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Valorization of Fruit and Vegetable waste

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Abstract:-
Fruit and vegetable wastes are produced in significant quantities by the agri-food sector, and because of their high moisture content and microbial load, they pose a serious threat to the environment. Nevertheless, they do contain a variety of healthy components, including anti-oxidants, oils, fibre, fatty acids, isoprenoids, lipids, proteins, saponins, and phytoestrogens, in both their structural components (stems, leaves, peels, pulps, seeds, and roots) and the by products after their juices are extracted. To create nutraceutical goods and functional foods, these bioactive substances can be employed as food additives, pharmaceutical excipients, or food matrices.

Studies have revealed that big Fruits and vegetables are often only eaten in their flesh or pulp, but they also contain considerable amounts of phytochemicals and critical nutrients in their seeds, peels, and other infrequently consumed parts. The demand for functional food has grown over the past several years as consumers have become more health aware. Functional food is defined as food that enhances a person's health, physical capacity, or state of mind in addition to being nutrient-dense.

The major functional food markets now on the market are in Asia-Pacific and North America, with 34 and 25% of the total market share, respectively. The top three nations, which together accounted for around 82% of In 2003, the USA, Japan and Europe, accounted for all sales of functional foods and supplements.

I. Introduction of Valorization: -

The ability to generate enough food to sustain the world's constantly expanding population is one of the main problems we currently face. Even though there is a lot of food produced, a lot of it is wasted before it even reaches the consumers. Throughout in the world, reducing food waste is a common goal. Action plans to minimize food waste are promoted by the EU and many other countries, including the Farm to Fork Strategy, the Circulating Economy Action Plan, and the EU Waste Law, because there is a significant awareness of the severity of the issue. Food waste reduction could be a key strategy for lowering lower the price of production and producing food in more efficient ways. Also, by reducing waste, it is possible to develop food systems that are more ecologically friendly and to enhance food security and nutrition.

Worldwide, there is a huge amount of food waste, which puts pressure on researchers to develop methods for managing it without damaging the environment and using it to recover some of the resources that were initially used for food production and processing. While 10 million tons can be prevented by changing mostly consumer behaviour, 8 million tons cannot be avoided. The creation of procedures to make the most of food waste is of vital relevance when one considers that the manufacturing of 10 million meals in Germany consumes 2.6 million ha of arable land and produces 21.8 million CO2 equivalents. ([1])

One of the measures being used by The Food & Agriculture Organization (FAO) to meet its specific goal under the Goals for Sustainable Development (SDGs), is decreasing food waste. According to estimates, households generate 44% to 47% of their overall food waste as a result of eating fresh fruits and vegetables. Yet, a large fraction of household trash (between 23 and 28 percent) comes from inedible fresh fruit & vegetable portions such as the trims, peelings, and skin ([1]). They are regarded as trash that will inevitably be produced unless consumption patterns change, regardless of the preventive measures that are put in place. Therefore, it is essential to take into account processing and management techniques & maximize These resources' potential. This can involve adding value to them through the creation of products like biofuel.

II. Importance of Valorization:

In the absence of oxygen, bacteria break down biodegradable materials through a process known as anaerobic digestion. The technology is often used to treat industrial, agricultural, and

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wastewater sludge because compared to the input material, it may lower volume and mass by as much as 50%. Since the generated biogas is methane-rich and may be used to generate power, it is regarded as a renewable energy source. Biogas with a high proportion of usable methane is produced through anaerobic digestion, which makes it preferable to composting for treating organic waste in metropolitan areas, As opposed to the latter, which mostly creates carbon dioxide (CO2) that cannot be used as fuel. ([2])

Using internal combustion engines or micro turbines, the power and waste heat created by burning the methane in biogas may be building heating or being used to warm the digesters. Combined heat and power (CHP) is the term for this process. Any extra electricity can either be used by locals or sold to suppliers. In addition, generators that produce steam and electricity may be run on biogas. It may be possible in some circumstances to sell the electricity to a nearby utility under a net metering contract. It is important to investigate this possibility as soon as possible to make sure the utility is open to such agreements. ([3])

Food Waste (FW), or wet waste, typically refers to kitchen waste, which includes waste from all types of food establishments, comprising green garbage from fruit and vegetable vendors/shops, eggshells, uncooked and cooked food waste, bones, fruit peels and flower, houseplant trash, etc. The peak of India's summer vegetable and other crop harvests coincided with an unexpected state wide shut down. These resulted in both a large decrease in agricultural productivity and an increase in food waste, both of which caused farmers to suffer significant financial losses. The Indian government had put in place many precautions during this economic crisis, such as ensuring that food was properly supplied to remote locations, maintained effectively, and quickly distributed to markets to prevent unprecedented food waste. ([4]) In India, the food processing sector, hotels, hostels, restaurants, cafés, supermarkets, apartment complexes and cafeterias on aeroplanes are the main producers of food waste. ([5])

Nowadays, mostly in India, food waste is sent for composting in-order to make fertiliser, but part of it is buried in the ground, which damages natural resources and pollutes the soil. Landfilling needs to be phased out because it is not regarded as a long-term sustainable alternative. Whereas historically linked to the spread of disease to both humans and animals, using food waste as animal feed is now regarded as a way to recycle food in a more circular and sustainable way. In spite of the fact that sero prevalence was the same in both groups, a cross-sectional investigation discovered that pigs given swill combined using heat-treated feed had increased sensitivity and danger from the Hepatitis E virus than pigs not fed swill. This is because the use of swill is uncontrolled in India. Hepatitis E virus incidence may be increased by improper swill management and feeding practises, it was determined. ([6])

Utilizing FW valorisation can provide multiple advantages including producing of renewable energy, less dependency on fossil fuels, decreased GHG emissions, enhanced increased food and energy security, and soil fertility, improved health and sanitization, protection of water resources, and self-sufficient and resilient communities. Utilizing the valorisation process to market high-value FW-derived products may also increase revenues while reducing costs. (Global Biogas Association, full report 2018). The practicality of converting FW to bioethanol at a lab scale and blending it with diesel and ethanol are the subjects of Case Studies 1 and 2 in this publication. In Case Study 1, it is investigated how FW is anaerobically digested to produce bio-slurry and biogas, which have is replace to potential LPG and other chemical fertilisers as well as traditional cooking fuels. Future technologies have also been discussed, like future valorisation for the FW generation of petrol and their potential low effect in developing countries.

III. Need of valorizing fruit and vegetable waste:

Food items or dietary supplements that enhance the host's quality of life while also providing for fundamental nutritional requirements health are referred to as bioactive substances or components.([7]) They are known to have anti-inflammatory, anti-microbial, and antioxidant effects on the host; however, their qualities depend on a variety of factors, including bioactivity, chemical structure, dose, and others. ([8])

They can be removed from wastes and They are a key source of bioactive ingredients, which are utilised to produce functional meals. Due to some bioactive chemicals' hydrophobicity and bioavailability, a possible delivery mechanism is needed in order to increase their functionality to carry out particular bodily duties.

In light of this, Nano emulsions have drawn a great deal of focus and have been used as a delivery method to increase the stability, and bioavailability solubility, of bioactive chemicals in the body as well as protect them from potentially hazardous environmental elements. (Moisture, light, temperature, pH, etc.). Nano emulsions are utilised to improve the physical, chemical, and visual properties of food systems that contain bioactive substances (clear suspension). They lessen sedimentation or creaming-induced particle separation as well. Given the aforementioned and the diagram illustrating the separation of various bioactive components from Fruit and Vegetable wastes (FVW).

However, they do contain a variety of beneficial compounds, as well as in the leftovers after the fruit or vegetable has been processed. Such bioactive compounds can be used to make functional foods, nutraceutical products, pharmaceutical excipients, or food or pharmaceutical matrices, respectively. The goal of this study is to present the most practical solutions for underutilised fruit and vegetable wastes that may be turned into high-value bioactive products. Possible obstacles to this strategy will also be covered. Waste-producing foods including pomegranate, artichoke, cardoon, and asparagus are able to change the opportunities they provide as proof of this. The last half of the study presents innovative techniques for efficiently extracting bioactive compounds from vegetable matrices.

IV. Medicinal important of fruits and vegetable waste product:

The capacity of FVW to extract phenolic compounds, dietary fibres, and other beneficial components has been investigated. FVW are rich in phytochemicals. ([9]) Since the majority of people only eat the flesh or pulp of fruits and vegetables, studies show that large levels of phytochemicals and essential nutrients may be found in the seeds, peels, and other rarely consumed parts of these items. ([10])

Considering the fact that FVW are at risk of microbial degradation, which might lead to foul odours and environmental problems, their storage is a crucial phase. Examples of significant biomolecules that may be made from FVW include the following list of bioactive chemicals.

i. Antioxidant Activity

According to a study, The high phenolic content chemicals in the bean and nut seed coatings can contribute to strong antioxidant action. By removing the seed covers, nuts' antioxidant activity can be lowered by up to 90%. ([11])

Subsequent research found that the black bean seed coverings' separated flavonoids and saponins are highly maintained even after baking. (8, 9). These bean seed black coat flavanoids and saponins are useful for development of food due to their thermal stability (10). Furthermore, it has been demonstrated that a variety of vegetable peels has potent antioxidant qualities. One study by Mohdaly et al., for instance, combined potato peels to vegetable oil as a source of antioxidants. ([12],[13])

The inclusion of potato peels increased the vegetable oil's hydrolytic stability, delayed thermal degradation, and stabilised the oil. Moreover, the addition of potato peel extract up to 200 ppm demonstrated stabilising effectiveness comparable to synthetic antioxidants. To enhance the nutritional qualities and health advantages of In addition to using potato peels as a useful ingredient. ([14]-[17])

ii. Antimicrobial and Antifungal Activity

Several types of vegetable peels have been identified in research to have strong antibacterial and antifungal properties. ([18]) Vegetable peels' phytochemical composition was examined, and of all the fruits and vegetables examined, the peels of Moringa Oleifera had the strongest antibacterial action against Gram-positive bacteria. Moreover, demonstrated similar findings in their investigation of the antibacterial properties of vegetable peels and fruit. ([19]).

These are only a few of the food-borne diseases that other peels, like pomegranate peels, are highly effective against. ([20],[21]) The antibacterial activity of mangosteen seed was the greatest of all mangosteen sections, in addition to its strong antioxidant profile. The mangosteen seed did, in fact, exhibit greater suppression of Gram-positive bacteria ([22].)

iii. Anticancer Activity

High flavonoid content citrus peels has anticancer properties. Citrus peels have been shown to have qualities that prevent cancer. Prostate cancer tumour sizes were considerably reduced by citrus peels, which also had potent anti-inflammatory, antiproliferative, and antiangiogenic properties as well as improved apoptosis-inducing actions. Azoxymethane-induced colonic carcinogenesis may also be successfully avoided by peel citrus with high anthocyanin content. ([23])

iv. Antidiabetic and Anti-hypocholesterolemic Activity

It has been discovered that several by-products of fruits and vegetables have anti-diabetic capabilities. In a study, Sarah et al. looked into how mango by-products affect blood sugar levels. Mango juice industry by-products, particularly mango peels and pulp, provide large amounts of soluble fiber,

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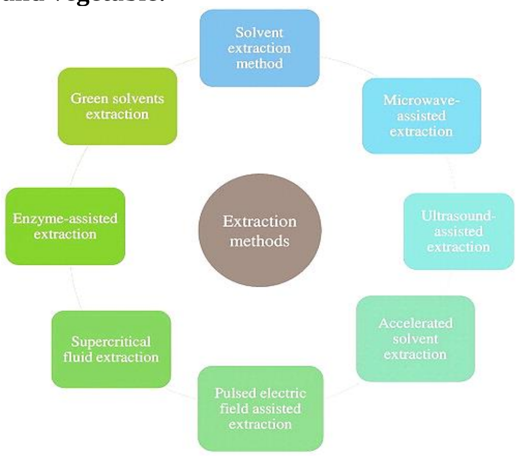
polyphenols, and carotenoids that mimic the effects of insulin. Moreover, high dietary fibre onion by products demonstrated hypoglycemic effects by blocking alpha-amylase activity and significantly reducing carbohydrate digestion. ([24]) Additionally, black bean seed coat extracts outperformed stigmasterol in their capacity to reduce cholesterol micellization by up to 55.4 1.9%.([25])

Black bean seed coats, which may be utilised to make functional meals that lower cholesterol and explore further uses for black bean and other seed coats, were a really fascinating contribution made by the authors. It has been shown that several by-products of Bioactive compounds are quite rich in fruits and vegetables that are directly connected to health benefits including antioxidant and antibacterial activity. Future study may focus on developing novel functional meals that include vegetable and fruit by-products to improve the food's nutritional safety available on market. ([26])

b. Nutritious foods

V. Method or techniques for valorisation fruits and vegetable:



a. Using green technology to extract bioactive substances

To extract the bioactive compounds, both traditional and non-conventional methods can be applied, and each has benefits and drawbacks of its own. But lately, study has turned to "unconventional" technology, also known as "green extraction" technology.

Numerous eco-friendly, environmentally friendly the extraction of natural compounds has been researched using a variety of extraction methods, including enzyme-assisted extraction, microwave extraction, pressurised liquid extraction,

The demand for functional food has grown over the past several years as people's awareness of their health has increased. Functional food is defined as "food that, in addition to its nutritional value, improves a state of mind, individual's health, physical performance." ([27])

Over the past few years, as people's awareness of their health has grown, so has demand for functional food. Food that improves a person's health, physical performance, or mental in addition, state to providing nutritional value is referred to as functional food. ([28])

The major functional food markets now on the market are in the Asia-Pacific and North American regions, with contributions of 34 and 25%, respectively. The top three were Europe, Japan, and the USA exporters of functional foods and supplements in 2003, accounting for 82% of global sales. Fortification of foods with specific vitamins or minerals led to the development of functional food. Due to the fortification of substances in recent years, functional meals have evolved. that may have various health advantages. ([29])
pulsed electric field extraction, ultrasonic extraction, and supercritical fluid extraction. ([30])

c. Supercritical fluid extraction:

Utilising solvents above the critical point, chemicals are extracted using this method. This critical point is described as "The exact temperature or pressure at which gas and liquid can only exist separate phases." Because of their viscosity, diffusion, and surface tension, which are characteristics of both liquids and gases, these fluids enable a larger yield to be produced quickly. These fluids also have characteristics, such as density and saving power that are comparable to those of liquids. ([31])

A transportable tank comprising a CO2 tank, a pump, the fundamental tools for supercritical fluid extraction are an oven, a trapping vessel, a controller, and solvent vessel. (SFE). 32 x (e.g., methanol, ethanol, dichloromethane, acetone, etc.). Some of the other significant constraints that prevent the scalability of this technique include the low solvent infusibility into the matrix, the prolonged extraction time, the requirement for high pressure, the cost of the infrastructure, the variation in consistency, and the reproducibility during continuous process. ([33])

d. Ultrasound assisted extraction

The normal vibrational frequency range for ultra sound assisted extraction (UAE) is 20 to 2000 kHz. Based on two facts: the first being diffusion through cell walls and second being the washing of the contents after cell disintegration, UAE is a cheap and simple extraction procedure. It functions according to the cavitation principle, whereby the waves force the matrix to expand and contract, which in turn causes the cell wall to permeabilize and yield more of the desired product. Several potential UAE mechanisms, such as increased mass transfer, particle breakup, and increased solvent accessibility to cells, have been identified by a number of investigations. The processing of liquid-solid or liquid-liquid materials has made extensive use of this technology.

All things considered, frequency is one of the key elements that significantly influences both the yield and the compound's attributes. The physico-chemical characteristics of the phytochemicals were reportedly impacted by the production of free radicals during extraction utilising more than 20 kHz energy ([34])

Because to its low temperature, UAE gives Numerous advantages over current solvent extraction procedures, go beyond a shorter extraction time and reduced heat degradation of bioactive compounds. At the laboratory size, it is a method that is often cost-effective; nevertheless, the scalability of this method is required to assess the process cost. In the food business, the UAE is typically used for a variety of purposes, including sterilisation, extraction, and preservation. ([35])

e. Microwave assisted extraction (MAE)

The microwave-assisted extraction (MAE) technique uses electromagnetic radiations that are conveyed as waves between 300 MHz and 300 GHz, with a typical frequency of usage of 2450 MHz, which is roughly equivalent to 600-700 Watts of energy. The principle behind this technique is that heat is created when energy is absorbed by the material when microwaves travel across it, simplifying the operation. ([36])

The hydrogen bonds between molecules in a solvent that is in contact with the sample are broken when the solvent is heated. As a result, the molecules become dipoles and the ions move about, allowing the solvent to diffuse and the components to dissolve. Cells' internal moisture evaporates, putting a lot of strain on the cell wall and altering the materials' physical characteristics and porosity, is one of the other potential explanations. The yield of biomaterials is further enhanced by the deeper penetration of the solvent. ([37], [37], [38])

f. Pulsed electric field assisted extraction

In this method, the materials inside the electrodes are exposed to high-voltage pulses for a limited length of time, generally between a few microseconds and a few milliseconds. When in this case an electric current goes through the suspension of cells, the cell structure is compromised, which causes the molecules to separate based on their different charges ([39]) Both batch and continuous operations of this approach are possible ([40])
When developing a process, various elements like field strength, energy, pulse number, material characteristics, and temperature must be taken into account because they have an impact on the extraction yield ([41])

This method accelerates the extraction of anthocyanins, be tannins, carotenoids, etc. the by-products of natural food sources while requiring less time, solvent, and/or temperature. ([42], [43])

The most astonishing thing about this method is that even though it lacks thermal properties, the final product's quality is unaffected. On both a pilot size and an industrial scale, it may be employed for continuous operations. As a result, it is one of the emerging technologies that has the greatest potential for use in the food processing sector for large-scale procedures.

g. Enzyme assisted extraction

When the phytochemicals are dispersed throughout the cytoplasm of the cell and Hydrogen or hydrophobic ties are often concluded in the polysaccharide-lignin network. making it challenging to remove the phytochemicals, this approach is frequently utilised. to extract the phytochemicals using standard techniques. However, due to its integrity, environmental friendliness, and enhanced product output, this technique has garnered more attention recently. ([44])

The concentration, content, size of the enzyme particles, the ratio of water to solids and the length of the hydrolysis are two important variables that affect the enzyme-assisted extraction of different bioactive substances. ([44]). The evocation of a variety of item, including lutein from pumpkin ([45]), anthocyanins from crocus sativus ([46]), and anthocyanin from grape skin, has been investigated using this method. ([47]).

Moreover, Pectinex®, Pectinex®, and Celluclast® were used to extract phenolics from grape remnants and apple pomace, respectively. Seeds Grape mare were found to provide 17–19 mg/g of phenolics when they were extracted. Due to this, the extraction procedure is extremely successful while employing enzymes like pectinase, cellulase, and protease to improve compound recovery. The expense of the enzyme, however, is a

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drawback of this method that prevents the process from being scaled up and further reduces the yield of the finished good. However, immobilisation strategies that allow the enzyme to be reused without compromising its specificity and activity can reduce the cost. ([44])

VI. Valorisation of certain fruits and vegetable waste:

i. Banana Peels

According to, the banana belongs to the Musaceae family and has numerous variants under the name Musa. The banana plant is one of the world's biggest fruit farms, which produces climacteric fruit. The plantation is the biggest in the world, covering more than 2.3 million hectares. The apple and orange each make up 11.4% of the world's fruit supply, with the banana contributing 16.8%. ([48]-[50])

Antioxidant functions

Antioxidant activity is a great sign of a useful benefit that plant extracts may offer. Numerous naturally occurring antioxidants that protect and preserve a plant's physical, metabolic, and genetic integrity may be found in the seeds that it produces. By lowering the cellular effects of oxidation, a number of these plant extracts and molecules are shown promise in reducing the visible signs of ageing on the skin. Vitamins C, E, anthocyanin, catechin, and rosmarinic acid (RA) are frequently utilised in foods and cosmetics because of their strong antioxidant properties and capacity to preserve stability. ([51]-[54])

Pectin

Subheadings may be used to separate this section. It should give a succinct and accurate description. Intricate polysaccharides in pectin were first discovered in fruit juice around 1790. Before the advent of new terms like "pectin," the word "pectus" in English came from the Greek meaning coagulated or hardened material. For the past ten years, most pectin research has been concentrated in this area. Pectin usually comes from the primary cell walls of several plants and the intermediate layer of the lamella. The word "pectic" was used by the American Chemical Society when describing a convoluted. molecule that may be derived from plants or found in plants that is formed of colloidal carbohydrate derivatives. ([55]-[57])

Anti-Microbial Actions

Antimicrobial activity is the process of eradicating or controlling disease-causing bacteria. Many antimicrobial drugs are used to achieve this. Antimicrobials possess antibacterial, antifungal, and antiviral effects. Each of them has a unique form of action to combat the virus. Methods for detecting antimicrobial activity in food have been around for as long as pharmaceuticals and cleaning supplies. Vaporized crushed garlic's antimicrobial properties on Mycobacteria species, and E. coli, serrated garlic, and B. subtilus. ([58]-[60])

Compositions and Resources

Apple's peel (8.93%), peels of pomelo (23.81%), the peels of lemons (26.31%), and the lime peels (11.31%) naturally contain the highest concentrations of polysaccharides, or pectic matter. According to Ha, and Bae, mature banana peels have a higher pectin content than other fruits. Pectin is found in great amounts in a range of fruits and vegetables because it has a strong and flexible cell wall as well as biological activities.

Amide groups, phenolic acids, methanol, and acetic acid are some alternatives to pectin. Also included were non-polar and polar carboxyl groups, polyesters, reduced sugars, polyacids, and polyhydric alcohols. ([61]-[64])

Method of Extraction

1. Soxhlet Extraction (*[65]*, [66])
2. Microwave-Assisted Extraction (MAE) (*[67]*-[69])
3. Ultrasound-Assisted Extraction (UAE) ([70]-[72])
4. Subcritical Water Extraction (SWE) (*[73]*-[76])

ii. Apple peel

Using a previously reported method with some slight changes, crude mixes from fresh or dry peels were extracted in triplicate for soluble polyphenols. 1 g of powder was blended with 40 g of chilled aqueous 80% ethanol or 80% acetone (v/v) for five minutes for each of the 103 dried peels. The final slurry undergone a vacuum filtering procedure. 15 mL of solvent were mixed with the remaining particles. for a second extraction, which was homogenised for 1 minute. The extracts were maintained cold in a dark, ice bath during the extraction process. After one minute, homogenization was halted, and it took at least another minute before it could resume. Using a Büchi rotavapor at 40 °C, the organic solvent was removed from the filtrates until only Aqueous phase was still present. The concentrated extracts were maintained at -20°C in the dark after being diluted with distilled water to a volume of 25 mL, filtered through N.1 Whatman paper, and stored. Before being examined, they were defrosted, centrifuged for 15 minutes at 8,000 rpm, and then filtered through a 0.45 m PTFE (Acrodisc, Pall, UK) membrane disc filter. ([77]-[79])

iii. Papaya peel (PP)

Papaya Peel (PP) contains a variety of beneficial elements, including minerals, fibres, carbs, proteins, fatty acids, and polyphenols. Since these compounds are present, PP can be used as a raw material for many products with added value. Polyphenol is suitable for usage in pharmaceutical applications due to its accessibility. (e.g., cosmetics and others). So, it includes either carbon and nitrogen, PP is an ideal substrate for microbes, making it ideal for the yeast manufacturing of valuable products such enzymes, biogas, and methane. Because PP contains a number of different chemicals, it may be used for a broad range of other things as well, such as a corrosion inhibitor, a capping agent, a meat tenderizer, an adsorbent, an animal feed and growth supplement, and in the environmentally responsible production of nanomaterials. Additionally, it can be utilised to extract some valuable compounds.

As Cosmetics:

PP is often utilised in numerous home medicines and cosmetics. The skin's damaged tissues can be repaired and replaced with the help of the vitamin A in PP. Additionally, PP can be used to lighten skin. PP can hydrate the skin and alleviate irritation when applied to the skin with honey. Vinegar prepared from lemon juice and PP, when applied to the scalp 20 minutes before shampooing, can help fight dandruff. Papaya Peel oil, and essential oils such as lavender, vinegar, orange, and rosemary can be added to bath water to make it more nourishing, peaceful, and effective at reducing pain and relaxing the muscles. ([80], [81])

iv. Pomegranate peel

Pomegranate peel (PP) is valuable since it may be used directly as a feedstock for animals and also in cosmetics. PP can be transformed into value-added goods physically, chemically or through unit processes. Enzymes, single-cell proteins, biogas/methane, and other compounds are produced during the fermentation of dry and powdered PP. High value-added chemicals including pharmaceuticals, bioactives, colour pigments, and dietary fibres can be produced using unit processes like solvent extraction and an appropriate separation technique. For the production of nanoparticles, PP extracts with metal salts may be utilised. PP with physical/chemical changes works well as a dye and heavy metal adsorbent.

Bio-fertilizer

Organic farming is becoming more and more popular because it significantly improves produce and product quality. Recalcitrance to anaerobic digestion is evident in PP. It was effectively composted by combining PP at a humidity of 50% to 5%, both with and without banana peels. C:N ratio decreased from 22.5 to 17. after 15 days of digestion. Vermicompost, *Pseudomonas aeruginosa*, *Aspergillus niger*, Trichoderma, commonly known as harzianum, mustard icing, neem cake, animal dung, Pseud luminescence, peels of bananas powder, and PP powder were among the 12 different organic ingredients used to make organic manure. It was discovered that the bio-fertilizer created using both of these techniques enhanced germination, shoot growth, root ramification, and leaf chlorophyll content. When compared to conventional These bio-fertilizers boosted yield and the quantity of phenolic acid concentrations in wheat grains in comparison to conventional farming. ([82], [83])

v. Onion

Active compound extraction

Due to the abundance of such high-quality nutrients, several attempts have been made to utilise this waste. In an effort to convert onion peel waste into sugars, a variety of enzymes, including cellulase, pectinase, and xylanase, were applied to onion trash at various concentrations. Cellulase, pectinase, and xylanase had the highest observed quantities at 0.72 mg/g, 0.16 mg/g, and 1.00 mg/g, respectively. The conversion of 98.5% of polysaccharides into their corresponding sugars occurred at this enzyme concentration. In order to separate quercetin from a complex matrix, the polymeric components had to be broken down, which increased extraction efficiency by 1.61 times.

The use of onion waste in the purification of water

Onion peel can be used in water treatment because of its capacity to absorb dissolved salts found in water. In addition to the salts, onion peel is known to absorb a variety of pigments and colours from the printing industry. It has the capacity to absorb numerous dangerous compounds in addition to dyes. By using activation methods like microwave treatment, onion trash can absorb more fluid.

Onion waste in enzyme production

In order to produce different enzymes, various onion wastes can be used. The enzyme known as

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peroxidase is known for its antioxidant properties and its capacity to alter a variety of flavonoids. Secondary flavonoids that also have antioxidant properties are created when peroxidase reacts with flavonoid molecules. Moreover, the enzyme can be applied to wastewater treatment to lower oxygen demand prior to disposal. It has been shown that pectinases generated from onion waste are heat-stable, with an ideal pH range of 3.0 to 6.0 and an ideal temperature of 80°C.

Manufacture of vinegar and alcohol from onion waste

Onion waste is a plentiful supply of polysaccharides that may be hydrolyzed into sugars and utilised to make lactic acid, vinegar, and alcohol. For the manufacturing of vinegar, a two-stage procedure might be used. S. Cerevisiae first turned juice containing 30 g/l sugar to alcohol, which was then transformed into vinegar. Acetic acid produced at its highest rate 37.0 g/l. ([84])

vi. Garlic peel and straw

Aged garlic clove extracts, garlic powder (Garlicin), garlic oil macerate, and garlic essential oil are the four types of variants that are included under the garlic umbrella. (Kyolic). In reality, there was a growth in worldwide output between 1998 and 2003, this resulted in a 13% increase in yield and an 18% increase in the area under cultivation. As a result of increasing output, a sizeable quantity of waste—25–30% solid waste—consisting of husk and straw is generated. Per kilogramme of garlic bulbs, about 760 g/kg of cloves and 240 g/kg of outer and inner husks are generated. As a result, garlic by-products may hold great promise for development as a priceless biological resource, and their valorization may provide residues a practical, lucrative, and sustainable choice. ([85], [86])

Applications in the environment:

The physical and chemical characteristics of disturbed soil have long been enhanced by the addition of organic soil amendments. To address soil-borne illnesses and plant parasitic nematodes, organic inputs can reduce the requirement for nematicides. As certain plant leftovers decompose, active compounds that combat pests are released, unlike other synthetic pesticides. These chemicals do not remain on the product. Sulfur-containing compounds are found in several liliaceous plants, including Allium sativum L., Allium cepa L., and Allium fistulosum L. These compounds are broken down to provide a range of isochiocyanates, which have different insecticidal, nematicidal, fungicidal, antibiotic, and phytotoxic characteristics. Remains from A. sativum have been demonstrated in several academic studies to lessen the damage that nematodes and other soil-borne illnesses cause to vegetable crops. The enormous quantities of garlic straw that are made represent an untapped source of anti-pathogen soil chemicals. ([87]-[90])

vii. Cauliflower:

With a global production of 14 000 000 tonnes per year, 71% of the world's supply of this crop is produced in China and India. Broccoli is the other major Brassica crop. With 374 000 tonnes (or around 3% of global production), Spain ranks fifth among producers. A substantial number of by-products are created during the processing of these veggies. In terms of the byproduct percentage, stem makes up the majority of the remaining by-products, with leaves making up around 50% of the total. These residues cause significant environmental issues in the industries, and in recent years, there has been an increase in interest in finding ways to lessen their environmental impact. Epidemiology studies have emphasised the ability of Brassica species to guard against specific types of cancer as well as to prevent cardiovascular disorders. The glucosinolates and their derivatives, along with the flavonoids and other phenolic chemicals, appear to be the components in charge of these qualities. By acting as scavengers of peroxyl and hydroxyl radicals, flavonoids' main role in preventing these illnesses is to decrease the oxidation of low-density lipoproteins. The antioxidant effects of flavonoids. ([91]-[94])

Antioxidant function.

Four in vitro antioxidant tests were utilised to systematically assess the possible antioxidant capacity of extracts from cauliflower by-products. Deeper examination (bioavailability, structure-activity connection, etc.), which is outside the purview of the current work, is required for further expansion to in vivo systems. One's resistance to free radicals is evaluated using the DPPH and ABTS tests. The DPPH• and ABTS+ tests were conducted in separate solutions, methanol and water, respectively. The DPPH• and ABTS•+ tests can therefore be used to assess the ability of both water-soluble and non-water-soluble substances to scavenge free radicals. ([95]-[96])

viii. Peas:

Peas (*Pisum sativum* L), which have a high protein level of 18 to 30%, are one of the most significant vegetable crops farmed worldwide1. Both frost-tolerant and cold-climate settings are suitable for pea cultivation. There are two sorts of peas: dried yellow peas and green peas that are either fresh or tinned. Large-scale pea wastes generated during industrial processing harm the environment and can discharge dangerous gases. Since they have a direct effect on the profitability of production, unsustainable waste disposal may likewise represent large economic expenses. Pea peel wastes, which make about 30–40% of the total weight of the peas, are readily available and abundant. Consequently, a variety of methods are needed to turn these wastes into marketable goods with high nutritional value. For instance, pea peel wastes might be utilised as animal feed and their bioactive chemicals could be a natural ingredient in foods and cosmetics, and medicinal products. ([97]-[99])

Cosmetics:

Legume extracts have numerous commercial uses in the cosmetics industry, but none of them are produced from leftovers or by-products. Pea peptide hydrolysates and dried seed legume protein fractions are used as skin moisturisers and calming/anti-itching active agents. High-fiber pea flour was used as an emulsifier, and legume proteins showed the ability to reduce perspiration. A pea extract sold for use in cosmetic goods (by BASF, Germany) called ACTIWHITE PW LS 9860 is being used as a skin-whitening ingredient.

It has been demonstrated in earlier research that bioactive protein/peptides, fibers, polyphenols, and other compounds may be effectively recovered from the processing residues of legumes for use as cosmetic components, in line with phenolic extracts derived from other types of agro-waste residues. ([100]-[105])

VI. Conclusion: -

Million tons of garbage is produced annually by the processing of fruits and vegetables. If this waste is not adequately managed, it might seriously harm the ecosystem. These byproducts are a great source of bioactive substances such phenolics, lignin, phenolic acids, phenolics, among other things, phenolics and phenols. Direct extraction of these materials or/and their transformation into high-value goods decreases environmental issues while also boosting the food industry's economic position. viability and sustainability. Applying cutting-edge technology would make it possible to create effective methods for extracting bioactive compounds, which would help to attain this aim. This framework provides a huge possibility for the recovery and manufacture of several important compounds in a cascade biorefinery system from industrial processing by-products such as banana peel, apple peel, papaya peel, pomegranate peel, onion peel, cauliflower, and peas.

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