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# Utilization of bioactive components present in pineapple waste: A review

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### Abstract
Among various fruits grown around the world and India, pineapple (*Ananas comosus*) is the most essential and delicious fruit. The growth in the use of food-based pineapple processing products has advanced rapidly globally as a result of this pineapple industry. With this, the production of waste also increases quickly. The utilization of waste in the fruit and vegetable processing industry is one of the most important and difficult jobs in the world. About 50% of the fruit mass ends up being discarded during industrial processing of the pineapple, becoming a residue. Crown, Peel, stem, and Core pineapple waste provides more than 50% misuse of the whole natural commodity. Several studies have validated the use of waste by various extraction, purification, and fermentation methods as novel, low-cost, economical well as natural sources of dietary fiber, antioxidants, enzymes, organic acids, food additives, essential oils, etc. This study explores the development characteristics of pineapple residue study focused on descriptive methods to examine the structure of knowledge in this field over the years, by year of publication, authors, the body of education, organizations, keywords, and citation analysis.

**Keywords:** pineapple, waste, bioactive components, waste utilization

### Introduction
Pineapple (*Ananas comosus*) is an admired tropical fruit having a short stem and slender hard leaves that grow to medium to large-sized fruit. After bananas and mangos, it is the third most important tropical fruit produced globally. Pineapples are cultivated on more than a million hectares of soil, resulting in US$ 9 billion to the global economy annually (Chen *et al*., 2019; Yabor *et al*., 2020) [1, 45]. India is one of the largest producers of pineapple and various processed goods, such as juice, jam, jelly, marmalade, etc. Thailand, the Philippines, Brazil, China, Nigeria, Mexico, Indonesia, Columbia, and the USA are the other leading producers. Pineapple is said to be primarily native to South America in Brazil and Paraguay. Piňa a, Nanas and Ananas are often referred to as pineapple. It's a perennial plant of tropical fruit and the only fruit of the Bromeliaceae family which can be edible or consume directly. Majorly four varieties of Pineapple available worldwide: Smooth Cayenne, Red Spanish, Queen, and Abacaxi (Saloni *et al*., 2017; Salve & Ray, 2020) [41, 42]. Due to their pleasant aroma and flavor pineapples and derived products are popular. Pineapple, at the side of its sweet flavor, is very wealthy in essential nutrients consisting of potassium and calcium, vitamin C, copper, folate, glycans, fiber, and different crucial factors. All these substances make pineapple an excellent candidate for part of a balanced dietary weight-reduction plan. One of the most favorable aspects of its composition is that it consists of a minimum amount of fat and sodium, but incorporates high quantities of carbohydrates. The leader medicinal aspect of pineapple is bromelain which turned into diagnosed within the late nineteenth century. Its therapeutic efficiency changed into found out in 1957 while for the first time it changed into observed that pineapple became one among its foremost sources. Bromelain is a protein extract that can seek advice from either the two digestive enzymes called proteolytic enzymes present in it or can refer to the mixture of all enzymes and different elements in it. It may be observed each in the fruit and stem of the pineapple plant and consequently is named for that reason as fruit bromelain and stem bromelain, respectively. The enzymatic composition of both sorts of bromelain also varies. Pineapple fruit is broadly used as a meal source, consequently, the foremost extraction source for bromelain is the stem of the pineapple plant (Wali, 2018) [44].
Merely 60% of the pineapple infructescence is edible, thus processing residuals range between 45 to 65% (Difonzo *et al*., 2019) [19]. The crown and stem of the pineapple are cut off before peeling and the center is eliminated in the course of processing. All these wastes like core, peel, stem, crown, and leaves account for about 50% (w/w) of general pineapple weight Two

types of waste may be labeled from pineapple production: POFW (Pineapple on Farm Waste) and PPW (Pineapple Peel Waste). Once pineapple harvesting is carried out, POFW normally involves leaves, roots, and stem leftovers at the farm. Pineapple is processed in many methods inside the pineapple product zone, together with slicing, pulping, and juicing. Before the pineapple product changed into processed, exclusive steps were taken to get rid of the crown, then put off the peels and core. A one of a kind volume of PPW is generated through every step. Researchers located that 9.12% of middle, 13.48% of peels, 14.4% of pulp, 14.87% of the top, and 48.04% of completed products have been produced by using Pineapple. Therefore with increasing pineapple production, pineapple waste increases proportionally. Waste disposal is a growing issue because it is usually prone to microbial spoilage and causes serious environmental problems. It directly represents the enormous challenge of pineapple waste disposal, which will further lead to environmental pollution. If not successfully used (Ayala-Zavala *et al*., 2010; Salve & Ray, 2020) [6, 42].

**Techniques for waste management**

When appropriate processes and technologies are applied, pineapple waste becomes a useful substrate to be transformed into different components. The exploitation of pineapple waste as an economic raw material for the production of phenolic compounds (Lubaina *et al*., 2020) [25], bromelain (Banerjee *et al*., 2020) [8], organic acids (Azizan *et al*., 2020) [41], and fiber (Asim *et al*., 2015) [5] have been focused by many researchers. Pineapple waste can also be used as a substrate for fermentation because of sufficient nutrients available for the cultivation of bacteria, and also as a carbon source for acid fermentation. Sugar fermentation and other nutrients extracted from pineapple waste could also produce various enzymes, single-cell proteins, organic acid sand, and bacterial cellulose. For instance, the growth of probiotic bacteria in the gut could be encouraged by the pineapple peel flour's prebiotic action. The possibility of producing vinegar and vanillin from pineapple waste has also been demonstrated by several studies. For example, the growth of probiotic bacteria in the gut could be encouraged by the pineapple peel flour's prebiotic action. Also, bioactive compounds in various fruit components have been identified as essential requirements for industries to develop novel, alternative, and innovative food products for nutrition and health improvement (Cheok *et al*., 2018; Roda & Lambri, 2019) [13, 39].

Another way we can use techniques employed in managing waste include the following methods: landfilling, incineration, pyrolysis and gasification, composting, and anaerobic digestion. The thermochemical or biological conversion methods can be used to treat pineapple waste sustainably. Pyrolysis, gasification, and fermentation are also an example of this. Pyrolysis is used in developed countries including Nigeria to manufacture domestic charcoal and as a waste management technique in pineapple management to produce char, gases, and bio-oil, which can be used to make other high-value-added goods. Pineapple waste can also be treated sustainably by gasification, producing syngas as well as combustion fuels, power, and other alternative technologies. Under managed conditions, anaerobic digestion can be used to treat pineapple waste. Proper pineapple waste management can result in economic growth empowerment, employment creation, and revenue for the community or countries. This however depends much on land availability, plant location, scale and choice of technology, and distribution of economic benefits (Rabiu *et al*., 2018) [37].

**Bioactive components present in pineapple waste**

Pineapple waste is a rich source of bioactive components. Pineapple primarily has its waste in the form of Crown, Peel, stem, and Core. There is a different bioactive compound present in each portion (Figure1). For example, citric acid in pineapple leaves, bromelain in the leaves, stem, and peel, ferulic acid in the leaves, ascorbic acid in the core, etc (Salve & Ray, 2020) [42]. Some of the major bioactive substances found in pineapple waste are described below. Moreover, phenolic compounds are of great interest in the pharmaceutical and food industry due to their biological properties with application on human health. There are few studies related to bioactive polyphenols from pineapple residues. Although we can mention some examples as myricetin, salicylic acid, tannic acid, trans-cinnamic acid and p-coumaric acid identified in a high dietary fiber powder from pineapple shell which is a part of waste and these compounds were reported as potent antioxidants. On the other hand, it has been shown that the polyphenols found from pineapple wastes such as ferulic acid and syringic acid, are responsible for antioxidant and antimicrobial activity.

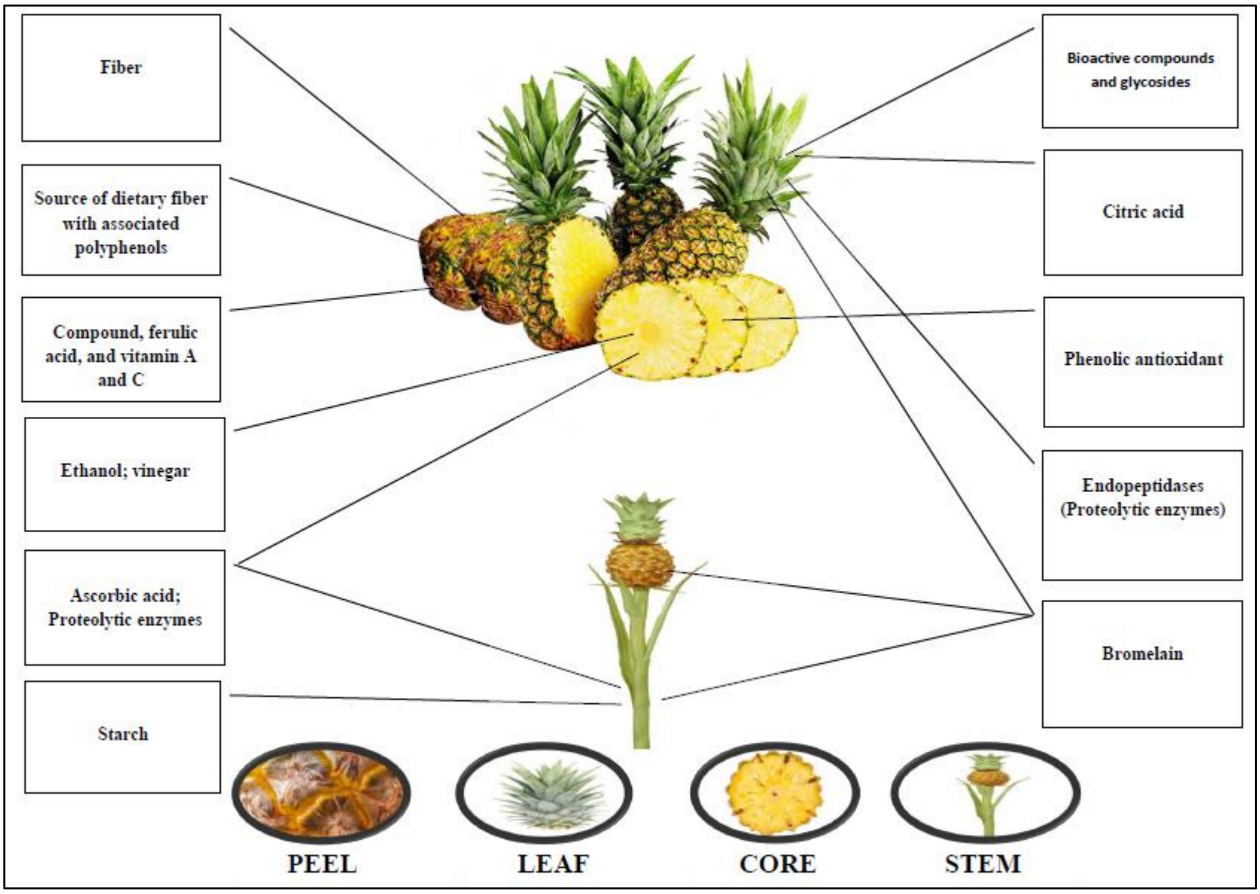


**Fig 1**: Bioactive components in different parts of pineapple

**Starch**

Starch can be obtained from pineapple waste, in particular from stem waste, using a milling process. (Nakthong *et al*., 2017) [30] isolated high purity starch, with unique and clear properties compared to starch obtained from rice, corn, and cassava. The substantial amylose content of pineapple stem starch (34.4 percent), which was approximately twice that of maize, more than double that of cassava starch (15.4 percent), and five times that of rice (6.5 percent), was responsible for certain technical characteristics such as high gelatinization temperature, enthalpy, and pasting temperature. As a result, the highest solubility percentage (more than 32 percent) is found in pineapple starch. Finally, pineapple starch, under normal cooking conditions, is distinguished by the lowest viscosity. Multiple food applications that can be used as resistant and thermoplastic starch have confirmed all these useful properties of pineapple starch.

**Table 1**: Bioactive components present in pineapple

| Bioactiv compounds | Type | Part of pineapple used | Amount | Extraction method/Fermented by | Health benifits | Reference |
|---|---|---|---|---|---|---|
| Starch | Amylase | Stem | 97.77% starch content (dry basis)/gm | Simple sample steeping method | Prevention of colonic cancer<br>Hypoglycemic effects<br>Resistant starch as a prebiotic<br>Inhibition of fat accumulation | (Ashwar *et al*., 2016) [4]<br>(Nakthong *et al*., 2017) [30] |
| Bromelain | Sulfhydryl proteolytic enzymes | Stem<br>Core<br>Peel<br>Crown | 23.33 µm/ml<br>24.13 µm/ml<br>13.158 µm/ml<br>113.79 µm/ml | Azocasein method | Anti-inflammatory Effects<br>Immunomodulatory Effects<br>Effects on Cancer Cells | (Amini & David, 2016) [2] |
| Dietary fiber | Insoluble | Core | 99.8% (dry basis) | Alcoholic extraction | | (Prakongpan *et al*., 2002) |
| Citric acid | – | peel | 45-46% yield | Fermentation with *Aspergillus niger* | Prevent from liver injury<br>Maintains tissue and cellular integrity | (Martínez *et al*., 2018) [27] |
| Ferulic acid | – | Core | 19.50 ± 1.93 mg/100g | Fermentation<br>HPLC–ESIMS | Prevention against atherosclerosis<br>Cholesterol-lowering activity<br>Antimicrobial activity | (Li *et al*., 2014) [24] |

**Dietary fiber**
Since humans lack the digestive enzyme needed to digest fiber, dietary fiber is a non-digestible source of carbohydrates (Park *et al*., 2011) [34]. Pineapple peel contains insoluble fiber-rich fractions that have greater potential and uses in the production of low-calorie, high-fiber foods (Huang *et al*., 2011). (Jr *et al*., 2021) [20, 22] reported that the use of pineapple pomace powder for fiber enhancement is due to its improved versatility due to the presence of a balanced amount of soluble and insoluble dietary fiber, as well as the presence of bioactive compounds associated with them. Also, for the juice processing industry to profit, it opens up a doorway of effective waste management.

**Ferulic acid**
Ferulic acid (FA) is the most common hydroxycinnamic acid found in plants. Pineapple peel and crown leaves have a high content of ferulic acid and are commonly available in the local agriculture industry (Tang and Hassan 2020). In-plant cell walls, it is covalently connected by ester linkages to polysaccharides and ether or ester bonds to lignin. There are two approaches for FA planning. Chemical synthesis of vanillin condensation reaction with piperidine-catalyzed malonic acid and extraction from natural resources where FA is one of the most abundant phenolic acids in plants. In the food and cosmetic field, it is commonly used. For ferulic acid-alkali extraction, pineapple peel has been widely used (Ashwini *et al*. 2008).

**Citric acid**
The worldwide demand for citric acid is around 6.0 x $10^5$ tons every year. Around 75% of citric acid's commercial use is for food and 12% is for the drug sector (Kareem, S. O. *et al*., 2010) [23]. It's commonly used as a base to improve and acidify taste in the dairy, medicine, and beverage industries. According to some researchers, citric acid was developed by solid-state fermentation of pineapple waste as substrates using *A. niger* (Kumar *et al*., 2003). Citric acid and its salts are commonly found in daily life. It's widely used as an additive in foods and cold beverages, to inhibit lipid degradation in frozen fish fillets, to aid phytoextraction of chromium by sunflower, and to boost the antioxidant protection mechanism and chromium absorption, among other things. However, problems do arise from time to time, and the apparent innocence of citric acid as a food additive is not necessarily true. Iron citrate complexes have recently been identified to form in the organism; these complexes are toxic because they also produce free radicals (Martínez *et al*., 2018) [27]. Under solid-state fermentation conditions, Yarrowialipolytica provided citric acid using pineapple waste (from a local juice manufacturer) as the sole substrate (Imandi *et al*., 2008). Citric acid was produced in greater quantities by solid-state fermentation using *Aspergillus foetidus ACM 3996* than by other fruit waste sources such as apple pomace, barley, or wheat brans. Researchers used four species of *Aspergillus* under controlled conditions to compare citric acid synthesis in solid-state fermentation. The yield of citric acid was 19.4 gm/100g of dried fermented pineapple waste (Nepal Food Scientists & Technologists Association. *et al*., 2005) [31].

**Other phenolic contents**
Polyphenolic compounds are very important fruit constituents due to their antioxidant activities, their chelation of redox-active metal ions, inactivation of lipid-free radical chains, and prevention of hydroperoxide conversion into reactive oxyradicals. Phenolic content can be used as an important indicator of antioxidant capacity and can be used as a preliminary screen for any product when intended to be used as a natural source of antioxidants in functional foods (Rashad *et al*., 2015) [38]. Due to their biological properties and future applications, polyphenolic compounds are major players in the medicinal and dietary supplement industries. While only a few studies (Table2) have looked at them in pineapple waste, p-Coumaric acid, Syringic acid, p-Hydroxybenzoic acid, Vanillin, Catechin, Epicatechin, Caffeic acid, Malic acid, and Cinnamic acid have all been found in pineapple peels. The biological activities can only be rationalized by separating and quantitating such compounds. Chromatographic methods play an important part in the identification of new and groundbreaking medicinal and biomedical compounds. Various analytical techniques such as gas chromatography, thin-layer chromatography, capillary electrophoresis, HPLC, HPLC-DAD-UV, and others may be used to determine the diversity of phenolic compounds in plants. Because of the advancement in chiral stationary phase of columns, HPLC is a common technique for the separation and quantification of enantiomers (Lubaina *et al*., 2020) [25].

**Table 2**: Phenolic components present in pineapple waste

| Phenolic contents | Source | Amount present | Extraction technique/Fermented by | Reference |
|---|---|---|---|---|
| p-Hydroxybenzoic acid | Stem | 680.45±12.42 GAE mg/100 g | HPLC | (Upadhyay *et al*., 2012) [43] |
| Vanillin | Stem | 141.00 mg L-1 of vanillin was produced from 5 g of pineapple cannery waste | Biotransformation of vanillic acid by *Pycnoporus cinnabarinus* | (Ong *et al*., 2014) [33] |
| p-Coumaric acid | Crown | 163.04 m/z | HPLC-DAD-ESI-MS | (Brito *et al*., 2021) [11] |
| Syringic acid | Stem | 788.21 ± 13.22 µg/g | GC-MS and HPLC | (Upadhyay *et al*., 2012) [43] |
| Catechin | Peel | 58.51 mg/100 g dry extracts | HPLC–ESIMS | (Li *et al*., 2014) [24] |
| Epicatechin | Peel | 50.00 mg/100 g | HPLC–ESIMS | (Li *et al*., 2014) [24] |
| Caffeic acid | Peel | 179.03 m/z | HPLC-DAD-ESI-MS | (Brito *et al*., 2021) [11] |
| Cinnamic acid | Stem | 149.27 ± 11.11µg/g | GC-MS and HPLC | (Upadhyay *et al*., 2012) [43] |
| Malic acid | Liquid pineapple waste | 0.016g/l | By using immobilized *Lactobacillus delbrueckii* | (Idris & Suzana, 2006) [21] |

## Application of pineapple waste (Food and Non-food)

Pineapple peel is a sustainable, bounty-accessible farm residue that requires further attention for multipurpose use. Pineapple has solid economic appeal after seeing the number of applications. It was confirmed that when directing an investigation of the outline of articles selected, specific subjects were given more frequency. Some of the applications listed below the bases of agro-industrial residues of pineapples.

### Wine production from pineapple peel

The processing industry accounts for 40 percent (w/w) of the entire weight of pineapple, a waste of pineapple peel. The presence of crucial bioactive substances and aroma compounds in pineapple peels indicates abundant evidence (Zhang *et al*., 2020) [46]. Developing pineapple peel wine minimizes the burden of waste disposal and also helps meet public demand for novel high-quality products. Although some study has already been performed on pineapple wine, there is a litter report on pineapple peel wine covering the entire fermentation process by *Saccharomyces cerevisae* (Table3) (Pino & Queris, 2010) (Dellacassa *et al*., 2017) [35, 16]. A clear role of the fermentation stages was noted in the final quality of the wine. The wine produced contained 14.71 percent vol (v/v) alcohol after fermentation, in line with the requirements of low-alcohol health wine. The soluble solids are only 7.50 ° Brix, the titratable acid content was 3.06 g citric acid/L, 182.76 mg GAE/L, and 675.43 mg GAE/L, respectively, total flavonoids and phenolic. To achieve pineapple peel wines with improved characteristics, it is necessary to further study how to preserve and improve the desirable wine properties as much as possible throughout the entire winemaking phase (Zhang *et al*., 2020) [46].

### Vinegar production from pineapple peel

Pineapple peel was converted to vinegar by simultaneous fermentation with *Acetobacter* (Table3), and the resulting vinegar was found to have phytochemical and antioxidant properties. Vinegar made from pineapple peel had higher antioxidant activity (2077 mg acetate equivalent/100 ml) than vinegar made from other fruit wastes, according to a comparative study of phytochemical screening and antioxidant ability. This substance, as opposed to synthetically formulated artificial vinegar, can be manufactured and sold in vast amounts for its medicinal benefits and environmental friendliness. Vinegar is made from pineapple waste through saccharification, and vinegar is then used to make disinfectants, food dressings, and preservatives (Rabiu *et al*., 2018) [37].

### Utilization of starch from pineapple stem for gelatinization

Starch is a so-called alternative green material and is a very promising potential candidate for future use. This is due to its low cost, renewable resource availability, and wide-ranging food and non-food product capabilities. As an alternative source of starch, pineapple stem is an agricultural waste with high potential. By wet-grinding, pineapple stem starch can simply be extracted from the pineapple stem. Compared to commercial rice, corn, and cassava starches, the extracted starch has distinctly unique properties. It has the highest amylose content, resulting in the highest temperature of gelatinization, enthalpy of gelatinization, and pasting temperature. Under the normal cooking condition, it has the lowest paste viscosity. For use as resistant starch or thermoplastic starch for food and non-food applications, these characteristics would be beneficial (Nakthong *et al*., 2017) [30].

### Pineapple leaf for extraction of fiber and the residual biomass for vermicomposting

A high textile grade commercial fiber is pineapple leaf fiber extracted by water retting. It contains 2.5-3.5% fiber that is covered by a waxy hydrophobic layer. Pineapple leaf fiber contains more alpha-cellulose and less lignin than jute fiber. The degree of polymerization and crystallinity of pineapple leaf fiber alpha-cellulose is nearly the same as that of jute, but cotton and ramie are much lower. It also appears from the chemical composition that pineapple leaf fiber is a better textile fiber than jute and also a better pulp and paper substrate. The newly developed machine can be used efficiently to extract the fiber from the pineapple leaves' agro-waste and the residual sludge obtained after scratching the leaves can be used for vermicomposting successfully. This integrated technology for pineapple leaf fiber extraction and vermicomposting is entirely remunerative for pineapple growers (Banika *et al*., 2011) [10].

### Dietary fiber from pineapple peel and pomace for utilization in various food products

Fiber makes up about 76 percent of pineapple by component (peel and pomace), with 99.2 percent being insoluble and 0.8 percent being soluble. In addition to being high in dietary fiber, pineapple pomace also contains calcium, phosphorus, and iron. They can be used as a food ingredient to increase the nutritional quality of foods (Devi *et al*., 2016) [17]. Even though only a few studies have been conducted on the addition of dietary fiber to food products. Cookies, Wheat bread, Cereal bar, Sausages, Yogurt, and Fruit cheese respectively used (Table 3) for the addition of dietary fibers from peel and pomace to increase its fiber content and antioxidant activities in its original product.

**Table 3**: Application of bioactive compounds in food products

| Utilization of pineapple waste into food products | | | |
|---|---|---|---|
| **Product** | **Part of pineapple used** | **Benefit/Microorganism used for production** | **Reference** |
| Cookies | Pineapple pomace | Fiber-rich cookies | (Devi *et al*., 2016) [17] |
| Wheat bread | Pineapple pomace | Increase in dietary fiber | (Jr *et al*., 2021) [22] |
| Cereal bar | Pineapple peel | Increase crude fiber content | (Damasceno *et al*., 2016) [15] |
| Yogurt | Pineapple peel | Antimutagenic and antioxidant activities | (Sah *et al*., 2015) [40] |
| Vinegar | Pineapple peel | Ethanol to vinegar - *Acetobacteraceti* | (Rabiu *et al*., 2018) [37] |
| Sausages | Pineapple pomace | Increase in dietary fiber<br>The hardness of the product decreased<br>Good water-holding and swelling capacity | ("Plant-Based Nat. Prod.," 2017) [36]<br>(Montalvo-González *et al*., 2018) [28] |
| Fruit cheese | Pineapple pomace | Rich in dietary fiber | (Anjali & Seth, 2015) [3] |

| | | | |
|---|---|---|---|
| | | Good source of carotenoids | |
| Wine | Pineapple peel | Sugar to ethanol - *Saccharomyces cerevisae* | (Okonkwo & Dilar, 2016) [32] |
| Tenderization of Meat Using Bromelain | Pineapple stem | Collagen fibers of meat as bromelain | (Manohar, 2020) [26] |

**Tenderization of meat using bromelain from pineapple peel**

Bromelain is a characteristic anticoagulant that works by separating the blood-coagulating protein fibrin and belongs to a set of protein-digesting enzymes that are commercially obtained from the pineapple fruit or stem. Bromelain, like papain, is widely regarded as a natural food additive. Bromelain is sometimes used to explain the haziness of beer in breweries. It's also been said to save apple juice and sliced fruits from browning (Banerjee *et al*., 2018) [9]. Bromelain also has certain anticancer activities and promotes the death of apoptotic cells (Ayuni, Manan, and Yousif 2020). (Manohar, 2020) [26] had reported that the physicochemical characteristics of the meat samples treated with bromelain were determined. The pH of meat in addition to various concentrations of bromelain seemed to decrease thus, tenderizing the meat as the acidity increased, with the lowest pH being 5.51. The water-holding capacity (WHC) gradually increased; however, there was a sudden drop in one of the bromelain-treated meat samples (from 9% to 8%). The highest WHC was recorded to be 11% in the meat sample with the highest concentration of bromelain. The moisture content, too, was analyzed and was found to be initially increasing and then decreased when the concentration of bromelain was the highest. Thus these results indicate that bromelain derived from pineapple extract can be used for the effective tenderization of meat.

**Single-cell protein from pineapple waste using yeast**

The pineapple skin waste was found to contain a decent measure of reducing and non-reducing sugars (10 and 13%, separately), which is generally positive for the development of microorganisms. It was additionally found to contain 0.6% protein. It was generally suitable for yeast fermentation. The bioconversion impact of pineapple waste into SCP was assessed utilizing yeast. The expansion in biomass content was seen when there was an increment in pineapple waste focus. The most elevated biomass substance of S. cerevisiae and C. tropicalis was recorded on seventh-day fermentation. The highest protein substance of S.cerevisiae and C. tropicalis was recorded on the third day of maturation at 5 % fixation. The most elevated reducing sugar substance of yeast was recorded on the third day of age at 5% focus. The usage of decreasing sugar was expanded with an expansion in the convergence of substrates. The current discoveries uncover that pineapple waste can be utilized as a viable substitute carbon hotspot for SCP creation (Dhanasekaran *et al*., 2019) [18].

**Pineapple peel for creation of naocellulose, film application, and packaging applications**

Pineapple peel is a sustainable rural buildup residue in abundance whose multipurpose usage merits more consideration. The current investigation focused on the isolation of nanocellulose from pineapple peel and the assessment of its fortification ability for gellan gum film. The needle-like nanocellulose (PPNc), isolated from pineapple peel utilizing sulfuric acid hydrolysis preceded by bleaching and soluble base medicines was utilized to strengthen gellan gum film. For film application, after being blended in with a gellan gum arrangement, PPNc/gellan gum scatterings expanded somewhat in viscosities with the expansion of nanocellulose content. PPNc ended up being superb support for the gellan gum film through the expanded crystallinity, warm solidness, and elasticity (Dai *et al*., 2018) [14]. The most reduced browning index is about 37.5% for bio-composite with an extra 9% PLM which was determined by utilizing new cherry (Muntingiacalabura. L). It's shown that the plastic bio-composite with an extra PLM shows high possibilities for new food bundling applications (Mutmainna *et al*., 2019) [29].

**Pineapple waste as animal feed**

Novel feedstuff from a blend of pineapple waste and wheat offal utilizing straightforward procedures for speedy change of pineapple waste into expected creature feed. This will add to the removal courses for pineapple waste and add to a decrease in natural aggravation from it. The method may require a further turn of events and refinement for the creation of better quality option feedstuffs. Further exploration needs extra assessment of the nutritive benefit of taking care of feeding animals (Zainuddin *et al*., 2014) had done pelleting of pineapple plant waste might build the utility of this forage as a characteristic fiber hotspot for ruminants. Pelleting additionally had an additional benefit of expanding its adaptability for taking care of. Therefore, densification of pineapple waste into pellets could diminish costs and tackle issues identified with taking care of, transportation, and capacity.

**Conclusion**

Pineapple has become a profitable fruit in recent years, given its unique aroma, abundant volatile compounds, and nutritional values. This study reviews the processing of waste into food and other application as a means of promoting innovative and sustainable development. In pineapple waste, many reusable substances with a high final value are found. Waste generated from pineapple fruit and the exploitation of such waste by appropriate extraction technologies to extract important nutritional and bioactive components is an important concern in the context of effective waste management. There are significant amounts of high-value bioactive compounds in various waste generated from pineapple, such as a crown, peel or skin, core, etc. Besides, these studies could provide new insights concerning the production of better pineapple yields. It is therefore useful to identify the fundamental issues relating to the pineapple with a view to the optimal exploitation of the fruit.

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