Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(3): 4642-4652
Received: 22-03-2019
Accepted: 24-04-2019

Vipul Chaudhary
Department of Agricultural Engineering, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Vivak Kumar
Department of Agricultural Engineering, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Sunil
Department of Agricultural Engineering, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Vaishali
Department of Agricultural Engineering, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Kavindra Singh
Department of Agricultural Engineering, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Ratnesh Kumar
Department of Agricultural Engineering, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Vikrant Kumar
Department of Agricultural Engineering, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Correspondence
Vipul Chaudhary
Department of Agricultural Engineering, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut
Uttar Pradesh, India

Pineapple (*Ananas cosmosus*) product processing: A review

Vipul Chaudhary, Vivak Kumar, Sunil, Vaishali, Kavindra Singh, Ratnesh Kumar and Vikrant Kumar

Abstract
Pineapple is the third most important tropical fruit in the world. It is known as the queen of fruits due to its excellent flavor and taste. It is good for the digestive system and helps in maintaining ideal weight and balanced nutrition. Processed pineapples are consumed worldwide and processing industries are trying out or using new technologies to retain the nutritional quality of the pineapple fruit. This is to meet the demand of consumers who want healthy, nutritious and natural products. The main objective of processing technique is to convert perishable fruits into stable products with longer life. Main purpose of processing is to minimize the qualitative and quantitative deterioration of the produce after harvest. Major export products include dried and preserved vegetables, jams, fruit juice, candy, wine. Moreover, some of these preserved products such as canned pineapple, fruit juices, dehydrated products and frozen fruits are gaining popularity in the foreign market and are good foreign exchange earners. In India only 2.2% of the total produce is processed as compared to 40 to 83% in developed countries.

Keywords: Pineapple, nutritional value, economic importance, pineapple processing

Introduction
Pineapple (*Ananas comosus*, family Bromeliaceae) is a tropical fruit grown in the tropical and sub-tropical regions. It's grown on large scale in India and now India is the second largest producer of fruits after Brazil. The Pineapple producing countries are Philippines, Thailand, China, Brazil, India, Mexico and South Africa. India is the fourth largest producer of pineapple in the world contributing almost 9 per cent to the world production of fresh pineapple (Anonymous, 2003) [6]. Pineapple is largely consumed around the world as canned pineapple slices, chunk and dice, pineapple juice, fruit salads, sugar syrup, alcohol, citric acid, pineapple chips and pineapple puree. It mainly contains water, carbohydrates, sugars, vitamins A, C and carotene and refreshing sugar-acid balance and a very rich source of vitamin C and organic acids (Bartolomew *et al.*, 1995) [11]. Pineapple is one of the most important fruit crops of north eastern India especially in Arunachal Pradesh of India. Thailand, Philippines, Brazil and China are the main pineapple producers in the world supplying nearly 50% of the total output. Other important producers include India, Nigeria, Kenya, Indonesia, Mexico, Costa Rica and these countries provide most of the remaining fruit. Green pineapple is also used for making pickles. After extraction of its juice, the left over is used as livestock feed and also the tender leaves are used for the same purpose. Various food items like squash, syrup, and jelly are produced from pineapple. Vinegar, alcohol, citric acid, calcium citrate etc. are also produced from pineapple. Pineapple is also recommended as medical diet for certain diseased persons. The U.S. National Library of Medicine lists bromelain as a proteolytic digestive enzyme. When taken with meals, bromelain aids in the digestion of proteins, working to break proteins down into amino acids. Pineapple contains 81.2 to 86.2% moisture, and 13-19% total solids, of which sucrose, glucose and fructose are the main components. Carbohydrates represent up to 85% of total solids whereas fiber makes up for 2-3%. Of the organic acids, citric acid is the most abundant in it. The pulp has very low ash content, nitrogenous compounds and lipids (0.1%). From 25-30% of nitrogenous compounds are true proteins. Out of this proportion, Ca. 80% has proteolytic activity due to a protease known as Bromelain. Fresh pineapple contains minerals as Calcium, Chlorine, Phosphorus and Sodium. (Farid *et al.*, 2015) [33].

Pineapple fruits exhibit high moisture, high sugars, soluble solid content ascorbic acid and low crude fiber. Thus pineapple can be used as supplementary nutritional fruit for good personal health. The pineapple fruits are normally consumed fresh or as fresh pineapple juice. Field ripe fruits are best for eating fresh, and it is only necessary to remove the crown, rind, eyes and core. Pineapple may be consumed fresh, canned, juiced, and are found in a wide array of food stuffs - dessert, fruit salad, jam, yogurt, ice cream, candy, and as a complement to meat dishes.

In Panama, very small pineapples are cut from the plant with a few inches of stem to serve as a handle. The flesh of larger fruits is cut up in various ways and eaten fresh, as dessert, in salads, compotes and otherwise, or cooked in pies, cakes, puddings, or as a garnish on ham, or made into sauces or preserves. Malayans utilize the pineapple in curries and various meat dishes. In the Philippines, the fermented pulp is made into a popular sweetmeat. The pineapple does not lend itself well to freezing, as it tends to develop off flavors. Canned pineapple is consumed throughout the world.

Nutritional Value

Pineapple is a wonderful tropical fruit having exceptional juiciness, vibrant tropical flavor and immense health benefits. Pineapple contains considerable amount of calcium, potassium, vitamin C, carbohydrates, crude fiber, water and different minerals that is good for the digestive system and helps in maintaining ideal weight and balanced nutrition. Fresh pineapples are rich in bromelain that used as anti-inflammatory, reducing swelling in inflammatory conditions such as acute sinusitis, sore throat, arthritis, gout. Various food items like jam, jelly, pickles are produced. (Hossain *et al.*, 2015) [38]. Pineapple is a common fruit in Bangladesh and it has minimal fat and sodium (Sabahelkhier 2010) [73]. It contains 10-25 mg of vitamin (Rasid and Hosain 1987) [69]. Pineapple composition has been investigated mainly in the edible portion. Pineapple contains 81.2 to 86.2% moisture, and 13-19% total solids, of which sucrose, glucose and fructose are the main components. Carbohydrates represent up to 85% of total solids whereas fiber makes up for 2-3%. Of the organic acids, citric acid is the most abundant in it. The pulp has very low ash content, nitrogenous compounds and lipids (0.1%). From 25-30% of nitrogenous compounds are true proteins. Out of this proportion, Ca. 80% has proteolytic activity due to a protease known as Bromelain. Fresh pineapple contains minerals as Calcium, Chlorine, Potassium, Phosphorus and Sodium (Dull 1971) [30]. Pineapple juice contains ascorbic acid and is a good source of Vitamin C. Ascorbic acid or vitamin C fights bacterial and viral infections which is an effective antioxidant and helps the body absorb iron. Half a cup of pineapple juice provides 50 percent of an adult's daily recommended amount of vitamin C. Several essential minerals exist in pineapples, including manganese, a trace mineral instrumental to the formation of bone, as well as the creation and activation of certain enzymes. Pineapples also include copper, another trace mineral. It assists in the absorption of iron and regulates blood pressure and heart rate (Debnath, 2012) [25].

Economic Importance

Pineapple is the third most important tropical fruit crop, after bananas and mangoes (citrus being considered mainly subtropical). Although cultivated in all tropical and subtropical countries, mostly between 30◦N and 30◦ S, minor plantations can be found beyond these latitudes in areas with mild climates, often under protective shelter (Nakasone and Paull, 1998) [56]. According to the Food and Agriculture Organization (FAO) statistics (http://apps.fao.org), world pineapple production increased from 3,833,137 tons in 1961 to 15,287,413 tons in 2004. Five countries, namely Thailand (17,000,000 t), the Philippines (1,650,000 t), Brazil (1,435,600 t), China (1,475,000), and India (1,300,000) contributed with about half of the world production in 2004. In India, pineapple is grown on an area of 78200 ha with a production of 12.211 lakh metric tonnes. The major pineapple producing states are Assam (2, 16,100tonnes), West Bengal (2, 79,500 tonnes), Kerala (84,600 tonnes), Meghalaya (81,700 tonnes) and Karnataka (81,193 tonnes) (Rashmi *et al.*, 2005) [68]. In Maharashtra, pineapple is grown on 400 ha with production of 900 MT (Anonymous 2007) [7] and it is mostly grown in the Konkan region due to hot and humid climatic conditions and sloppy land.

A second group of significant producers that includes countries as disparate as Nigeria, Mexico, Costa Rica, Indonesia, Kenya, Colombia, Ivory Coast, Venezuela, Vietnam, Malaysia, United States, and South Africa supply about one third of the total world production. Approximately 70% of the produced pineapple is consumed as fresh fruit in the country of origin (Loeillet 1997) [54]. The world pineapple trade consists mainly of processed products as canned slices, chilled fresh cut chunks and spears, juice and juice concentrates. For example, worldwide exports of concentrated juice represent more than US$ 250 million and the value of exported canned pineapple more than US$ 600 million. Even so, the value of the fresh fruit market is rapidly increasing, particularly the chilled, fresh-cut fruit market (Rohrbach *et al.* 2003) [71]. Pineapple is also a source of bromelain, used as a meat-tenderizing enzyme, and high quality fiber. The waste resulting from industrial processing is used for animal feed.

Processing of Pineapple

Tropical fruits, which are at present under-utilized, have an important role to play in satisfying the demand for nutritious, delicately flavored and attractive natural foods of high therapeutic value. They are in general accepted as being rich in vitamins, minerals and dietary fiber and therefore are an essential ingredient of a healthy diet. Apart from nutritive, therapeutic and medicinal values, quite a few of these tropical fruits have excellent flavor and very attractive color. Pineapple is not an easy to eat out of hand item. The pineapple can be processed for preparation of various products. For all type of products, pineapple slice is the first requisite. As the storage quality of the whole fruit cannot be maintained for long period of time, improvement in the post-harvest processing will enhance the effective utilization of the fruit. Because of its hard shell, mucilaginous texture and numerous seeds, it is not popular as a fresh fruit. The fruit has excellent aroma which is not destroyed even during processing. Therefore, there is tremendous potential for processing this fruit into various products. It is usually processed into products like preserves, refreshing beverages, powder, leather, squash, nectars, toffee, jam, syrup. These products being highly nutritive and therapeutically important can be very easily popularized in internal as well as international markets (Joy, 2010) [48]. Nearly 80 per cent of pineapple production found in the market is in processed form, out of which 48 per cent is used for single or concentrated juice and 30 per cent for canned fruits in the world (Saad, 2004) [72]. The processed products prepared from pineapple are mainly slices in tins, juice, squash, dehydrated slices and jam. Fruit core is also used for preparing candy. Processed pineapples are consumed worldwide and processing industries are trying out or using new technologies to retain the nutritional quality of the pineapple fruit. This is to meet the demand of consumers who want healthy, nutritious and natural products with high organoleptic qualities.

Osmotic dehydration of pineapple

Osmotic dehydration is a useful technique for the concentration of fruit and vegetables, realized by placing the solid food, whole or in pieces, in sugars or salts aqueous solutions of high osmotic pressure. It gives rise to at least two major simultaneous counter-current flows: a significant water flow out of the food into the solution and a transfer of solute from the solution into the food. (Chavan and Amarowicz 2012) [22] studied on the osmotic dehydration process for preservation of fruits and reported that it has potential advantage for the processing industry to maintain the food quality to preserve the wholesomeness of food. It involves dehydration of fruit slices in two stages, removal of water using as an osmotic agent and subsequent dehydration in a dryer where moisture content is further reduced to make the product shelf stable (Chaudhary *et al*., 2018) [21] reported that the osmotic dehydration of pineapple slices. Effects of osmotic dehydration on mass transfer and weight reduction during osmotic dehydration of pineapple cubes were investigated in order to determine the usefulness of this technique as pretreatment for further drying of pineapple slice. Water loss, weight reduction and solids gain increased with time.

Rahman and Lamb (1990) [65] reported that temperature above 50 ºC may not have a positive effect on solute gain during osmotic dehydration of pineapple with a sucrose solution. They concluded that sucrose were not capable to distribute as simply as water through the cell membrane at high temperature

Laura *et al.,* (2005) [53] reported that osmotic dehydration of pineapple slices (0.6 mm thick) in sucrose solution (60% w/w) at three temperatures (30, 40 and 50 ºC). As temperature increased from 30 to 50 ºC, the apparent moisture and sucrose diffusivities (DW and Ds) increased 3.8 and 2.8 times therefore, the dehydration efficiency index (Dw/Ds) increased with temperature.

Ramallo and Mascheroni, (2005) [53] studied the water loss (WL), solid gain (SG) and variation in concentration of glucose and fructose during osmotic dehydration of pineapple slices (0.6 mm thick) in sucrose solution 60% (w/w) at three temperatures 30, 40, and 50 ºC. It showed that solute content was a linear function of the water content in the pineapple fruit during osmotic dehydration and this ratio was independent of temperature.

Jose *et al.,* (2011) [46] studies osmotic dehydration of pineapple the effects of temperature (25-45^{0}C) and citric acid concentration (0.5 -2.5% w/w) in osmotic dehydration of pineapple in a sucrose solution. The results suggest that WL, ML and SG can reach 42.62%, 36.54% and 292.16% respectively, after 4 to 6 h of the process, with 100% sensory acceptance and reductions in microbial counts.

Chaudhari *et al*., (2015) [20] reported that the osmotic dehydration of pineapple. Effects of osmotic dehydration on mass transfer and weight reduction during osmotic dehydration of pineapple cubes were investigated in order to determine the usefulness of this technique as pretreatment for further drying of pineapple cubes. Water loss, weight reduction and solids gain increased with treatment time.

Saini and Sharma (2016) [74] reported that the effect of storage on the color and quality parameters of uncoated and pectin coated dehydrated pineapple sampleswere studied during storage. The browning was more observed in uncoated samples than coated samples, which increased in the later stages of storage. Rehydration ratio decreased, while moisture content increased with storage.

Pineapple Juice

Pineapple processing plays an important role in juice preservation. Because the quality of the pineapple juice is affected by the processing technology applied, the effects of pasteurization and other preservation methods on the overall juice quality were discussed (Islam *et al.,* 2014) [43]. During juice processing, microorganisms are destroyed and chemical changes occur. To optimize processing conditions, knowledge of the kinetics of these reactions is needed, but as of yet, data on the degradation of the amino acids and vitamin C and the change in sugar contents during pineapple juice pasteurization are scanty. Furthermore, the kinetics of hydroxyl methyl furfural production should be investigated by a precise technique such as high-performance liquid chromatography. (Hounhouigan *et al.,* 2014) [39].

Reverse osmosis has been used for the concentration of fruit juices with promising considering the quality of the obtained products. The objective of this study was to concentrate single strength pineapple juice by reverse osmosis by (Couto *et al.,* 2011) [23]. The concentration was carried out with polyamide composite membranes in a 0.65 m2 plate and frame module at 60 bar transmembrane pressure at 20 °C. The permeate flux was 17 L.hm–^{2}. The total soluble solid content of the juice increased from 11 to 31 °Brix corresponding to a Volumetric Concentration Factor (VCF) of 2.9. The concentration of soluble solids, total solids, and total acidity increased proportionally to FCV. The concentrated juice and three commercial concentrated pineapple juices were evaluated regarding preference and purchase intention by 79 pineapple juice consumers. The concentrated juice by reverse osmosis was the preferred among consumers. It can be concluded that this process may be considered an alternative to the pre-concentration of fruit juices.

Pineapple fruit juice was prepared by (Jori *et al.,* 2013) [45]. Different parameters such as shelf life of pineapple juice, its sensory evaluation with respect to the concentration (10%, 12%, and 15% of juice with carbonation at 100 psi) and time were studied. The chemical factors such as acidity, pH, and sugars were studied and the changes were observed with respect to time. The sensory evaluation study was done with Hedonic scale along with the help different panel members. The best results were obtained for 15% fruit juice concentration with the initial values of pH, acidity and Total sugars 4.10, 0.58%, 13.80Bx, was reduced to 2.98, 0.63 and 120 Bx, after 9 weeks respectively. The decrease in the pH value and increase in the acidity with respect to time period was observed which indicates the increase in the shelf life of prepared carbonated pineapple juice.

Essien, and Usoh (2016) [32] studies on the rheological property of pineapple juice was investigated over a wide range of temperature (30 to 75 °C) using a Couette rotational viscometer. The speed of rotation of the outer cylinder varied from 5.1 to 1021 s-1. The values of viscosity was in the range of 12.65 cP to 300 cP and was dependent on the temperature as well as the shear rate applied. From the results obtain, the test pineapple juice exhibited a non-Newtonian flow behaviour known as shear-thinning behaviour typical of pseudoplastic fluids. This was further confirmed using the Power-law and Herschel-Bulkley model. Arrhenius-type equation was used to analyse the effect of temperature on the juice and equation parameters were obtained. Thus, using the Arrhenius equation and parameters, the viscosity of pineapple juice at any temperature for a specific shear rate can be predicted. Coefficient of determination obtained were between 0.9 - 0.95

Pineapple Jam

Jam is an intermediate moisture food containing fruit pulp, pectin, sugar and acid. The effect of sugar and pectin concentration, pH, shear rate and temperature on the time dependent rheological properties of pineapple jam was studied using a rheometer. Pineapple jam exhibited thixotropic behavior. Shear stress of the pineapple jam at a particular time of shearing depended on the shear rate, temperature and composition. Weltman, Hahn, and Figoni and Shoemaker, models were applied to describe the time dependent flow properties of pineapple jam. Hahn model described adequately the rheological characteristics of pineapple jam by (Basu *et al.*, 2017) [12].

Value added papaya and pineapple jams were prepared by (Doke *et al.*, 2017) [27]. The selected jams were prepared by following standard procedures. Five variations of each jam were prepared for organoleptic evaluation. Variation I was basic recipe which was prepared without incorporation of any ingredient selected for value addition and it served as control. Variations II to V were experimental variations with varying levels of incorporation of selected nutritious ingredients. Beetroot powder, deoiled soya meal powder, milk powder and watermelon powder were incorporated at different levels in the selected fruit jams. The level of incorporation was 1 to 12 per cent. The major ingredients replaced by selected nutritious ingredients were sugar and fruit pulp in the preparation of jams. The ingredients used and procedures followed for the preparation of selected fruit jams by (Gopalan and Mohanram 1996) [36].

Jam Production from Blends of Banana, Pineapple and Watermelon Pulp were prepared by (Awolu *et al.*, 2018) [10]. Jam components are in ratios 0.45: 0.55 of fruit pulp: sugar respectively. The formulation therefore consisted of 584 g fruit pulp and 713 g sugar. Others were 2.9 ml of pectin, 0.03 g citric acid and 0.06 g sodium benzoate. The pulp was made from blends of banana (Musa paradisiaca), pineapple (Ananas comoscus) flesh, and watermelon (Citrullus lanatus) flesh. Each of the fruits were washed, dried, peeled and sliced into smaller sizes for blending. Immediately after blending, they were refrigerated till further use. The mixture of the fruit pulp was boiled for 10 min to soften the fruit pieces and to pasteurize it. Sugar (713 g) was added after 10 min to the boiled pulp while mixing and pectin solution was added as thickener. Preservatives (citric acid and sodium benzoate) were later added to the mixture. After 55 min of mixing, colorant was added and mixed to obtain a uniform and desired color, and until gelation was formed. The mixture was poured directly into an already sterilized jar and lid, and then cooled in cold water

Ber-Pineapple Jam was prepared by (Sucharitha *et al.*, 2012) [80]. Three different proportions were carried out with different ratios of ber to pineapple pulp. The prepared ber-pineapple jams were filled into glass jars by sealing cap tightly and stored at ambient temperature. All the samples were subjected to sensory evaluation to determine their acceptability, using 5 point hedonic scale rating method. Based on the scores of sensory evaluation the composition of the product was standardized. Maximum scores for organoleptic characters like colour and appearance, taste, flavor and overall acceptability was recorded.

Preparation of Pineapple Jam Blended With Carrot by (Farooqui *et al.*, 2015) [34]. jam was standardized to 100% pineapple pulp, 75% sugar, 1% citric acid as per the prescribed standards for jam by FSSAI, 2011; and treatment T_1 was standardized to 90% pineapple pulp, 10% carrot pulp, T_2 was standardized to 80% pineapple pulp, 20% carrot pulp & T_3 was standardized to 70% pineapple pulp, 30% carrot pulp whereas the concentration of sugar and citric acid was kept constant throughout the treatments. The chemical analysis for prepared jam samples from different treatments and control was performed as: Moisture, Reducing Sugars, Total Soluble Solids (TSS), Acidity, Ascorbic Acid, Ash, and pH; for estimating its nutritional content and safety. Also, organoleptic characteristics like (Flavour and Taste, Body and Texture, Color and Appearance) were scrutinized by trained panelists using 9-points Hedonic Scale. The treatment T*3*, containing 30% carrot pulp scored the highest acceptability.

Pineapple Candy

Candy is defined as preparations of sugar, honey, or other natural or artificial sweeteners in combination with chocolate, fruits, nuts, or other ingredients or flavorings in the form of bars, among others (Anonymous, 2016 and Hamid, 2007) [8, 37]. It was established that one of the options for food security and the ght against poverty is a developing ready-to-consume foods, including compressed bars (Pee and Bloem, 2009) [62]. The bar itself is defined as a combination of ingredients which gives the food strength and low water content, providing a source of nutrients as opposed to candies that are consumed as sweetened products

The present investigation was made with an attempt to develop gummy candy using pineapple juice and carrot juice. This value added nutrient rich gummy candy with functional properties will impart endless nutrient benefits to consumer with high beta-carotene. (Achumi *et al.*, 2018) [1] concluded that the gummy candy can be successfully prepared by using pineapple juice and carrot juice with addition of agar-agar and sugar. It is found that the experimental gummy candy in treatment T_3 was best in organoleptic characteristics and received highest score in organoleptic evaluation.

Khanom *et al.*, (2015) [49] Prepared pineapple candy from fresh pineapple using 40, 50 and 60% sugar solution and then dried in solar drier. Acceptability of the product was also assessed. The thickness of pineapple slices were 0.5 and 1.0 cm. The pineapple slices were dipped into 40, 50 & 60% sugar solutions for overnight and then dried in solar drier. It was found that 0.5 cm thick of pineapple slices dried quickly than 1 cm thick slices. Sensory quality attributes of the prepared pineapple candy were analyzed on the basis of color, flavor, texture and overall acceptability using. Samples having 0.5 cm slice, osmosed in 60% sugar solution and 0.5 cm slice, osmosed in 50% sugar solution were the preferred samples with respect to quality attributes and ranked as “like very much”. The samples having 0.5 cm slice, osmosed in 60% sugar solution was the most acceptable among candies prepared under the study

Kumar and Kirad (2013) [51] studied on the different sugar levels for preparation the pineapple candy and to investigate the physic-chemical changes during storage in order to assess acceptability as well as shelf life of the product. Out of three levels tested, the 75% total soluble solids treatment was found optimum for getting desired results. Ascorbic acid was totally lost during treatments and product preparation. There was a little progress in acidity and reducing sugar upto 60 days of storage period. After 60 days quality product decrease. Fruit processing with 75% total soluble solids observed best in phsico-chemicals during storage period.

Jothi *et al.*, (2014) [47] developed and investigate pineapple (Ananas comosus) preserve and candy to assess its prospect in marketability and study their storage life. Pineapple slices were treated with 2% solution of common salt to prevent browning, then cut into cube shape and treated with 1% calcium chloride and 0.25% potassium metabisulphide solution and finally processed. The preserves were processed with 60° Brix, 65° Brix and 70° Brix sugar syrup. The candies were processed with 65° Brix, 70° Brix and 75° Brix sugar syrup. Initially the composition of pineapple preserves processed with different level of sugar ware found in the range as moisture content 33.09-35.65%, ash 1.36-1.42%, protein 1.01-1.07%, fat 0.61-0.66%, total sugar 61.37-63.73% and reducing sugar 30.52-31.46% and pineapple candies were found in the range as moisture content 19.05-20.88%, ash 1.52-1.58%, protein 1.15-1.21%, fat 0.72-0.77%, total sugar 75.70-77.35% and reducing sugar 45.16-46.39%. The sensory results showed that color, flavor, texture, taste and overall acceptability scores differed significantly ($p<0.05$). The preserve (P2) processed from 65° Brix sugar syrup and the candy (C2) processed from 70° Brix sugar syrup was the favorite sample of the sensory evaluation with the highest overall acceptability among others of the similar product. The shelf-life of candy (6 month) packed in high-density polyethylene bag is higher than preserve (4 month) packed in glass bottle when stored at ambient temperature (27° C to 30 °C).

Pineapple Beverages

Low calorie Pineapple RTS beverage by using artificial sweeteners were prepared by (Mansoor *et al.*, 2017) [55]. For preparing this add calculated amount of juice, sugar, sweeteners, citric acid and water according to different blending ratio. The recipe of RTS beverage with 15 per cent juice, 14 per cent sugar (sucrose) and 0.3 per cent citric acid was used as standard control recipe However, sugar substitutes were used in place of sugar (based on sugar equivalents) for preparation of RTS beverages. The treatments include RTS beverage with aspartame, sucralose, 50% sucrose+50% sucralose, 50% sucrose+ 50% sucralose It can be finally concluded that a good quality organoleptic ally acceptable low calorie pineapple RTS beverage can be prepared by using 50% sucrose + 50% sucralose. The prepared low calorie pineapple RTS beverage provide almost half calories than that provided by control sample.

Spiced pineapple ready-to-serve beverages was prepared by (Amaravathi *et al.*, 2014) [3]. The pineapple RTS beverages were processed with extracts of ginger, green chillies, pepper, cardamom and nutmeg. The combined spices extracts such as ginger + pepper, ginger + cardamom and ginger + nutmeg were blended with pineapple juice and prepared the RTS beverages. The spiced pineapple RTS was standardized based on organoleptic evaluation. The nutrient content such as Total Soluble Solids (TSS), pH, acidity, reducing sugar, total sugar, tannin, β-carotene, ascorbic acid and non-enzymatic browning were analyzed. The sensory evaluation revealed that the all the beverages had good sensory properties except B2 and B3 beverages.

Flavored and blended RTS beverage was prepared by (Sindumathi and Premalatha 2015) [79]. using 15% of total soluble solids (TSS) and 0.3% of acidity and 10% of blended juices of different blending ratio of (A) 70% papaya juice + 30% pineapple juice, (B) 60% papaya juice + 40% pineapple juice, (C) 50% papaya juice + 50% pineapple juice and (D) 80% papaya juice + 20% pineapple juice. In the best blending ratio of papaya and pine apple RTS beverage the extracts of flavoring agent was added in varying proportions. Best blended and flavored RTS beverage was selected by organoleptic test which was conducted on 9 point Hedonic scale for appearance, color, taste, flavor and overall acceptability by a panel of 25 semi trained judges having prior experience of sensory evaluation of fruits and vegetable product.

Ginger based pineapple drinks were prepared by (Ekeledo *et al.*, 2013) [31]. Turmeric and ginger were processed into flours, combined in the ratios 9:1, 4:6 and 7:3(w/w) and used as spice for preparing fried rice. Extracts of pineapple, turmeric and ginger were also made and blended in the ratios 13:6:1, 6:3:1 and 4:3:3(v/v) to prepare turmeric: ginger-flavored pineapple drinks. The pH and total soluble solid contents of the drinks were determined and sensory evaluation of the drinks and fried rice samples were carried out. The drinks prepared from the turmeric, ginger and pineapple extracts in the ratios 6:3:1 and 4:3:3 were acceptable to the Taste Panelists and these drinks were found to be as good as the commercial pineapple drink used as standard. The acidity and total solids contents levels of the drinks also compared favorably with that of the standard drink. There were no significant differences ($P>0.05$) among the turmeric: ginger-spiced fried rice samples with respect to color, taste, aroma and general acceptability, and they were found as acceptable as the curried sample used as control. A combination of turmeric and ginger in the right proportions is recommended as flavoring and preservative for pineapple fruit drinks and a suitable spice for fried rice and other cereal foods.

Shukla *et al.*, 2013 [78] developed a probiotic beverage using whey and pineapple juice. Lactobacillus acidophilus was used as the probiotic organism. The level of pineapple juice addition was optimized on the basis of sensory quality evaluation. Fermentation time using 1 per cent inoculum of L. acidophilus was optimized on the basis of sensory quality evaluation, growth and activity in terms of pH and acidity. The 65:35 blend ratio of whey and pineapple juice fermented for 5 hr gave desirable results with highest sensory scores for overall acceptability and a total viable count of more than 106 cfu.ml-1.

Bhuiyan and Kabir (2012) [16] developed of fruit drink based on pineapple, orange and grapefruit. There were six different combinations of fruit juices to make drinks. Among them the best formulated drink was identified on the basis of overall acceptability. In the experiment flavor was more influential on overall acceptability rather than color. The best combination of the fruit juices was 8% pine apple, 1% orange and 1% grape fruit. Per liter best fruit drink was made of 80 ml pineapple juice, 10ml grape juice, 10ml orange juice, 150g sugar, 3g citric acid and 900ml water. TSS showed linear whereas acidity and vitamin C concentration showed inverse relation with storage period. The RFT (4±10C) storage ensured better retention of chemical and sensory properties than RMT (30±20C) storage. The storage stability of the drink was higher in RFT than RMT.

Blended Beverage prepared by (Biswas, *et al.*, 2016) [17]. For fresh Juices of pineapple and Aloe Vera were optimized to a blended beverage which was stored for 21 days in glass bottles (200 ml capacity) at refrigerated temperature. The protein content was observed to be increasing with the increasing amount of Aloe Vera. The acidity increased (0.179-0.192) and pH of the juice decreased progressively during the storage period. The overall acceptability scores of more than 8.5 for juice samples up to 30% Aloe Vera juice incorporation indicated the commercial scope for manufacturing good and nutritious pineapple juice blended

with Heat pasteurization (97 °C for 2-3 min) was more effective for inactivating the microbial flora. However the shelf life of juice was established within 14 days.
The pineapple flavored chhana whey beverage was prepared by with the addition of 5, 10 and 15 per cent of pineapple pulp in chhana whey. (Bhavsagar *et al.,* 2010) [15] studies for the acceptability on an average the pineapple flavored chhana whey beverage of treatment T0, T1, T2 and T3 contained fat 0.55, 0.51, 0.48 and 0.45 per cent, protein 0.57, 0.66, 0.73 and 12.57 per cent, ash 0.44, 0.60, 0.76 and 0.78 per cent, total solid 13.40, 13.89, 14.38 and 14.57 per cent, moisture 86.71, 86.20, 85.62 and 85.50 per cent, respectively. The observations in respect of pH for above treatment combinations were 3.91, 3.88, 3.86 and 3.89 per cent and titratable acidity 0.59, 0.62, 0.63 and 0.62 per cent lactic acid, respectively. The overall acceptability score of T1 and T0 was found to be at par whereas, T2 scored highest (7.9) and lowest score (7.4) was found in T_3.

Pineapple Leather

The general process of making fruit leather involves the preparation of the fruit puree, with or without addition of other ingredients before mixing and then drying. These processes may vary depending on the fruit used, the nature of the additional ingredients, and the drying method and technology. The advantages and disadvantages of the method of preparation of the different fruit leathers. As the results show, most fruit leathers have few disadvantages which are mostly on the lack of preservatives to protect the color. (Diamante *et al.,* 2014) [26].
The physicochemical characteristics and sensory optimization of pineapple leather was studied by (Phimpharian *et al.,* 2011) [63]. They researched the effects of glucose syrup (2%, 4%, and 6%) and pectin (0.5%, 1.0%, and 1.5%) concentrations. They prepared pineapple puree by removing the stalk and rinsing each whole pineapple, then removed the skin, divots, and leafy crown, then rinsed the treated pineapple flesh with tap water, cut them into pieces, and chopped for 30 s into a puree. The puree was placed into plastic bags and then stored at −18 ºC for up to 2 weeks until used. They left the pineapple puree in a refrigerator overnight before being used the next day. Pineapple puree was heated at 85 ± 5 ºC while stirring with an automatic pot stirrer at a speed of 57 rpm for 15 minutes and then mixed with pectin, glucose syrup, sugar (fixed at 15%), and maltodextrin (fixed at 2%). The puree was heated and stirred for another 80 minutes to obtain pineapple paste. They fed every 500 g portion of pineapple paste through the cylinder (an inner diameter of 42 mm) located on the top of the leather forming machine, and pressed the paste into the extruder zone with a pneumatically driven ram at a pressure of two bars, and then extruded them through a die (27mm width × 2.2mm thickness) at a screw speed of 50rpm to obtain a flat rectangular paste. The flat pineapple paste was placed on a conveyor belt lined with a polypropylene plastic sheet, cut, and then dried in a hot air dryer at 60 ºC for 10 hours to form the pineapple leather.

Pineapple powder

Pineapple powder is an interesting product because of its long shelf life at ambient temperature, convenience to use and low transportation expenditure. Pineapple powder can be consumed as an instant juice powder or a flavoring agent. So far, there have been merely few studies about the production of pineapple powder. Some researchers claimed that drying of fruit juice could produce the fruit powder that reconstituted rapidly to a fine product resembling the original juice (Gabas *et al.,* 2007) [35]. It is because the product temperature is rarely raised above 100ºC during drying process (Adhikari *et al.,* 2004) [2]. There are some difficulties in drying the fruit juice with high sugar content like pineapple due to their thermos plasticity and hygroscopicity at high temperatures and humilities causing their packaging and utilization in trouble. (Bhandari *et al.,* 1997 and Chauca *et al.,* 2005) [14, 19].
Pineapple powder specimens were produced using a spray dryer under various drying conditions by (Jittanit *et al.,* 2010) [44]. Fresh pineapple juices were added with maltodextrin (MD) at 15, 20 and 25% before exposing to the drying temperatures at 130, 150 and 170oC with the feed rate 0.020, 0.022 and 0.035 liter per minute respectively. Then, the qualities of pineapple powders and reconstituted pineapple powders were investigated in the aspects of moisture content, solubility, color, pH and the consumer acceptance. The results indicated that the pineapple juice should be added with MD at 15% and dried at 150oC. Furthermore, the moisture content and solubility of the pineapple powder produced under this condition were 5.1% and 6.2 minutes respectively while its solution had the lightness 58.8, redness 5.2, yellowness 25.1 and pH 3.5.
Foam mat drying is an economical process compared to drum drying, spray drying, and freeze drying for the production of fruit powders. The aim of this study was to determine the effect of foaming agent concentration and whipping time on pineapple powder properties by (Shaari *et al.,* 2017) [77]. Pineapple juice was foamed using egg albumen (EA) at different concentrations (5, 10, and 20%, wt/wt) and whipping time (10, 20, and 30 min). Physicochemical properties such as water absorption index, water solubility index, total phenolic content, total soluble solid, pH, color, water activity, moisture content, bulk density, hygroscopicity, and rehydration ratio were evaluated. As the concentration of foaming agent increases at constant whipping time, foam density was reduced and foam expansion was increased. The results indicated that foaming properties and physicochemical properties of powder were significantly affected by the whipping time ($p < .05$) and EA concentration ($p \leq .05$)
Pineapple puree and juice of 11 to 12 °Brix were used to obtain pineapple powder using oven-drying technique. Addition of maltodextrin in treatments 2 and 4 yielded good quality powder, however addition of sugar and maltodextrin in treatments 1 and 3 resulted to sticky product which was processed to pineapple leather. Treatment 2 composed of pineapple puree and maltodextrin resulted to significantly higher powder recovery compared with treatment 4 which composed of pineapple juice and maltodextrin. The solubility of pineapple powder improved as maltodextrin concentration is increased from 40.00% to 60.00%. Addition of maltodextrin also reduced stickiness of the final product. An instant pineapple powder of 5.47 and 5.33% moisture content could be produced by oven-drying. This level of moisture content will prohibit bacterial growth in the pineapple powder but may have mold or yeast growth with increase storage period at environments with high humidity. Molds were observed on the 17th day at 89.00% relative humidity as exhibited by the moisture sorption isotherm data. This suggests that appropriate packaging with moisture barrier is recommended for pineapple powder. (Domingo *et al.,* 2017) [28] studies that by using appropriate ratio of juice, puree, and maltodextrin and appropriate oven drying conditions, a good oven-dried pineapple powder could be obtained.

Pineapple Vinegar

Processing pineapple into vinegar is a good way of turning over ripe, blemished or surplus fruits, discarded cores, peels and trimmings into money. Although not as popular as coconut vinegar, pineapple vinegar is already being exported in small quantities. Pineapple vinegar can be produced by alcohol and acetic acid fermentation.

(Raji *et al.,* 2012) [66] preparing vinegar from fermented pineapple peel. The process was carried out in two-stage fermentation with baker yeast (Saccharomyces cerevisae) and other reagents. Pineapple peel was allowed to ferment for 48hrs for conversion of sugar to ethanol. Then a chanced approach was applied for the conversion of ethanol by acetic acid bacteria (Acetobacter aceti) to vinegar with continuous aeration for nine days. The results indicated that vinegar yield increased with an increasing acidity. The results also revealed that pineapple peel produced the desired and optimum yield of vinegar. Hence, the following parameters; pH, density, refractive index, viscosity, % acetic acid and acid value were evaluated and recorded as; 2.80, 1.08 g/ml, 1.390, 0.94cp, 4.77 and 0.0477 respectively, these values compare well with the standard values. The conversion of pineapple peels (waste) to vinegar (useful product) will reduce environmental pollution and in addition yield value added product.

Vinegar Production from Pineapple Wastes –Preliminary Scarification Trials by (Roda *et al.,* 2014) [70]. The purpose of the present study was to deep saccharification process, the first step of vinegar production from pineapple wastes, looked into feasibility of producing the greatest yield of reducing sugars from peel and core of pineapples. Pre-treatments and enzymatic saccharification procedures were evaluated for the conversion of pineapple waste fibers to monomeric sugars with different enzymes (cellulolytic, amylolytic and invertase). Firstly, cellulolytic enzymes followed by invertase were added achieving final reducing sugars of almost 67 and 100 g/kg of fresh weight of pineapple peel and core, respectively. Optimal time-temperature conditions of this enzymatic hydrolysis were proven to be 24 h-50 °C. Secondly, to open the bundles of lignocelluloses in order to access the polymer chains of cellulose and hemicelluloses to enzymatic action, a 10 min- 143.27 kPa treatment was performed. Finally, it was turned out that addition of thermostable α-amylase during the 143.27 kPa pretreatment and the subsequent hydrolysis with a mix of cellulolytic and amylolytic enzymes allowed reaching about 100 and 330 g/kgfw of reducing sugars in pineapple peels and core, respectively.

Zhenhua *et al.,* (2006) [83] developed pineapple vinegar by mixed-yeast fermentation. After juice was extracted from pineapple bran, its residue was added with yeast and lactic acid bacteria for alcoholic fermentation at 22 ℃. When alcohol content stopped rising, acetic acid bacteria was added for acetic fermentation at 30 ℃ with full ventilation. When acid contents stopped rising, acetic fermentation was stopped and vinegar was aged at 18-20 ℃ for 30 days. The physical and chemical indexes of pineapple vinegar such brewed included a total acid of 4.52g/100mL (in acetic acid) and a reducing sugar of 1.58g/100mL. Gas chromatography and mass spectrometry were used for test and analysis of the vinegar which centrifugation and filtration were carried on and was blended for a concentration of 2%. The result showed that the vinegar contained 36 flavors, including 13 volatile components and 23 nonvolatile components. The combined action of these substances brought pineapple vinegar unique flavor.

Nanwei *et al.,* 2010) [57] studied the fermentation process of pineapple bran into vinegar by comprehensive consideration of vinegar's acetic acid content and sensory evaluation. This fermentation's optimal process conditions included: juice extraction rate would be the highest if pectinase addition was 200mg/L. For alcoholic fermentation, the initial sugar degree was controlled at 16°Bx with an inoculum concentration of 11%, a fermentation temperature of 18 ℃ and a fermentation time of three days. For acetic fermentation, its optimal conditions included an initial alcohol content of 12%, an inoculum concentration of 12%, a fermentation temperature of 29 ℃ and a fermentation time of four days. Accordingly the vinegar such brewed tasted soft and fruity with moderate sweet and sour.

Caiqin *et al.,* (2010) [18] studied the fermentation process of pineapple bran into vinegar by semi-solid method. This method used pineapple bran as its main raw material, fruit-wine yeast and Hennaing 1.01 acetic bacteria powder as its microbial strains and semi-solid fermentation and secondary sugar supplementation as its processes to define its optimal brewing process parameters. The results showed that for alcoholic fermentation, its optimal conditions included a yeast addition of 0.3%, a fermentation temperature of 22 ℃, a sugar degree of 16°Brix, a pH of 3.5, and a fermentation time of 6 days; for acetic fermentation, the best process conditions included a glucose addition of 2%, an initial ethanol fraction of 8% (in volume), a fermentation temperature of 29 ℃, an acetic bacteria powder addition of 0.09%, and a fermentation time of 3~4 days. Finally, a semi-solid mixture of pineapple vinegar with a total acid (acetate) content of up to 6.78g/100g was formed with an acetic acid conversion rate of 82.5%. After soaking, filtering and aging for 1~2 months, the final product of pineapple vinegar with a total acid content (acetic acid) of 3.672g/100ml was formed which looked golden, clear and transparent with both acidic aroma and pineapple's fruity aroma and also soft and refreshing taste.

Pineapple Wine

Wine is an alcoholic beverage typically made of fermented fruit juice (Okafor 2007) [61]. Any fruit with good proportion of sugar may be used in producing wine and the resultant wine is normally named after the fruit. The type of wine to be produced dictates the fruit and strain of yeast to be involved (Amerine and Kunkee 2005) [4]. Preservatives used in wine making include sulphur-dioxide, potassium sorbate, sorbic acid and metabisulphides (Idise and Izuagbe 1988) [42]. High concentration of these preservatives in wine, aside causing off odors, can induce lots of systemic disorderliness such as breathing problems in Asthmatic patients and gastrointestinal disturbances in allergic persons. The effects of bioaccumulation of these chemicals could further compound these situations (Okafor, 2007) [61]. Wine were produced from pineapple using its innate micro-organisms, granulated sugar and baker's yeast in varying proportions. There was evidence of Malo-lactic fermentation. The wines produced showed no appreciable differences in the tested parameters – pH, temperature, optical density, specific gravity, total aerobic counts, % alcohol (v/v) and % titratable acidity – taste-testing as well as statistically at 95% confidence level. They could be consumed within 48 h. No chemical preservatives were required. However, there is the need for further research to ascertain the shelf life of the wines. (Idise and Emmanuel 2012) [42].

Prakitchaiwattana *et al.,* 2017 [64] studies aimed to evaluate the de-acidification of fresh whole pineapple juice wine by secondary malolactic fermentation with lactic acid bacteria (LAB). Pineapple juice was primary fermented with a mixed yeast of Saccharomycodes ludwigii S1 and Hanseniaspora uvarum TISTR5153 at 25–30 ºC for 7 d and then secondary LAB fermented with Oenococcusoeni LALVIN 31TM and/or O. oeni Enoferm ALPHA at 25–30 ºC for 4 weeks. Optimal secondary fermentation was found in the co-presence of both LAB, which decreased the malic acid content to 5.58 g/L forming lactic acid (4.39 g/L). The secondary ferment still contained 10% (v/v) alcohol but had a higher TTA (10.6 g/L) and pH (3.80). The sensory score of the wine after fermentation with both LAB isolates was increased and this was higher than when fermented with either LAB alone. Thus, secondary fermentation of pineapple wine using O. oeni could significantly improve the wine quality.

The fermentation process of pineapple fruit wine was studied (Ningli *et al.,* 2017) [60]. The juice was inoculated with 5% (v/v) active yeast and held at 20 °C for 7 days. Total sugar and pH decreased while the alcoholic strength increased with increasing length of fermentation. The fermented fruit wine contains 2.29 g/L total acid, 10.2% (v/v) alcohol, 5.4 °Brix soluble solids, pH 3.52. Pineapple wine detected 68 kinds of aroma components, including 34 esters, 13 alcohols. The ester material accounted for 52.25% of the main aroma components. The quality and sensory evaluation results indicated that pineapple fruit wine belongs to a kind of low alcohol wine, so it is easy to be accepted by the public.

Production of wine from mixed fruits by Archibong *et al.,* 2015 [9]. In this study was aimed at investigating the suitability of two fruits (Orange and Pineapple) as substrates for wine production and the efficiency of yeast isolated from palm wine for alcoholic fermentation of fruits. During fermentation aliquot samples were removed daily from the fermentation tank for analysis of pH, temperature, alcohol content and reducing sugars, using standard procedures. pH of the fruit “must”. During the period of fermentation ranged from 3.0 to 3.5. During the fermentation period consistent increase in alcohol content was observed with time. At the end of 21days fermentation, the concentration of alcohol in the fruit wine was observed to be 4.2%. The reducing sugar content of the wine was observed to be 0.082. This study revealed that acceptable wine could be produced from these fruit with yeast from palm wine.

Utilization of pineapple waste

Tropical and subtropical fruits processing have considerably higher ratios of by-products than the temperate fruits (Schieber *et al.,* 2001) [76]. Pineapple by-products are not exceptions and they consist basically of the residual pulp, peels, stem and leaves. It is anticipated that discarded fruit as well as the waste material can be utilized for further industrial processes like fermentation, bioactive component extraction, etc. There has been numerous works on the utilization of waste obtained from fruit and vegetable, dairy and meat industries. In this regard, several efforts have been made in order to utilize pineapple wastes obtained from different sources. The wastes from pineapple canneries have been used as the substrate for bromelain, organic acids, ethanol, etc. since these are potential source of sugars, vitamins and growth factors (Larrauri *et al., 1997*; Nigam, 1999 a,b; Dacera *et al.,* 2009) [52, 58, 59, 24]. Several studies have been carried out since decades on trying to explore the possibility of using these wastes. In past, sugar has been obtained from pineapple effluent by ion exchange and further use it in syrup for canning pineapple slices (Beohner and Mindler, 1949) [13]. This paper would try to collect and gather information regarding the utilization of pineapple wastes. Upadhyay, *et al.,* 2010 [82] concluded that the pineapple wastes have promising prospect. Thus, environmentally polluting by-products could be converted into products with a higher economic value than the main product. However, verification of this hypothesis is indispensable in order to apply pineapple cannery waste as industrial raw materials

One pineapple fruit total weight is 400 gr of which 60 g is of peel wastes. In order to reduce such pineapple peel wastes (PPW), processing to a valuable product using an environmentally friendly technique is indispensable. PPW contained phenolic compound, ferulic acid, and vitamin A and C as antioxidant. This study aimed to PPW using ethanol and water as well as to analyze its chemical properties. Both dried and fresh PPW were extracted using mixtures of ethanol and water with various concentrations ranging from 15 to 95% (v/v) at room temperature for 24 h. The chemical properties, such as antioxidant activity, total phenolic content (Gallic acid equivalent/GAE), and total sugar content were determined. (Saraswaty *et al.,* 2017) [75]. The results showed that the range of Inhibition Concentration (IC) 50 value as antioxidant activity of extracts from dried and fresh PPW were in the range of 0.8±0.05 to 1.3±0.09 mg.mL-1 and 0.25±0.01 to 0.59±0.01 mg.mL-1, respectively, with the highest antioxidant activity was in water extract. The highest of total phenolic content of 0.9 mg.g-1 GAE, was also found in water extract.

Bioethanol production from pineapple wastes by (Tropea *et al.,* 2017) [81]. The purpose of this study was to investigate the potential to transform such residues into ethanol after enzymatic scarification of plant cell walls, and fermentation of the resulting simple sugars using the Saccharomyces cerevisiae NCYC 2826 strain. Three different fermentation modes, direct fermentation, separate hydrolysis and fermentation, and simultaneous scarification and fermentation of the biomass were tested and compared. The results show that the main sugars obtained from pineapple waste were: glucose, uronic acid, xylose, galactose, arabinose and mannose. The highest ethanol yield was achieved after 30 hours of simultaneous scarification and fermentation, and reached up to 3.9% (v/v), corresponding to the 96% of the theoretical yield.

Saccharomyces cerevisiae and Zymomonas mobiles were grown on pineapple waste and their alcohol production characteristics compared by Koffi and Han 1990 [50]. The pineapple waste consisted of 19% cellulose, 22% hemi-cellulose, 5% lignin and 53% cell soluble matters but concentration of soluble sugars, which included 5.2% sucrose, 3.1% glucose and 3.4% fructose, was relatively low and pretreatment of the substrate was needed. Pretreatment of pineapple waste with cellulose and hemi-cellulose and then fermentation with S. cerevisiae or Z. mobiles' produced about 8% ethanol from pineapple waste in 48 h.

Pineapple bran contains a variety of vitamins and amino acids with rich nutrition and is suitable for brewing fruit vinegar. Pineapple resources are rich in China and the development of pineapple bran into vinegar can add the value of pineapple fruit processing by 10% or more. This not only can improve the utilization and conversion rate of pineapple bran, but also realize the comprehensive utilization of limited natural resources by making waste profitable, achieve the efficient utilization of pineapple by-products, reduce resource waste, and ease the pollution of pineapple by-products on ecological environment significantly. In addition, it conforms to the developmental trend of condiment functionalization in both China and foreign countries. So, wide market prospect and high social and economic benefits can be found from it (Huanga *et al.*, 2017) [41].

Conclusion

Pineapple has a lot of potential to be processed for value addition. Its flavor is acceptable by almost all classes of the people as a refreshing drink in the summer. Pineapple is a tropical fruit which is consumed fresh or in a processed form. It contains nutrients which are good for human health. It also contains antioxidants and protease. It is useful against malignant cell formation, thrombus formation and inflammation. Processed pineapples are consumed worldwide and processing industries are trying out or using new technologies to retain the nutritional quality of the pineapple fruit. Pineapple wastes from these processing industries can be utilized to produce methane, animal feed and manure. The health and functional foods from the pineapple is an area which still requires the attention of scientific fraternity.

References

1. Achumi LV, Peter ES, Das A. Studies on preparation of gummy candy using pineapple juice and carrot juice. International Journal of Chemical Studies 2018; 6(5):1015-1018, P-ISSN: 2349–8528 E-ISSN: 2321–4902.
2. Adhikari B, Howes T, Bhandari BR, Troung V. Effect of Addition of Maltodextrin on Drying Kinetics and Stickiness of Sugar and Acid-rich Foods During Convective Drying Experiments and Modeling. J. Food Eng. 2004; 62:53-68.
3. Amaravathi1 T, Vennila P, Hemalatha G, Parimalam P. Spiced Pineapple Ready-To-Serve Beverages. Indian Journal of Science and Technology. 2014; 7(11):1827-1831, ISSN (Print): 0974-6846 ISSN (Online): 0974-5645.
4. Amerine MA, Kunkee RE. Microbiology of Winemaking. Am. Rev. Microbiol. 2005; 22:232-258.
5. Amerine MA, Kunkee RE. Microbiology of Winemaking. Am. Rev. Microbiol. 2005; 22:232-258.
6. Anonymous. Competitiveness in pineapple canning Industry, 2003. http//:www.hicbusiness.org/A
7. Anonymous. Agricultural and processed food products export development authority. Area and production of pineapple, 2007. http://www.apeda.com.
8. Anonymous. Sales of Food, Information Bulletin 29, State of Indiana, Indianapolis, IN, USA, 2016.
9. Archibong EJ, Ezemba CC, Chukwujama IC, Archibong, UE. Production of wine from mixed fruits: pineapple and orange using yeast isolated from palm wine World Journal of Pharmacy and Pharmaceutical Sciences. 2015; 4(8):126-136, ISSN 2278 – 4357
10. Awolu OO, Okedele GO, Ojewumi ME, Oseyemi FG. Functional Jam Production from Blends of Banana, Pineapple and Watermelon Pulp. International Journal of Food Science and Biotechnology. 2018; 3(1):x-x. doi: 10.11648/j.ijfsb.20180301.12.
11. Bartolomew AP, Pilar R, Foster C. Pineapple fruit: morphological characteristics, chemical composition and sensory analysis of Red Spanish and Smooth cayenne cultivars. Food Chemistry, 1995; 53:75-79.
12. Basu S, Shivhare U, Raghavan G. Time Dependent Rheological Characteristics of Pineapple Jam. International Journal of Food Engineering. 2007; 3(3), Art. 1, DOI: 10.2202/1556-3758.1229
13. Beohner HL, Mindler AB. Ion exchange in waste treatment. Ind. and Eng. Chem., 1949; 41:448-452.
14. Bhandari BR, Dutta N, Howes T. Problems Associated with Spray Drying of Sugar-rich Food, Dry. Technol., 1997; 15(2):671-684.
15. Bhavsagar MS, Awaz HB, Patange UL. Manufacture of pineapple flavored beverage from chhana whey. J. Dairying, Foods & H.S. 2010; 29(2):110-113.
16. Bhuiyan MHR, Kabir MR. Development of drink based on pineapple, orange and grapefruit. Bangladesh Research Publications Journal ISSN: 1998-2003, 2012; 7(2).
17. Biswas S, Masih D, Singh M, Sonkar C. Development and Quality Evaluation of *Aloe vera* and Pineapple juice Blended Beverage. International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056, 2016; 3(10), p-ISSN: 2395-0072.
18. Caiqin GU, Wanling C. Semi-solid Process of Fermenting Pineapple into Vinegar [J]. Food Science Journal. 2010; 31(6):56-60.
19. Chauca M, Stringheta PC, Ramos AM, Cal-Vidal J. Effect of the Carriers on the Microstructure of Mango Powder Obtained by Spray Drying and its Functional Characterization, Inno. Food Sci. Emerg. Technol. 2005; 6:420-428.
20. Chaudhari AP, Dhake KP, Bari Manisha. Osmotic dehydration of pineapple. International journal in it and engg. 2015; 3(4):2321-1776.
21. Chaudhary V, Kumar V, Singh GR, Singh J, Chauhan N, Kumar K. To study the osmotic dehydration characteristics of pineapple (*Ananas comosus*) slices. International Journal of Chemical Studies. 2018; 6(5):1081-1083, P-ISSN: 2349–8528 E-ISSN: 2321–4902.
22. Chavan UD, Amarowicz R. Osmotic Dehydration Process for Preservation of Fruits and Vegetables Journal of Food Research. 2012; 1(2).
23. Couto DS, Cabral LMC, Damatta VM, Deliza R, Freitas DC. Concentration of pineapple juice by reverse osmosis physicochemical characteristics and consumer acceptance Ciênc. Tecnol. Aliment. Campinas, 2011; 31(4):905-910, out.-dez. ISSN 0101-2061
24. Dacera DDM, Babel S, Parkpian P. Potential for land application of contaminated sewage sludge treated with fermentaed liquid from pineapple wastes. J of Hazardous Materials. 2009; 167:866-872.
25. Debnath P, Dey P, Chanda A, Bhakta T. A Survey on Pineapple and its medicinal value. Scholars Academic J Pharm. 2012; 1(1).
26. Diamante LM, Bai X, Busch J. Fruit Leathers: Method of Preparation and Effect of Different Conditions on Qualities Hindawi Publishing Corporation International Journal of Food Science. 2014; Article ID 139890, 12 pages http://dx.doi.org/10.1155/2014/139890
27. Doke A, Arya A, Bhalerao JG, Shinde RS. Development of value added papaya and pineapple jams. Food Sci. Res. J. 2017; 8(1):76-82,
DOI: 10.15740/HAS/FSRJ/8.1/76-82.
28. Domingo CA, Vera WM, Pambid RC. Exploring Oven-drying Technique in Producing Pineapple Powder Asia Pacific Journal of Multidisciplinary Research. 2017; 5(4):90-96. Part II P-ISSN 2350-7756 E-ISSN 2350-8442.

29. DP, Paull RE, Rohrbach KG (eds) The Pineapple: Botany, Production and Uses. CABI Publ, Oxon, UK, p.1-12
30. Dull GG. The pineapple: general. In: A. C. Hulme (Ed.). The biochemistry of fruits and their products, Academic Press, New York. 1971; 2:303-324.
31. Ekeledo EN, Omodamiro RM, Oti E. Development and evaluation of turmeric: Ginger based pineapple drinks and food flavourings, Asian Journal of Plant Science and Research. 2013; 3(3):139-141, ISSN: 2249-7412.
32. Essien SO, Usoh EU. Effect of temperature on the rheological properties of pineapple juice. International Journal of Latest Research in Science and Technology. 2016 ISSN (Online):2278-5299, 2016; 5(2):86-90, ISSN: 2278-5299 86,
33. Farid Md. H, Shaheen A. Nutritional Value and Medicinal Benefits of Pineapple. International Journal of Nutrition and Food Sciences. 2015; 4(1):84-88. doi: 10.11648/j.ijnfs.20150401.22
34. Farooqui A, Peter S, Ibrahim M. Preparation of Pineapple Jam Blended With Carrot. International Journal of Multidisciplinary Research and Development. 2015; 2(8):82-84 e-ISSN: 2349-4182, p-ISSN: 2349-5979
35. Gabas AL, Telis VRN, Sobral PJA, Telis-Romero J. Effect of Maltodextrin and Arabic Gum in Water Vapor Sorption Thermodynamic Properties of Vacuum Dried Pineapple Pulp Powder, J Food Eng. 2007; 82:246-252.
36. Gopalan I, Mohanram M. Fruits. National Institute of Nutrition. Indian Council of Medical Research, Hyderabad. 1996, 1- 53.
37. Hamid S. Carl Linnaeus (1707-0778) and plants in the traditions (Hadith) of Prophet Muhammad. Indian Journal of Traditional Knowledge. 2007; 6(4):692-694.
38. Hossain MF, Akhtar S, Anwar M. Nutritional Value and Medicinal Benefits of Pineapple. International Journal of Nutrition and Food Sciences. 2015; 4(1):84-88. doi: 10.11648/j.ijnfs.20150401.22
39. Hounhouigan MH, Linnemann AR, Soumanou MM, Vanboekel MAJS. Effect of Processing on the Quality of Pineapple Juice. Food Reviews International. 2014; 30:112-133, ISSN: 8755-9129 print / 1525-6103, DOI: 10.1080/87559129.2014.883632
40. http://apps.fao.org
41. Huanga H, Liao L, Lin L, Wang X, Gong X, Zhang F, Gong J. Progress in the Study of Pineapple Bran Vinegar, Advances in Engineering Research, 2017; 125.
42. Idise, Emmanuel O. Studies of wine produced from pineapple, International Journal for Biotechnology and Molecular Biology Research. 2012; 3(1):1-7. DOI: 10.5897/IJBMBR11.034 ISSN 2141-2154 ©2012 Academic Journals
43. Islam MA, Ahmad I, Ahmed S, Sarker A. Biochemical Composition and Shelf Life Study of Mixed Fruit Juice from Orange & Pineapple J. Environ. Sci. & Natural Resources. 2014; 7(1):227-232, 2014 ISSN 1999-7361
44. Jittanit W, Niti-Att S, Techanuntachaikul O. Study of Spray Drying of Pineapple Juice Using Maltodextrin as an Adjunct Chiang Mai J. Sci. 2010; 37(3):498-506. www.science.cmu.ac.th/journal-science/josci.html
45. Jori D, Ladole M, Gore A, Bhand B. Study on Effect of Carbonation on Storage and Stability of Pineapple Fruit Juice. International Journal of Engineering Research & Technology (IJERT). 2013; 2(12), ISSN: 2278-01
46. José E, Zapata M, Johan M, Arias A, Gelmy L. Ciro G. 2011. Optimization of osmotic dehydration of pineapple using the response surface methodology optimization osmotic pineapple (*Ananas cosmoses*.) aplicando superficies de respuesta Agron. Colomb. 29.
47. Jothi JS, Islam M, Islam MS, Rahman RT, Akther S. Development and Shelf-Life Prediction of Pineapple Preserve and Candy. International Journal of Innovation and Scientific Research. ISSN 2351-8014, 2014; 10(1):77-82.
48. Joy PP. Benefits and uses of pineapple. Pineapple Research Station, Kerala Agricultural University, Kerala, India, 2010. [http://www.kau.edu/prsvkm/Html/BenefitsofPA.htm]
49. Khanom SA, Rahman M, Uddin MB. Preparation of pineapple candy using osmotic dehydration combined with solar drying. A Scientific Journal of Krishi Foundation. 2015; 13(1):87-93, ISSN 2304-7321 (Online), ISSN 1729-5211.
50. Koffi BL, Han YW. Alcohol production from pineapple waste World Journal of Microbiology and Biotechnology. 1990; 6(3):281-284.
51. Kumar R, Kirad KS. Effect of Different Levels of Sugar in the Preparation of Pineapple (*Ananas comosus* L.) Candy. World Research Journal of Biotechnology. ISSN: 2322-0600 & E-ISSN: 2322-0619, 2013; 1(1):01-03.
52. Larrauri JA, Ruperez P, Calixto FS. Pineapple shell as a source of dietary fiber with associated polyphenols. J. of Agri. and Food Chem. 1997; 45:4028-4031.
53. Laura A, Ramallo, Rodolfo HM. Rate of Water Loss and Sugar Uptake during the Osmotic Dehydration of Pineapple. Brazilian archives of biology and technology in international journal. 2005; 48(5):761-770.
54. Loeillet D. The world pineapple market: the importance of Europe. Acta Hort. 1997; 425:37-48.
55. Mansoor B, Sawate AR, Patil BM, Kshirsagar RB. Studies on development of low calorie pineapple RTS beverage by using artificial sweeteners. Food Sci. Res. J. 2017; 8(1):59-63, DOI: 10.15740/HAS/FSRJ/8.1/59-63.
56. Nakasone H, Paull R. Tropical Fruits. CABI Publ, Wallingford, UK, New York, USA, 1998.
57. Nanwei LI, Changhai LIU, Jinming H. Study on Process of Fermenting Pineapple into Fruit Vinegar [J]. Chinese Condiment Journal. 2010; 35(4):76-78.
58. Nigam JN. Continuous ethanol production from pineapple cannery waste. Journal of Biotechnology. 1999a; 72:197-202.
59. Nigam JN. Continuous cultivation of the yeast Candida utilis at different dilution rates on pineapple cannery waste. World J of Micro. and Biotech. 1999b; 15:115-117.
60. Ningli Q, Lina M, Liuji L, Gong D, Jianzhi Y. Production and Quality Evaluation of Pineapple Fruit Wine. 1st International Global on Renewable Energy and Development (IGRED 2017) IOP Publishing IOP Conf. Series: Earth and Environmental Science, 2017; 100. 012028 doi:10.1088/1755-1315/100/1/012028
61. Okafor N. Microbiology and Biochemistry of Oil Palmwine. Adv. Appl. Microbiol. 2007; 24:237-255.
62. Pee S, Bloom MW. Current and potential role of specially formulated foods and food supplements for preventing malnutrition among 6- to 23-month-old children and for treating moderate malnutrition among 6- to 59-monthold children. Food and Nutrition Bulletin. 2009; 30(3):434-463.
63. Phimpharian C, Jangchud A, Jangchud K, Therdthai N, Prinyawiwatkul W. Physicochemical characteristics and

sensory optimization of pineapple leather snack as affected by glucose syrup and pectin concentrations. International Journal of Food Science and Technology. 2011; 46(5):972-981.
64. Prakitchaiwattana C, Boonin K, Kaewklin P. De-acidification of fresh whole pineapple juice wine by secondary malolactic fermentation with lactic acid bacteria, International Food Research Journal. 2017; 24(1):223-231.
65. Rahman MS, Lamb L. Osmotic dehydration of pineapple. J Food Sci. Technol. 1990; 27:50-152.
66. Raji YO, Jibril M, Misau IM, Danjuma BY. Production of vinegar from pineapple peel. International journal of advanced scientific research and technology. 2012; 2(3). ISSN: 2249-9954
67. Ramolla LA, Mascheroni RH. Rate of water loss and sugar uptake during the osmotic dehydration of pineapple. Braz Arch Biol Technol. 2005; 48(5):761-770.
68. Rashmi HB, Doreyappa G, Mukanda GK. Studies on osmo-air dehydration of pineapple fruits. J. Food Sci. Technol. 2005; 42:64-67.
69. Rasid, Kader, Hosain. Fruits of Bangladesh, 1st ed. Rashid Publishing House, Joydevpur, Gazipur, Bangladesh. 1987; pp.232.
70. Roda A, De Faveri DM, Dordoni R, Lambri M. Vinegar production from pineapple wastes –preliminary saccharification trials, Chemical Engineering Transactions, 2014; 37:607-612. DOI: 10.3303/CET1437102
71. Rohrbach KG, Leal F, Coppens D, Eeckenbrugge G. History, distribution and world production. In: Bartholomew, 2003.
72. Saad S. The world pineapple market; when growth goes hand in hand with diversity, 2004. http//:www.tanusi.com/
73. Sabahelkhier KM, Hussain AS, Ishag KEA. Effect of maturity stage on protein fractionation, in vitro protein digestibility and anti-nutrition factors in pineapple (*Ananas comosus*) fruit grown in Southern Sudan. Afr. J. Food Sci. 2010; 4(8):550-552.
74. Saini CS, Sharma HK. Effect of pectin coating on colour and quality of dehydrated pineapple during storage. Asian Journal Dairy & Food Res. 2016; 35(2):120-129. Print ISSN: 0971-4456 / Online ISSN: 0976-0563.
75. Saraswaty V, Risdian C, Primadona I, Andriyani R, Andayani DGS, Mozef T. Pineapple peel wastes as a potential source of antioxidant compounds, IOP Conf. Ser.: Earth Environ. Sci. 2017; 60:012-013.
76. Schieber A, Stintzing FC, Carle R. By-products of plant food processing as a source of functional compounds-recent developments. Trends in Food Sci. and Tech. 2001; 12:401-413.
77. Shaari NA, Sulaiman R, Rahman RA, Bakar J. Production of pineapple fruit (*Ananas comosus*) powder using foam mat drying: Effect of whipping time and egg albumen concentration J Food Process Preserv. 2017; e13467. https://doi.org/10.1111/jfpp.13467
78. Shukla M, Jha YK, Admassu S. Development of Probiotic Beverage from Whey and Pineapple Juice. J Food Process Technol. 2013; 4:206. doi:10.4172/2157-7110.1000206.
79. Sindumathi G, Premalatha MR. Development and Storage Studies of Naturally Flavored Papaya-Pineapple Blended Ready-to-Serve (RTS) Beverages, International Journal of Science and Research (IJSR). ISSN (Online): 2319-7064, 2015; 4(2).
80. Sucharitha KV, Beulah AM, Sahitya C. Development and standardization of ber pineapple jam. International Journal of Food, Agriculture and Veterinary Sciences. ISSN: 2277-209X, 2012; 2(3):126-130.
81. Tropea A, Wilson D, Torre LG, Curto RB, Saugman P, Davies PT, *et al*. Bioethanol production from pineapple wastes Journal of Food Research. 2014; 3(4), ISSN 1927-0887 E-ISSN 1927-0895
82. Upadhyay A, Lama JP, Tawata S. Utilization of Pineapple Waste J. Food Sci. & Technol. Nepal, 2010; 6(10-18).
83. Zhenhua FU, Huayong C, Yonghua W. Analysis on Pineapple Vinegar’s Flavor [J]. China Brewing Journal. 2006; 12:118-121.