

A Review of Production, Losses and Processing Technologies of Guava

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ABSTRACT---- *Guava (Psidium guajava L.: Myrtaceae) is considered as “apple of the poor” due to its low cost, easy availability and high nutritive value. Owing to its considerable nutritional significance, guava is often marketed as “super-fruits”. Guava can be consumed fresh or can be processed into juice, nectar, pulp, jam, jelly, slices in syrup, canned guava puree, fruit bar, ready to serve beverage, dehydrated products, flavoring agent in candies, cakes, biscuits, and chocolate bars, as well as being used as an additive to other fruit juices or pulps. Different processing methods of guava into new food products which include production of powder, preparation of jams and jellies and the quality attributes of the products obtained from processed guava were reviewed. It was concluded that subjecting guava to processing methods will help enhance and improve the value of the fruit and make it available all year round for better utilization. In the current review, production, losses and different processing technologies of guava fruit has been discussed to provide collective information on its versatile commercial values and industrial applications.*

Keywords---- Guava, processing technologies, production, storage

1. INTRODUCTION

Guava (*Psidium guajava* L.: Myrtaceae), the apple of tropics, considered to be originated in the southern part of Mexico and Central America (Somogyi *et al.*, 1996). The genus '*Psidium*' comprises about 150 species, out of which the “Common Guava” (*Psidium guajava* L.), “Cattley guava” (*Psidium cattleianum* Sabine) “pear guava” (*Psidium pyriferum* L.) and “apple-guava” (*Psidium pomiferum* L.) are some of the important species. In Pakistan, the species *Psidium guajava* L., which yields about 100-300 fruit per tree, is widely cultivated for its delicious fruit (Panhwar, 2005). Guava is a climacteric fruit that ripens rapidly and is extremely perishable, shelf-life duration vary from 2-3 days at room temperature (Bassetto *et al.*, 2005). The fruits vary in size, shape and flavor depending on the variety. The better varieties are sweet while others may be astringent (Yan *et al.*, 2006). Guava fruit has a distinct musky flavor, which slightly reduces during processing. The weight of guava fruit ranges from 150 to 250 g (Ayub *et al.*, 2005). It bears fruit twice in a year but the best quality fruit is obtained in winter (Bal and Dhaliwal, 2004). Guava fruit is round, varying from 3-10 cm in diameter, and features a yellow or pink peel at maturity in some species (Lee *et al.*, 2010). Its delicate nature, short postharvest life and susceptibility to chilling injury and diseases, limit the potential for commercialization of guava fruit. Storage of fruit below 10°C may cause severe chilling injury symptoms in the form of surface pitting, skin and flesh browning (Singh and Pal, 2007). Guava is a very productive and highly profitable fruit crop. It's liked by fruit farmers owing to its wide adaptability and higher returns per unit area (Hassan *et al.*, 2012).

Commercial cultivars of guava in Pakistan include Safeda (Gola and Surahi) and seedless while other varieties like Allahabad, Karela, red fleshed and apple color is less frequently cultivated (Usman *et al.*, 2012). Guava fruits can be taken twice a year that is why guava fruit is usually available in the market throughout the year. White Allahabadi, Red Allahabadi, and loca/Desi Amroad grown in Kohat valley. White Allahabadi is commercially accepted guava fruit due to its good quality, colour, shape (rounded in shape and white in colour) and reasonable shelf life. While Red Allahabadi is also good quality, rounded shape and red colour but its shelf life is not up to the mark. Local/Desi variety, which has got two different shapes i.e., rounded rough surface and oval. It is also commercially not accepted due to its low shelf life (Pervaiz *et al.*, 2008). The characteristics of different varieties of guava vary considerably. Fruit shape ranges from round to pear shape. Skin colour of mature ripe fruit can be various shades of green or yellow. The flesh colour can range from white to yellow to pink and red. Texture and taste of different guava as well as the seed content also vary (Augustin and Osman, 1988).

Under subtropical conditions, guava has two crops in a year (summer and winter season crops) and remains available for 8-9 months in the market (Samson, 1986). Guava starts flowering during the months of April-May and November-December and is harvested in the months of July-August and February-March in both summer and winter

seasons, respectively. The 'Gola' and 'Surahi' are the two leading varieties of guava in Pakistan having an average yield of 19.2 and 18 tons ha⁻¹, respectively (Anon., 2008).

Guava can be consumed fresh or can be processed into pulp, juice, nectar, jelly, jam, slices in syrup, canned guava puree, fruit bar, ready to serve beverage, dehydrated products, flavoring agent in candies, cakes, biscuits, and chocolate bars, as well as being used as an additive to other fruit juices or pulps (Leite *et al.*, 2006). It is also stewed and utilized in sauce, marmalade, butter, ice-cream and chutney etc., but its diversified utilization gives potential to combat malnutrition by developing innovative and novel products which could be prepared from guava pulp as such and in combination with other fruit pulp by blending (Jain *et al.*, 2011). These products have good potential for internal plus external trade. The use of guava for beverage preparation and Intermediates Moisture (IM) products has not been discovered much. Guava pulp could be utilized as a base for preparing these products (Kadam *et al.*, 2012).

In the current review, production, losses and different processing technologies of guava fruit has been discussed to provide collective information on its versatile commercial values and industrial applications.

2. PRODUCTION AND LOSSES

Guava is one of the major fruit of Pakistan grown throughout the country. In Pakistan, it is grown on an area of 62.3 thousand hectare giving 512.3 thousand tons total annual production and 8223 kg per hectare yield (Anon., 2010). The places like Lahore, Faisalabad, Qusoor Haiderabad, Larkana, Kohat, Haripur, Mardan, Charsadda and Swabi are very famous for the quality of guava. In Pakistan, total area under guava cultivation is 64.3×10³ hectares, which includes 52.2 in Punjab, 7.2 in Sind, 3.3 in NWFP and 1.6 thousand hectares in Balochistan. Production of guava in Pakistan was 538.5×10³ tonnes, which includes 444.4 in Punjab, 53.7 in Sind, 32.3 in NWFP and 7.6% tonnes in Balochistan (Agric. Stat., 2002). Guava is grown in all the districts of Punjab where climate and soil are suitable for this crop. In Sindh, excellent pear shaped guava with smaller seed core is grown in Larkana, Dadu, Shikarpur and Hyderabad district. In NWFP Kohat, Bannu, Haripur, D.I. Khan and Malakand are famous for good quality guava production. In NWFP during 2004-2005 an area of 1557 hectares was under guava cultivation, which produced 18570 tons of guava fruit; of which Kohat alone produced 33% (Agric. Stat. of Pakistan 2004-2005). Among the major fruits of Pakistan, guava occupies the third position after citrus and mango in terms of area. 1,94,700 hectares are under citrus, 90,900 hectares under mango while an area of 56,800 hectares is under guava. Area-wise it is more than the combined area under apples and peaches (49,000 ha). The reason for covering huge area throughout the country lays in the fact that guava is the hardiest, drought tolerant and with stands the pH ranging from 4.5 to 8.5 (Singh, 1990). In terms of production, guava ranks fourth subsequent to citrus, mango and bananas in Pakistan. However, the yield of guava is quite low, 8.1 tones ha⁻¹; considerably less than the potential yield of 25 tones ha⁻¹ (Anka, 2003).

Due to inappropriate handling, transportation and processing 20-25% of guava fruit is totally spoiled before reaching the consumer (Yadav, 1997). Consequently, the upgrading of low price processing technology of guava is extremely needed, to use the produce at the time of surplus and to save it from spoilage (Jain and Nema, 2007). About 10-15% of the total production of fruit is wasted from picking to the end user. Some of the investigator also explained that about 4% of the production is decreased due to the imperfect collection, mechanical injure, picking up unripe fruit and inappropriate packing, while about 3% was lost owing to substandard methods of transport, and negligence. Practically there is no refrigeration system in transporting vans and owing to lack of cold storage facilities 6% of produce is decayed (Haq, 1985).

As fresh fruit has restricted shelf life so it's essential to use the fruit for manufacturing diverse products to enhance its accessibility over an extended period and to stabilize the price throughout the glut season (Leite *et al.*, 2006). The preservation of fruits particularly guava is the pre requisite for cost-effective and competent utilization of this perishable commodity in Pakistan. Because of its perishable nature it can't be held in storage for an extended time period. Throughout peak harvest season the excess amount of the fruit remains unsold and goes to waste (Ayub *et al.*, 2005).

If guava fruits are not preserved appropriately they cannot be held in reserve for long time. So, products from these are not accessible in the market. Due to inappropriate handling, transportation and processing 20-25% of the fruit is totally spoiled. These losses of the seasonal surplus of the guava fruit can be avoided by processing and preserving the fruit into different products like guava juice, nectar jam and jelly.

The fatalities of the cyclic surplus of the guava fruit can be avoided by processing and preservation skills at farmers' level and at industrial level. If guava fruits are not preserved appropriately they cannot be held in reserve for long time. So, products from these are not accessible in the market. Therefore some appropriate techniques are required to be developed for preserving these fruits into various products that could be made accessible all the year round for the consumers as well as producers use. Consequently it will benefit both producer and consumer, therefore, judicious to develop products for household and public consumption (Hossen *et al.*, 2009).

3. GUAVA FRUIT-PROCESSING TECHNOLOGIES

Dehydrated products

Guava powder is obtained by dehydration process which is an efficient alternative for storage of fruit, because the reduction of water activity is related to the decline of chemical and enzymatic reactions responsible for the deterioration of foods. Dehydration process is relied on extraction of water contained in foods up to a minimal level which is enough to their conservation for long time. Osorio and Carriazo (2011) manufactured guava powders by two dehydration methods and conducted its structural and thermal study. Two food products (powders) were obtained by hot-air drying or lyophilisation methods on the whole guava fruit. The powders were characterized by sensory and thermal analyses, infrared spectroscopy (IR), X-Ray Diffraction (XRD) and Scanning Electron Microscopy (SEM). X-ray diffraction indicated a semi-crystalline profile. Sensory analysis exposed an aroma extremely associated with guava.

Instant guava-drink-powder samples are obtained by dehydrating the concentrated guava juice using different drying techniques. Dehydration of guava juice into powdered particles gives a considerable reduction in volume and is an effective method of prolonging the shelf life. Mahendran (2010) produced guava powders using tunnel drying freeze and spray drying methods and evaluated the effects of drying on the quality characteristics of the fruit powders. He conducted consumer preference test to determine the sensory attributes of the reconstituted guava juice and compared the final product with the commercial products available in the market. Studies indicated that freeze dried product had superior sensory and nutritional qualities, though spray dried powder was stable and highly economical to prepare free flowing guava powder having good stability.

Low caloric sweetened dehydrated guava slices is an intermediate moisture candy type product and is a readymade best food for diet conscious people of all ages and especially for diabetic patients. Ayub *et al.* (2005) prepared low caloric sweetened dehydrated guava slices using non nutritive sweeteners. They conducted a study to evaluate the effect of various concentrations of non nutritive sweeteners individually and in combination along with chemical preservatives i.e., potassium metabisulphite (PMS) and potassium sorbate (PS) and antioxidants including citric acid (CA) and ascorbic acid (AA) on microbial and sensory characteristics of dehydrated guava slices during storage period of 90 days. Samples treated with chemical preservatives found to have negligible microbial population throughout storage. Studies showed that guava slices treated with non-nutritive sweeteners were leathery in appearance due to severe loss of moisture. Maximum overall acceptability was found in the slices treated with potassium metabisulphite and ascorbic acid.

Guava pulp

Guava pulp as such and in combination with other fruit pulp by blending could be utilized as a base for preparing different products. Jain and Asati (2004) evaluated guava cultivars for pulp preparation. Guava pulp was prepared from guava cultivars Allahabad Safeda, Lucknow-49, Apple color, chittidar and Red Fleshed. Pulp was analyzed for Total Soluble Solids (TSS), acidity and ascorbic acid contents initially and after storage for 30 and 60 days at low temperature. Both chemical composition and organoleptic evaluation indicated that Allahabad Safeda was best cultivar followed by Lucknow-49.

Jain *et al.* (2011) evaluated the quality of guava and papaya fruit pulp as influenced by blending ratio and storage period. The analysis of organoleptic characters (i.e., color, flavor, texture, taste and overall acceptability) and qualitative characters (i.e., TSS, pH, acidity, ascorbic acid content) of guava and papaya fruits was conducted on prepared and mixed pulp as well as fresh fruit. With increase in storage period decrease in overall acceptability of both the pulp was observed with increase in storage period. Organoleptic and qualitative characters were influenced by blending of both the pulp in different ratios.

Purree, juice and nectar

Fruit processing into purée and juice production are the most important technologies. Preservation of characteristic nutrients, taste, flavor as well as color, long shelf-life, easy handling, and convenience, make juice a valuable and attractive product for both customers and the food industry. Guava puree is processed by juice processing plants and then frozen until supplied to the food company for manufacture into various juice blends. However, pasteurized guava puree undergoes deterioration during storage at frozen temperatures, resulting in development of off-flavor and decreased sensory quality of guava juice. The results indicated that traditional processing could not prevent the changes of flavor and quality of juice (Yen and Lin, 1999).

Santos and Riascos (2010) evaluated the effect of processing and storage time on the vitamin c and lycopene contents of nectar of pink guava. The production of nectar from fresh guava reduced titratable acidity, lycopene and vitamin C while pH and soluble solid increased significantly. Vitamin C content fell by 89.3% to 6.67 mg/100 g fresh weight ($p < 0.001$). Studies showed that guava nectar storage at 10°C retained 46% of the content of vitamin C for 120 days.

Jam, jelly and preserve

Guava jelly is a sweet, apparent, semisolid, a bit resilient spread or preserve made from fruit juice and sugar boiled to a thick consistency. Hossen *et al.* (2009) conducted a study for processing of jelly from guava juices at different stages of extraction. Sensory attributes and storage studies of the jellies were also evaluated. The analysis of chemical composition of guava jelly prepared from composite of first and second extraction juice was found moisture 21.53%, ash 0.28%, TSS 67%, total sugar 64%, acidity 0.70% and pH 3.10. On the basis of sensory evaluation the guava jellies prepared from different extractions of juice considering, smell and taste, colour, texture and overall acceptability the jelly prepared from composite of first and second extractions of juice was more acceptable. Storage study of jellies for nine months at room temperature (23-30°C) and relative humidity 80 to 85% was conducted. It was observed that TSS, pH and acidity of jelly did not show any remarkable changes. Color and flavor was acceptable up to 210 days but after 210 days the color and flavor of jellies were changed due to fungal growth and incipient spoilage.

Guava preserves are the result of the appropriate processing of the edible parts, with added sugars, water, pectin (0.5 to 1.5%), pH adjuster (3 to 3.4), besides other ingredients and permitted additives until reaching adequate consistency, assuring product stability. After the processing, the preserves should be packaged properly and stored under environmental conditions. Guava jam or preserves should have color characteristic of the product, varying from yellowish red to brownish red, odor and characteristic flavor reminiscent of guava and a gelatinous and solid appearance, allowing cutting. Menezes *et al.* (2011) evaluated the interference of potassium sorbate and cellophane film, polypropylene and metallic packaging on the quality of guava preserves in storage, by physicochemical, physical and microbiological characteristics. The analyses showed that the different types of packaging did not interfere in the stability of the guava preserves until the 5th month of storage. The potassium sorbate caused an increase of the soluble solid levels and decrease in water activity.

Guava leathers

Guava leather is prepared by dehydrating fruit puree into a leathery sheet. Leathers can be consumed as a confection or cooked to give a sauce. There is a dearth of information on the chemical and organoleptic properties of guava leathers in the tropics. Ashaye *et al.* (2005) prepared guava and pawpaw leathers and evaluated the chemical and organoleptic properties of guava and pawpaw leathers. Higher protein and fat content was found in guava leather. This was also observed in the ash contents with pawpaw leather having (2.67%) and guava leather (2.87%). Studies indicated that guava leather is significantly higher in fruitiness smell and overall acceptability and showed better compositional attributes.

Canned slices

Guava in syrup is the product maintaining the original shape and appearance of the fruit. Such a process consists of soaking the fruit in syrup at high temperatures for a pre-determined period. The high sugar concentration of the syrup reduces the water activity (A_w), enhancing product shelf-life. Sato *et al.* (2006) studied the effect of process temperature and calcium concentration in the cooking syrup of guava. All of the processed guava quality parameters were compared with those of the fresh fruit and of a commercial sample to evaluate the effects of processing on the final quality of product. Elevated temperature throughout processing influenced the color of final product. However, more calcium content in the cooking syrup produced lighter samples, with color parameters nearer to those of the fresh fruit. Generally, calcium addition supported better texture.

Minimal processing

The minimal processing of fruits is defined as the process that eliminates non-edible parts, such as rinds, stems and seeds, followed by cutting, washing, classification, sanitization, centrifugation, packaging and storage, possibly including low levels of irradiation and whitening, making them ready-to-eat without losing their freshness, with good quality and degree of sanitization (Durigan, 2000).

Lima *et al.* (2010) evaluated the sanitization effect on the quality of minimally processed guava. Following this, the guava cv. Paluma underwent two sanitization sequences using dehydrated sodium dichloroisocyanurate compound, in 50 ppm concentration, sanitization prior to (S1) and after (S2) being cut; removal of excess water; conditioning in PET packaging and PS-PVC and storage at $3\pm 1^\circ\text{C}$. Physicochemical analysis [pH, total soluble solids (TSS), total labeled acidity (ATT), ascorbic acid (AA), total sugars (AT) and reducers (AR)], textural sensorial and microbiological analyses were used to monitor the quality of the products. The consumers preferred the guava cut in halves with pulp and packed in PET, although this packaging promoted condensation of water vapor on the inner surface of the lid, compromising the appearance of the product. The two sanitization sequences and the two kinds of packaging did not significantly affect the pH, SST, ATT, SST/ATT, texture and AA values. The AT and AR tenors increased significantly in the MP guavas stored in the PS-PVC package. Both sanitizations were efficient in the bacterial control of the indicators of the hygienic-sanitary conditions, although the S1 sanitization proved to be more efficient in the control of autochthonous aerobic microbiota (aerobic mesophilic microorganisms). It can be concluded that guava cv., Paluma packed in PS-PVC can be conserved for 6 days when stored at 3°C .

Alcoholic beverages

Guava wine may prove to be a quality wine with alcohol (stimulant) and high contents of phenols and ascorbic acid (antioxidants) besides increasing the economic status of Indian farmers especially during period of glut. Kocher and Pooja (2011) conducted a study on production of wine from guava. Guava juice requires 'chaptalization' so as to adjust its brix and prepare a perfect wine out of it. The chaptalized juice ("must") is treated with pectinase or a combination of enzymes and fermented with traditional yeasts at a temperature range of 22 to 30°C and inoculum size of 6 to 11% (v/v). Ageing and racking of guava wine improves the organoleptic and sensory characteristics of wine.

4. CONCLUSION AND OUTLOOK

Guava is useful in food and many other commercial and industrial applications. Guava fruit is not only a rich source of vitamins and antioxidants but also a good source of minerals. The preservation of fruits especially guava is the pre requisite for the economical and efficient utilization of this perishable commodity in Pakistan. Due to its perishable nature it cannot be stored for a longer period of time. During peak harvest season the surplus quantity of the fruit remains unsold and goes to waste. If guava fruits are not preserved appropriately they cannot be held in reserve for long time. So, products from these are not accessible in the market. Due to inappropriate handling, transportation and processing 20-25% of the fruit is totally spoiled. These losses of the seasonal surplus of the guava fruit should be avoided by processing and preserving the fruit into different products like guava nectar jam and jelly etc. Moreover the upgrading of low price processing technology of guava is extremely needed, to use the produce at the time of surplus and to save it from spoilage.

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