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Review Article

A short review: Biotechnological potentials of food waste

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Abstract

Food waste is hub of broad spectrum bioactive molecules. Either they are utilized as it is or required as raw material to prepare other valuable compounds. Approximately half of vegetables and fruits are wasted at different levels of their handling, processing, storage and transportation annually and this food wastage is not restricted to a specific region but it is considered as a global issue, in a current era of resource constraints. That is why; it is the need of time to channelize our future research efforts towards utilization of waste food to get different useful compounds like biofuels, medicinal and many other benefits. Though reported data did great contribution in this regard but still attention of researchers is required to fill this research gap by generating low cost bioactive biomolecules from wasted vegetables and fruits. Similarly, organized efforts for general public awareness about the biotechnological potentials of wasted food components from both government and cooperate sectors are required which in turn promote the concept of recycling and use of local low or no cost products.

Keywords: Bioactive molecules; Biofuels; Food waste; Fruits; Global issue; Vegetables

Introduction

The wastage of food is a serious issue of current era and according to recent estimation approximately more than one third of the dietary produce is spoiled before consumption **[1, 2]**. This type of waste is generated during transportation, storage, and processing of food **[3]**. The reported data highlights that around 42% of wasted food is generated by household activities whereas 39% food loss occurs during manufacturing process in the food industry and 14% have been observed during other food service i.e., ready to eat food, catering and restaurants, in addition to this 5% is lost during food supply **[4]**.

On other hand, the wasted food management system is also not much established yet. It is a major form of waste which enters the landfills and also contributes in causing greenhouse effect **[5, 6]**. But even these spoiled food items like rotten fruits and vegetables etc. possess considerable amount of sugars, amino acids, fatty acids and diverse

metabolites e.g., phenolics, alkaloids, glycosides, volatile oils, mucilage and gums along with reusable fibers, flavoring agents, and other functional phytochemicals [7-9]. Moreover, with the appliance of current food waste handling strategies, broad spectrum useful compounds are prepared from spoiled and wasted food components which include biodegradable plastics, lactic, acetic, and propionic acids, biofuels, enzymes, bioactive compounds, and nanoparticles [10-12]. The most commonly used microbes for biodegradation of waste food include *S. cerevisiae* [13], *Cupriavidus necator*, *Escherichia coli* [14], *Bacillus megaterium*, *Alcaligenes latus* [15], *and Bacillus cereus* [16] to attain following biotechnological benefits (Fig. 1).

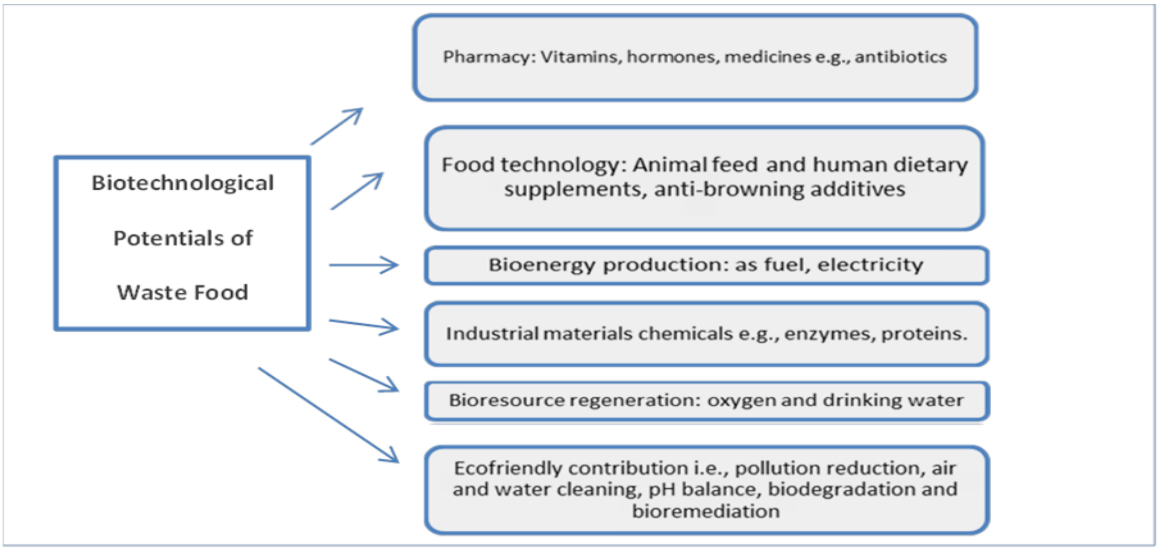

Figure 1. Biotechnological Potentials of food waste

Types of waste food and their biotechnological products

Though food waste is of diverse types which usually include wasted crops, rotten pulp, remaining peels and seed coats, left over fibers, waste generated during packing and transport and a huge bulk of cooked wasted food. But in current review authors have focused on biotechnological potentials of raw vegetables and fruits' pulp, peels and seeds based food waste (Table 1).

Table 1. List of reported bioactive compounds obtained from food waste

Plant		Bioactive Compounds	Ref.(s)
Waste of peels & rotten pulp	Apple (*Malus domestica*)	Dihydrochalcones, cedar, fodder, flavanols, fertilizer, pectin, anthocyanins pharmacognosal compounds & phenolic acids	[17-21]
	Banana (*Musa* sp.)	Catecholamines, phenolic acids & flavonols	[21-25]
	Pineapple *(Ananas comosus)*	Extracted starch	[26]
	Berries	Phenolics, flavonols & anthocyanins	[27, 28]
	Pomegranate	Polyphenolic compounds	[29]

	(*Punica granatum)*		
	Citrus fruits	Pectin, phenolic acids (e.g., hydroxybenzoic and caffeic acids), eriocitrin, hesperidin, apigenin-glucoside, limonoids & diosmetin-glucoside	**[30]**
	Mango (*Mangifera indica)*	Phenolic acids, flavonoids, catechins, hydrolysable tannins, xanthanoids, xanthones, carotenoids, vitamin C, tocopherol & mangiferin	**[31-33]**
	Plum (*Prunus domestica)*	Phenolic acids, flavonols & anthocyanins	**[34]**
	Exotic fruits	Miraculin, polyphenols, flavonoids, anthocyanins, carotenoids, anthocyanin, quercetin glycoside fatty acids alkaloids, annonaceous acetogenins, phytosterols, polyphenolics, tocols, dietary fiber, essential minerals, oil, Vitamin C, polyphenolic acids (i.e., caffeic, coumaric, gallic, syringic, ellagic acids), trans-isoeugenol & eugenol	**[35, 36]**
	Cauliflower (*Brassica oleracea)*	Kaempferol, quercetin ,sinapic, ferulic, isothyiocynates, glucosinolates & hydrolysate enzyme	**[37, 38]**
	Potato (*Solanum tuberosum)*	Phenolic acids e.g., chlorogenic acid and glycoalkaloids, pectin	**[39]**
	Tomato *(Solanum lycopersicum)*	Carotenoids (β-carotene and lycopene), proteins, sugars, waxes & oils	**[40]**
	Carrot (*Daucus carota)*	Phenolic compounds, α- and β-carotenes, lutein, tocopherols, vitamins & essential minerals	**[41-43]**
	Beet root (*Beta vulgaris)*	Nitrates, flavonoids, carotenoids, betalains, phenolic acids, vitamins & minerals	**[44-46]**
	Broccoli (*Brassica oleracea)*	Glucosinolates, epigallocatechin, gallate, sulphur-containing secondary metabolites & their byproducts	**[47, 48]**
Waste of seeds	Longan, Jackfruit, Avocados & Mango	Rich source of polyphenolic compounds	**[49]**
	Lemon & Orange	Gallic and caffeic acids, ichangin, deacetylnomilin, limonin, nomilin, obacunone, hesperidin & narirutin	**[50, 51]**
	Berries	Oil enrich in tocopherols	**[52]**
	Plum (*Prunus domestica*)	Oil with high content of oleic and linoleic acids and with percentage of unsaturated/saturated fatty acids, diverse proteins, antioxidant peptides and angiotensin-converting enzyme inhibitors	**[53]**
	Mango *(Mangifera indica)*	Polyphenols, flavonols, alkylresorcinol, xanthones, gallotannins, phytosterols (stigma-and campe-sterol), sito-sterol (b-sito-sterols) and tocopherol. Source of	**[54]**

		lipids. High essential amino acids index. Mango seeds lipid (5–13%) & the oil has high levels of saturated fatty acids (mainly palmitic, oleic and stearic acids)	
	Custard apple *(Annona squamosal)*	Acetogenins	**[55]**
	Pomegranate *(Punica granatum)*	Oil having high amounts of conjugated fatty acids & dietary fibers	**[56]**
	Avocado (*Persea americana*)	Oil contains high amounts of polyphenols, flavonoids, flavonols, procyanidins, tannins, phenolic acids, hydroxycinnamic acids & essential fatty acids.	**[57]**
	Rambutan *(Nephelium lappaceum)*	Alkaloids, saponin & tannins	**[58]**
	Red pitaya (*Hylocereus polyrhizus)*	Phenolic compound with greater percentage of catechin & ascorbic acid	**[59]**
	Grapes *(Vitis vinifera)*	Phenols, tannin, resveratrol, quercetin, flavonoids & anthocyanins	**[60, 61]**
	Date (*Phoenix dactylifera*)	Polyphenolic compounds, flavonoids, flavonols, anthocyanins, proanthocyanidins & ascorbic acid	**[62]**
	Rapeseed (*Brassica napus*)	Sterols, tocopherols, polyphenols, flavonoids, tannins & phospholipids	**[63]**
	Camelina (*Camelina sativa*)	Unsaturated fatty acids like omega 3- and -6 fatty acids (linoleic and linolenic acids), phenolic acids, flavonoid aglycons & carotenoids	**[64]**
	Canavalia, Entada scandens, Pometia pinnata, Mucuna, Nelumbo, Sesbania	Polyphenols, flavonoids & vitamins	**[65-68]**
	Cupuassu *(Theobroma grandiflorum)*	Sulfated flavonoid glycosides (theograndins I and II), flavonoid antioxidants, catechin, epicatechin, kaempferol, quercetin, quercetin 3-O-β-D-glucuronide, isoscutellarein hypolaetin 8-O-β-D-glucuronide, & isoscutellarein 8-O-β-D-glucuronide 6″-methyl ester	**[69]**

Future perspective

The wasted food items are of diverse types like rotten raw pulp, peels, fibers and seeds or cooked products. In this review a brief account of bioactive compounds is mentioned to highlight the pace of progress in this specific domain. But still research gap exists to utilize maximum potential which is wasted in huge amount on daily basis. The way energy crisis is hitting whole world, first of all, more new floral testing and developmental of protocols are required to generate biofuels, substrates, antioxidants, saccharides, amino acids, organic acids, food additives and other several economically

important compounds **[70]** at low cost based on local and low cost produce **[71-73]**.

Authors' contributions

Conceived and designed the experiments: A Javed & N Jamshaid, Performed the experiments: M Hassan & A Ashfaq, Analyzed the data: N Sadiq & A Ali, Contributed materials/ analysis/ tools: A Mobeen & S Chauhdry, Wrote the paper: HMI Sultani, M Adnan & A Khanim.

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