage from ripened guava using *Saccharomyces cerevisiae* strain having titrable acidity range from 1.11 to 1.95%. The residual sugar in fermented fruit juice varied from 5.87 to 13.86%.

Pectin

Guava fruits are an important source of food-grade or natural pectin. Pectin is used in food products as an inexpensive source of natural food thickener and gelling agent. Pectin is extracted from guava fruits by boiling and concentrated by vacuum evaporation. The use of sodium hexametaphosphate at 0.25-0.75% concentration or 1:1 mixture of ammonium oxalate and oxalic acid at 0.25-0.75% concentration during extraction gave higher yields of pectin with high jelly grade and higher number of jelly units from winter guava (Dhingra and Gupta, 1984).

Seed Oil

Guava seeds are usually discarded during processing of juice and pulp. The seeds contain about 5-13% oil, but

guava seed oil (Table 1) is rich in essential fatty acids. Oleic (54%) and linoleic (29%) are the major fatty acids found in guava seed oil. The oil can be readily used in salad dressing.

Guava seeds are a waste product of guava fruits used for processing. Chemical analysis of the shells after elimination of fermentable substances and being ground into a powder revealed a high lignocellulose content and low mineral content. The ground seed powder can be suitable for use as an abrasive material for use in cosmetics. Oil from the kernels had a high (88%) unsaturated fatty acid content with (80%) linoleic acid predominating (Bourgeois- *et al.*, 1998)

Vinegar

Guava fruits (Psidium guajava cv. Banarasi Surkha)

Table 1. Characteristics of Guava Seed Oil (Landgraph, 1960).

Characteristic	Value
Specific gravity (25°C)	0.8902-0.9135
Refractive index (25°C)	1.4712
Saponification value	154-198
Acid value	3.4-7.0
R-M number	0.08-0.35
Iodine number	96-141
Polenske number	0.08-0.10
Acetyl number	74
Unsaponifiable matter (%)	0.5-3.5
Total saturated fatty acids (%)	10.1-16.0
Total unsaturated fatty acids (%)	84.0-89.9

are converted into vinegar using *Saccharomyces cerevisiae* yeast culture and ber vinegar (inoculum) for acetic acid fermentation (Simmon *et al.*, 2004). Results revealed that the vinegar prepared from fresh guava had the highest total acid (3.84 and 4.20%) and ascorbic acid (6.40 and 2.40 mg/100 ml) contents in both pulp: water dilutions (1:1 and 1:2); the vinegar prepared from guava pomace had the least total acid (3.22 and 3.10%) and ascorbic acid (1.05 and 0.65 mg/100 ml) contents. Sensory evaluation showed that the vinegar prepared from fresh guava had the highest overall acceptability for colour, appearance and taste with minimum astringency in 1:2 dilution. The vinegar prepared from 1:2 diluted pulp gave good colour and appearance.

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