International Journal of Agriculture and Allied Sciences July-December 7(2): 1-4, 2022 ISSN 2582-6336

APPLICATION OF FRUITS AND VEGETABLES IN FOOD INDUSTRY

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Received July25, 2022 and Accepted October, 22, 2022

ABSTRACT: Horticultural crops include the fruits and vegetable which is highly used food product. They can be eaten after cooking, nominally cooking or uncooked depending on their characteristics and desired taste and texture. Due to increasing population and shift in food preferences, the fruit and vegetable processing needs improvement to meet the demand in current as well as future scenario. Fruit and vegetable-based industries produce large amount of peel waste which has increased nutritional and economic loss as well as environmental problems world-wide.25-30% of the total product is wasted during processing. Peels include seeds, pomace, seeds, rinds etc. that are rich source of bioactive compound. Applications of peels include development of wholesome films, probiotics in food industry as well as other industries for beneficial product. To develop value added product by utilization of fruit and vegetable peels is a great step in food industry. The purpose of the review is to sum up the various wastes from fruit and vegetable and also emphasise on their capability to develop probiotics, carbon dots, edible films, biochar, microbial media and nanoparticles.

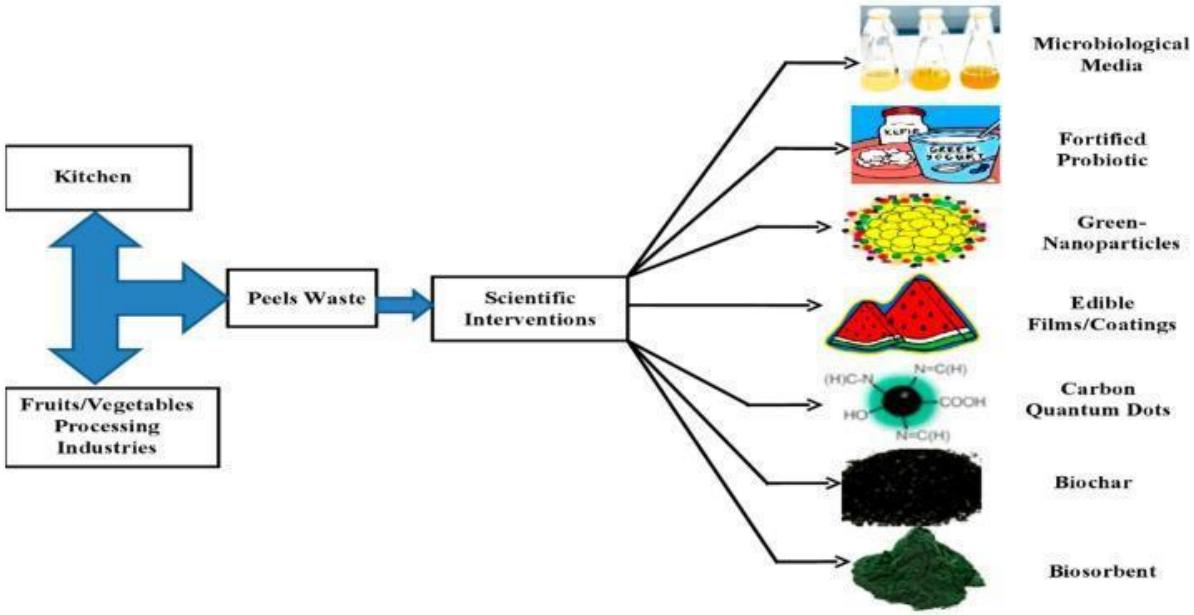
Key words: Probiotics, nanoparticles, carbon dots, fruits, vegetables

Food waste of approx. 89 million tonnes is generated in the European Union and according to experts this value is deemed to rise by 40 times in future scenario (Plazzotia S.et al, 2017). Approximately 40% of food in India is thrown away. As per FCI there is 10 to 15% loss of loss of the total produce. Fruit and vegetables losses are estimated to be 12 and 21 million tonnes respectively. Fruit and vegetable by products consist of undigestible seeds, rinds, skin, pomace which are left out at different stages including collecting, handling, shipping and processing. So, the appropriate term for fruit and vegetable waste (F.V.W.) is fruit and vegetable loss.

Vegetable By Product: They are often thrown away at various stages of food processing. There is about one third of wastage in preparation. Vegetable parts like bagasse and seeds are thrown away. Stems and leaves of vegetables like cauliflower, broccoli is not edible. Seed coat protects seeds from outer damage and is also considered waste.

Fruits by Product: Fruits by products is one among the major root causes of environmental hazard. (International Journal of Agriculture Environmental Biotechnology 2017). Seeds are rich source of nutrition and are used in developing functional food. FVW contains phytochemical constituents and are investigated for dietary fibres, bioactive compounds extraction and phenolic compounds. Research has proved that peels contain essential nutrients and phytochemicals. FVW can also be used in cosmetic industry, textile to extract as well as obtain bioactive compound. Proper utilization of FVW can act as strategic approach to improve health as well as environment by fortified food containing nutrients. (Sagar N.A et al, 2018).

This review summarises the research and the latest advances in utilizing FVW as a precious commodity of future.



Utilization of fruits and vegetable peel-based waste into novel industrial products (Kumar et al 2020)

FORTIFIED PROBIOTICS

Probiotics are one of the main functional food products. Peels of fruits and vegetables are highly nutritive and great source of bioactive compound. Antioxidants, fibres and oligosaccharides are present as functional ingredient in mango, citrus, pomegranate

and barbary fig peel. Probiotics help reduce the probability of colon cancer and help relieve constipation.

Researches show that probiotic yoghurt enriched with pineapple peel powder improved antibacterial, antioxidant and anti-cancer activities against E. coli while no remarkable effect was observed on Staphylococcus. Probiotic yoghurt when enhanced with apple, passion fruit and banana peel powder improved the rheological properties and promote the growth of Lactobacillus casei, Bifidobacterium animalis, Lactobacillus paracasei, Acidophilus (Kumar et al; 2020). Orange, passion fruit and pineapple composite peel powder was used in different ratio i.e. 1%, 0.5%, 0.7% (w/v) respectively to make fat free and sugar free probiotic set yoghurt(Pgi D.Jwa S, 2020).Yoghurt incorporated with 0.5% peel mixture was observed to have increased firmness and acceptability, reduced syneresis and high lactic acid bacterial counts were observed to have increased firmness and acceptability, reduced syneresis and high lactic acid bacteria counts were observed (Kumar et al;2020).

EDIBLE COATING

It is made up of various thin layer on the outer surface of food to enhance shelf life, maintenance of properties, characteristics and functionality of food at reasonable cost. Edible coating extends shelf life, act as antimicrobial agent (Prakash et al, 2019). Coating preserves fruit and vegetable during transportation from microbes, insects pre and post harvesting stage. Edible coating helps in developing modified atmosphere so as to introduce variation in fruit and vegetable in various fields such as sensory quality, colour, antioxidants property, restricted microbial growth, ethylene production and organic compound under anaerobic condition (Ullah A. Abbasi, 2017). Research have shown that presence of essential oil and their main component lemon grass citral has antimicrobial activity against pathogens EO are completely safe (Alpaslan Y.2017). Biodegradable nature and high myofibrillar protein content make fish gelatin a important biopolymer source for making biofilm. Vegetable peel-based films show less water permeability (Hanami Z.A.N et al, 2019). Potato peel constitutes of cellulose, starch, hemicellulose and fermentable sugar. When compared low concentration potato peel with higher concentration potato peel the former was found to have higher WVP (Borah P.P et al, 2017). Orange peels when embedded in carnauba wax and montmorillon nano clay on blood orange show less deformation, highest acidity and dissolved solid. They also show more brightness when coated with montmorillon nano clay (Nasirifar et al, 2018). Edible coatings made

Table -2: Fruit and vegetable based edible films.

Fruit/Veg. Common name	Matrix	Applied on food item	Technique used	Beneficial effects	References
Apple	CMC	Fresh beef patties	Micro fluidization	Complete inhibition of lipid oxidation and microbes. No effect on sensory characteristics	Shin S-H;et al 2017
Pomegranate	Mung bean protein			Pomegranate enriched peel showed higher phenolic content, antioxidant activity, antibacterial capacity compared to control mung bean protein. These films help develop bio functional edible films used for packing food products.	Moghadam M. et al, 2020

Metallic Nanoparticles derived from fruit and vegetable peel

Some biomolecule act as capping agent, restrict agglomeration of nanoparticles, others play the role of modelling agent by directing particles in specific direction. FVW synthesised nanoparticles have been found in research to be trustworthy, sustainable, eco-friendly technology as compared to chemical.

Application of metallic nanoparticles synthesised from fruit and vegetable peels.

Fruit/Veg	Type of nanoparticle synthesised	Reaction time	Morphology	Size	Application	Reference
Orange; Lemon; Sweet lemon	Silver	24 h	ND	ND	Antibacterial activity against *Pseudomonas aeruginosa*, *E. coli* and *Salmonella typhimurium*	Reenaa et al; 2017
Lemon	Silver	30 min	Sphere	2-3nm	Antibacterial activity against P. aeruginosa, E.coli, Acinetobacter baumanni. Antifungal activity against candida albicans	Samreen F.G et al, 2018

CARBON DOTS

Synthesis of carbon dots can be done from fruit and vegetable waste offering economic benefit. Functional component in peel act as carbon sources for carbon dots. Fruits and vegetable are rich source of antibacterial, antioxidants and dietary fibre. Further

their toxic free nature, cheap, biocompatibility, photostability, innocuousness properties make them suitable for basic building material (Lau et al; 2021). Oxygenolysis with concentrated acid, pyrolyzation, carbonization, polymerization, oxidation and nucleation are required during peels treatment to synthesise CDs. Application of CDs in biomedical field to energy storage devices, studies related to environment, detecting metals and additive in food and water purification have great potential. Huang C. et al, 2019). Mango peels are utilised in cellular labelling ferrous ion detection in food and water purification process and can detect heavy metals up to 1.2µm (Jiao et al; 2019).

BIOCHAR

It is used to purify water bodies by filtering different types of pollutant containing heavy metal. Biochar act as transition for production of ethanol from food processing industries biological waste and agricultural plant residue. To remove H_2S Potato Peel Waste was utilised to produce biochar by fast pyrolysis. To remove hexavalent Chromium from aqueous solution. Biochar was derived from pomelo peel, pineapple and sweet lime. To remove Congo red, methyl orange and malachite green from waste water. Pomelo and litchi peels were used (Kumar et al; 2020).

Table -5: Fruit and Vegetable peel based microbiological media

Fruit/vegetable	Process conditions Required for Biochar Formation	Applications	References
Banana	Hydrothermal carbonization at 230 °C for 2 h	Showed excellent lead clarification capability of 359 mg/g and 193 mg/g, respectively	Zhou N. et al, 2017
Pomelo	Pyrolysis at 450 °C for 1 h	One gram of biochar adsorbs 150 mg/L methyl orange dye	Zhang B et al,2019

Microbiological Media

Commercially available media are expensive so the peels of fruits and vegetable for example cabbage, carrot, gooseberry etc. are used as an alternative for nutrient agar to culture fungi and bacteria. FVW contains both simple and complex sugar that are digested by microorganism and are utilized in animal feed, bio ethanol and bio gas production. Melon peels, grape fruit and banana peels are rich in carbohydrate so act as a substrate for amylase production.

Economical and effective medium for the growth of fungi is banana peel. Macronutrients such as lipid, protein are found in water melon peel. The researchers reported that watermelon peel is best medium for growth of Lichtheimia corymbiform, Rhizopus oryzae, Fusarium oxysporum and Aspergillus niger. The studies also showed that watermelon peel dextrose agar media could be used as a substitute for PDA and Czapek Dox Agar. (Hasanin M. et al, 2019)

Biosorbents

Biosorption is a mechanism of reaction of sorbate with biosorbent that results in attunement of sorbate ion on the surface of biosorbent thus reducing concentration of sorbate in solution. Researches were done to develop biosorbent from fruits peel. Sponge gourd peel is very economical natural biosorbent. It helps remove malachite green. (Lau et al, 2021)

Table -7: Fruit and Vegetable peel derived bio sorbent and their applications

Fruit/Vegetable	Medium Composition	Purpose/Utilization	References
Dragon fruit	Dragon fruit peel powder (33.3 g/L), peptone (20 mg/mL) and agar (1.5%)	Viability analysis of *Escherichia coli*	Putri C.H. et al, 2017
Fruit/Vegetable	**Drying Temperature/Time**	**Applications**	**References**
Dragon fruit	105 °C/24 h	A dosage of 0.06 g adsorbed 192.31 mg/g of methylene blue	Jawad A.H. et al, 2018
Grapefruit	105 °C/24 h	Adsorbed 52.48 mg/g copper ion: Cu(II)	Romero- Cano l.A. et al 2017

CONCLUSION

Fruits and vegetable waste management is the need of the present scenario. The problem requires sustainable solution that can utilize the complete potential of FVW and help in achieving the benefits i.e., social, environmental and economic. Utilization of fruit and vegetable waste help in development of many value added products namely probiotics, carbon dots, edible film, nanoparticle, biosorbent and biochar. that are environment friendly and sustainable method to create new business opportunities and operationalizing this for a convenient purpose. Most of these researches are at beginner's level and requires technological advances and finding. Therefore, there is need to develop view point of a research and industrialist as well to improve the potential of FVW by supporting initial investment. This will help in utilizing FVW for producing value added commodities.

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