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Pineapple Waste and Its Utilization

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ABSTRACT

Pineapple is one of the most consumed fruits in tropical and subtropical regions as it is a good source of essential minerals and vitamins with negligible fat content. The major concern in recent light is the waste obtained from pineapple. Waste from pineapple accounts for a large portion of landfill garbage which acts as pollutants. Thus, we need innovation and thoughts to utilize the pineapple waste in a useful form. In this paper, we have talked about its nutritive value, production figure, varieties and utilization. Pineapple waste, particularly peels, has a high sugar content, thus it can be used for making wine and vinegar production. Also, from pineapple waste, organic acids can be obtained like lactic acid and citric acid. A proteolytic enzyme obtained from pineapple waste is commonly known as bromelain. And application across various fields, for instance, it can be used in the making of paper bags, animal feed, and biogas and the abundance of cellulose content in pineapple particularly in pineapple leaves can be used for the production of cellulose Nano crystals.

KEYWORDS:Application, nutritive value, pineapple, utilization, waste

1. INTRODUCTION

The pineapple (Ananas comosus) is a prominent tropical and subtropical plant. It is one of India's most important commercial fruit crops. With an annual production of roughly 1.2 million tonnes, India is the sixth-largest pineapple producer in the world. Thailand, the Philippines, Brazil, China, Nigeria, Mexico, Indonesia, Colombia, and the United States are among the top producers [1]. The pineapple is the most popular edible species of the Bromeliaceae family. This plant has a wide range of pharmacological activities, including antibacterial, antihyperlipidemic, anti-dysuria, antidiabetic, and anticancer capabilities, in addition to agricultural purposes such as nourishing food [2].

Pineapple is one of the most loved fruits in the tropical and subtropical region as its consumption is on the higher side, hence the wastage also. Thus we need innovation and thoughts to utilize the pineapple waste in a useful form. One of the ways of utilizing pineapple waste is a biorefinery. Biorefinery is a similar concept like petroleum refinery where biomasses are converted into energy and other beneficial byproducts such as biofuels, biochemicals etc. Biorefinery systems have emerged as a promising path for energy generation in the form of combined heat and power (CHP) and biofuels, as well as chemical plants, with significant environmental benefits [3]. The pineapple peels and core are a good source of the protease bromelain, which has potential uses in the food and pharmaceutical industries. Bioethanol, bio-butanol, xylitol, succinic acid,lactic acid, polyhydroxy butyrate, and other biobased compounds can be made from the carbohydrate-rich waste of pineapple [4].

The conversion of pineapple waste to biobased compounds appears to be the most sustainable option to reduce reliance on fossil fuels as well as to reduce the bio wastage. As a result, the general goal of this study is to offer a comprehensive overview of pineapple's nutritive value, pineapple waste utilization and its application. With these findings, pineapple growers and researchers may be able to obtain a better understanding of the pineapple by-products.

2. NUTRITION FACTS

The pineapple fruit contains minerals, fibers and enzyme, which helps in digestion and also maintaining balanced nutrition. The nutritional facts are shown in the following table below.

Minerals

In this table minerals contained are given mg/100gm, pineapple contains traces of zinc and chromium while potassium contained is the highest followed by sodium content.

Table CCLXXIII: Minerals content [5]

Minerals (mg/100 g)	
Potassium	37
Sodium	34.7
Magnesium	33
Calcium	20
Sulphur	20
Chlorine	13
Phosphorus	9
Iron	2.42
Manganese	0.56
Copper	0.13
Zinc	0.11
Chromium	0.011

The Food value of pineapple

In this table values are given in percentage; pineapple is a hydrating fruit with negligible fat contained.

Table CCLXXIII: The food value of pineapple [5]

Moisture (%)	87.8
Carbohydrate (%)	10.8
Protein (%)	0.4
Mineral matter (%)	0.4
Fat (%)	0.1
Calories (kcal./100 g)	48
Fiber (%)	0.5

Production of Pineapple

In this table yearly pineapple production are mentioned from the year 2017 to 2021 and values are in '000MT'. Pineapple production was highest for the year 2020-2021 with 1799000MT.

Table III: Production of Pineapple [5]

Years	Production of pineapple '000MT'
2017-2018	1706
2018-2019	1718
2019-2020	1729
2020-2021	1799

State wise variety of pineapple

The above table showcases the variety of pineapple produced across India. Queen variety is predominant in the country whereas Kew is most favored commercial variety of pineapple.

Table IV: State wise variety of pineapple [6]

States	Variety of Pineapple
Assam and Northeast states	Kew, queen, Mauritius
West Bengal	Giant kew, Queen
Kerala	Mauritius, kew, queen
Assam	Jaldhup, Lakhat

Pineapple production in 2012-2013

This table depicts the state wish pineapple production for the year 2012 to 2013 and the values are in '000MT'. West Bengal produced the highest amount of pineapple in that tenure.

Table V: Pineapple production in 2012-2013 [5]

States	Production (000 MT)
West Bengal	310.00
Assam	268.82
Karnataka	169.30
Tripura	165.01
Bihar	139.22
Manipur	124.14
Meghalaya	109.39
Nagaland	85.00
Kerala	72.86
Arunachal Pradesh	67.58
Other	59.27
Total	1570

3. PINEAPPLE WASTE UTILIZATION

Pineapple waste contains several compounds that can be used to develop new and emerging technologies such as nutraceuticals, food, pharmaceuticals, biogas and bioethanol production. Bromelain extraction from pineapple waste has been studied extensively, but dietary fibers and phenolic antioxidants may be a new nutraceutical resource that could provide significant low-cost nutritional dietary supplements for low-income communities. The rapidly expanding functional food market has opened up new avenues for utilizing natural resources. In this regard, low-cost substrates such as pineapple wastes have a promising future. As a result, polluting by-products could be converted into products with a higher economic value than the main product; thus, valuable products from pineapple wastes could be obtained using sustainable pineapple waste utilization and novel scientific and technological methods [2]-[7].

Approximately 80% of pineapple parts, such as the crown, peels, leaves, core, and stems, are discarded during pineapple processing, transportation, and storage and end up as waste [8]-[9]. These wastes contain high levels of moisture, sugar, albumins, lipids, and vitamins that are susceptible to microbial degradation, contributing to environmental issues [10]. The growing amount of waste in landfills causes serious environmental issues because it inhibits the biological and chemical oxygen demand of ecosystems, causes site contamination, and increases the risk of infectious diseases [11]. These wastes can be converted into valuable products via biochemical (microbial fermentation and anaerobic digestion), thermochemical (pyrolysis, gasification, combustion, and incineration), and physicochemical (Trans esterification) processes [12].

Pineapple can be used to make a variety of valuable products, including nanocrystals, bromelain enzyme, bioactive compounds, wine, vinegar, biopolymer, bio-packaging, organic acid, adsorbent, biofuel, and biogas. Previously, pineapple waste was used to make phenolic antioxidants, anti-dyeing agents, and animal feed. Several studies focusing on the conversion of pineapple waste are discussed.

Bromelain enzyme

Bromelain is a proteolysis enzyme found in pineapple. It helps in digestion and is useful in a variety of applications like bromelain is recommended as a dietary supplement for lowering pain and swelling after surgery or injury, particularly in the nasal passage, gums, and other body regions. It's also used to treat osteoarthritis, cancer, digestive issues, and muscular pain. For burns, topical bromelain is recommended [13]. The main protease found in the bromelain enzyme is known as stem bromelain (EC 3.4.22.32) and fruit bromelain (EC 3.4.22.32) [14]. Peel or flesh have more bromelain activity than stem because of the enzyme and antioxidant of bromelain present in pineapple [15]. Bromelain was purified by tubular ceramic membranes and for enzyme recovery, transmembrane pressure and crossflow velocity were used. Bromelain's two-stage foam break-up achieves a high specific activity of 165.6 U/mg with a recovery rate of 45.2 per cent [16]. Bromelain filtration employing water micellar two-phase systems with ionic liquids acting as co-surfactants resulted in greater than 90% bromelain healing [17].

Bioethanol

Price-effective conversion of renewable resources into alcohol using pineapple waste started in the last decade. For ethanol fermentation, organisms like Saccharomyces cerevisiae and Zymomonasmobilis were used [18]. Because of a short supply of sugars such as sucrose, glucose and fructose for pretreatment, enzymes such as cellulase and hemicellulase were used for alcohol production. If the juice was not pretreated liquid effluents from various manufacturing stages were added. At a dilution rate of 0.05 h-1, the ethanol production was 92.5 per cent of the theoretical value. Immobilization of yeast in k-carrageenan boosted volumetric ethanol productivity by 11.5 times that of yeast cells at a 1.5 h-1 dilution rate [19]-[20].

Organic Acid

Organic acid has a wide range of applications in various industries for its demand as additives and chemical feedstock [21]. Lactic acid occupies a prominent position in the carboxylic acid family due to its use in both the food and non-food industries. It's used in the food industry as a preservative and acidulant. However, due to the raw materials used, commercial production of lactic acid is expensive (exploitation of biological waste). Using Lactobacillus lactis and the enzyme invertase to hydrolyze sucrose into glucose and fructose, some researchers have used pineapple syrup, a food processing waste, as a low-cost substrate for the production of lactic acid [22]. They obtained yields of 20 and 92 g/l from 20 and 100 g total sugars/l, respectively [22]-[23] used liquid pineapple waste as a substrate for Lactobacillus delbrueckii to ferment to lactic acid under anaerobic conditions for 72 hours. They used calcium alginate as an immobilization matrix to achieve a maximum yield of 0.7822- 0.8248 g lactic acid/g glucose under various temperature and pH conditions. Rhizopus arrhizus and Rhizopus oryzae produced 19.3 and 14.7 g/L of lactic acid from pineapple waste, respectively [24]. In addition to lactic acid, pineapple residues have been converted to succinic acid. The yield of succinic acid produced from pineapple liquid waste was nearly identical to that produced from other carbon feedstocks, according to the results of the fermentation [25]. Pineapple waste was also used to make citric acid. Aspergillus niger produced 15.51 g/L and 60.61 g/kg citric acid in the SSF of pineapple peel waste [26]-[27].

Wine and vinegar

Pineapple waste, particularly peels, has high sugar content, making them a valuable source for wine and vinegar production. As a result, it expands the possibilities for using pineapple waste to produce alcohol and acetic acid, which can then be used to make vinegar [8]. The optimum acetic acid yield (6.15 g/L) was found at 72 h fermentation time using the propionic bacterium acidipropionici acetic acid bacterial strain when making vinegar from pineapple peek using three different acetic acid bacteria strains [28]. After that, it was oxidised to acetic acid (vinegar), which had a total acidity of 3%. Wine made from pineapple peels and core, on the other hand, had a lower alcohol content of 7 per cent [29]. As a result, wine made from pineapple wine produced by Saccharomyces cerevisiae (6.60 per cent) and Saccharomyces bayanus (6.75 per cent) has a lower alcohol content [30]. Roda et al. reported in another study that good quality wines required a physical and enzymatic combination before alcohol fermentation. A significant difference in the wine's fruity character was detected by varying the Saccharomyces cerevisiae strain and temperature [31].

4. APPLICATION OF PINEAPPLE WASTE

The demand for pineapple is skyrocketing, and as a result, a lot of waste is being produced. During pineapple preparation, shipping, and storage, over 80% of the pineapple pieces, including the crown, peels, leaves, core, and stems, are abandoned and end up as waste material [8]-[9]. Thus, it is an important step to find other applications of waste material produced from pineapple. Here few of the applications are talked through.

Cellulose Nano crystals

The abundance of cellulose in biomass produces cellulose nanocrystals (CNC), which are one of the most suitable materials for nanocomposites. CNC is currently used as a reinforcing agent in the field of nanocomposites. CNC has a huge surface area, is non-toxic, hydrophilic, biocompatible, and biodegradable, and has a high mechanical strength [32]. When the CNC extracted from pineapple leaves waste is utilized as reinforcing fillers in natural rubber, the mechanical characteristics of the rubber are improved [33]. CNC extracted from pineapple waste has a crystallinity value of 92.13 per cent [34].

Biogas

Biogas is a combination of gases mostly made up of carbon dioxide and methane. It is a source of renewable energy. Crop residues, manure, municipal trash, plant products, effluent, green waste, and food waste are used for making it[42]. Biogas can be produced from pineapple peel and core [11]. Biogas produced from pineapple consists mainly of methane and carbon dioxide in a ratio of 3:2 [35].

Bioactive compound

Pineapples, as well as their waste, are high in antioxidants. A phenolic compound which has antioxidant, antibacterial, and anticancer properties, can inhibit the generation of free radicals induced by the oxidizing of biological molecules [36].The auto hydrolysis procedure yields polyphenols with significant antioxidant activity from pineapple waste. Rashad et al. evaluated the antioxidant and anticancer properties of pineapple wastes [37].

Use of pineapple waste for the production of decomposable pots

Decomposable pots are made from pineapple waste from the food industry, to substitute for plastic plant nursery bags and decrease trash. A 1:0 ratio of pineapple waste to adhesive, a coarse texture, and a pot thickness of 1 cm was the best formula [7].

Production of animal feeds

Several studies have reported the potential for use of pineapple waste for animal feed [38]. Pineapple waste includes leaves (crown) and stems that can be converted into food pellets for domestic birds and animals [39].Pineapple waste is rich in fiber and thus can serve as a good energy source while enabling digestion in poultry, and cattle [39].

Production of papers

The use of paper bags has been replaced by polythene bags in the last century. As polyethene bags are compostable so they pose as pollutants in nature. As a replacement for plastic, paper bags made of different plant-based or organic materials are reintroduced into the market. One such example is paper made from pineapple waste. Pineapple leaves (crown) are one of the agricultural wastes that might be used as a fiber source in papermaking. Holocellulose (70–82%), lignin (5–12%), and ash are all found in pineapple leaf fiber (1.1 per cent). Agricultural cellulosic fiber sources are sought after because of their constant supply, ease of use, and being renewable [40]-[41].

6. CONCLUSION

Pineapple is one of the most loved fruits in the tropical and subtropical region. And as its consumption is on the higher side, hence the wastage also. Pineapple waste contains a variety of substances that are useful in the development of new and emerging products, nutraceuticals, food, pharmaceuticals, and the production of biogas and bioethanol and even beverage also. Bromelain extraction is an example of supreme utilization of pineapple waste, where it is used as a dietary supplement with numerous benefits. Hence, we can conclude that pineapple waste is really not a waste as we can produce so many by-products from it which is economical as well as sustainable in nature

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Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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