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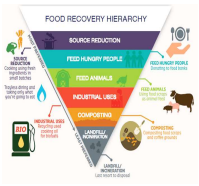

Food by-product processing for sustainable growth and profitability

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The food industry generates large amount of wastes or by-products annually around the world from a variety of sources. The waste management is one of the major parts of food industries. The large volume of the by-product and huge costs associated with their disposal result in economic losses. Therefore, the conversion of by-products to products giving health benefits can result in economic benefit to labour, stakeholder and country. Most of the food wastes or by-products are an excellent source of nutraceuticals, bioactive compounds, inherently functional and possess many components that are good for human health. Food wastes or by-products can be converted to the functional food ingredients. The market for the functional foods has seen a tremendous demand in the recent years.

Fruit and vegetable by-products: Fruit and vegetable processing industries has grown tremendously around the globe as a response to reduce postharvest losses and generate income. However, processed food industry has accounted 30-40 per cent losses and wastages in the form of organic waste such as peel, stem, core, seeds and pomace from juice extraction. By-product obtained from fruit processing plants offers untapped potential of producing low cost natural bio-components having food applications. Hence, there is need to give attention to utilize tons of pomace produced each year to address environmental issues and generate new income source. Utilization of pomace in food applications is important from nutritional point of view as they possess good amount of tocopherols, phytosterols, carotenoids and antioxidant activity. Processed fruit and vegetable industry has accounted 25 per cent losses and wastages after processing of fruits and vegetables that includes 10 per cent during distribution and 7 per cent during consumption. This results in localized production of large tonnages of waste by-products. The waste management is often achieved by landfill, land spreading or selling as animal feed or for its production (Kaushal *et al*., 2002). The major waste produced includes the organic waste such as peel, stem, core, seeds and pomace. This remaining matter can be converted using suitable technology to produce multifunctional food ingredients or can be used as raw material in the secondary processes. Moreover, it can be utilized in operating supplies or for producing new products. These by-products can be used as a valuable source of biological food additives that can be significant alternative toward alleviation of food safety issues. These can also be used for development of food additives or supplements with high nutritional value that are economically feasible. Studies have been conducted on the possibility of utilizing fruit and vegetables by-products to produce high dietary fibre jam. These by-products are excellent source of low priced functional food components and the jam made by using carrot peel, apple pomace, banana peels and mandarin peels was rich in dietary fibre, vitamin C, enhanced minerals, total flavonoids and antioxidant activity. This transformation of by-products into a high value product makes it possible for food companies to reduce their cost and generate benefits, thereby, improving their competitiveness (Kodagoda and Marapana, 2017).

Apple pomace: Apple production is the backbone of the rural economy of Jammu and Kashmir state. Though mainly this fruit is used as a whole fruit, a portion of it is used in the value added products like concentrates, juices and cider. The pomace is the solid remains of apple fruit which mainly contain the skin, pulp, seeds and stalk of the fruit. Apple pomace is the major by-product of the apple juice industry, representing 25 per cent, whereas approximately 75 per cent of the fruit weight is extracted as juice. This apple pomace has a high fermentation potential, contains large amount of water and is wet in nature, creating high chemical oxygen demand (COD) of

250-300 g/kg and a high bio chemical oxygen demand because of its biodegradability (Kaushal *et al*., 2002). For a safe disposal and a pollution free environment some extra labour and technological costs are involved. The utilization of the pomace to various useful products can solve the waste disposal problems and production of value added products can bring economic benefits to the processor. Conventionally, apple pomace is used as animal feed or is thrown away and causes environmental pollution. But it can be converted into edible products as pomace is a rich source of pectin, carbohydrates, fibres, and minerals. Food products like apple pomace jam, sauce, *papad* can be prepared and also have application in confectionery industries.

Orange waste: By-products obtained from orange pulp and peel after juice extraction is the cheap and abundant source of dietary fibre. Dietary fibre powder can be prepared from this. After proper washing, it is dried at a temperature below 65^{0}C for 12 hrs. Care should be taken that functional properties and polyphenols, tannins, anthocyanin like compounds remain unchanged. After drying it is ground and this powder can be used for value addition in various food products.

Potato peels: A large amount of potato peel is generated as potato is mostly consumed vegetable worldwide. Potato peel is rich in fibres. Fibres play an important role in human health and help in the prevention of diseases. To prepare potato peel fibres, potato peels are washed with water and dried in an oven at 60^{0}C for 12 hrs. After this it is milled and stored under refrigeration for use in various value added products.

Carrot pomace: It is produced during the carrot juice extraction process. This solid waste is a rich source of carotenoids, fibres and phenolics compounds. After processing, it can be used in making carrot based condensed milk. The powder can be prepared by vacuum drying and it can be used as a good fibre source in many bakeries and other food products.

Green pea peels: Peels obtained from green peas are generally thrown away but they can be utilized efficiently. Peels are rich in dietary fibres. The powder can be prepared by drying in an oven at 60^{0}C for 12 hrs, grinding and sieving. Many value-added products can be prepared from this. It is the potential source for the cellulose production (Aparicio *et al*., 2010).

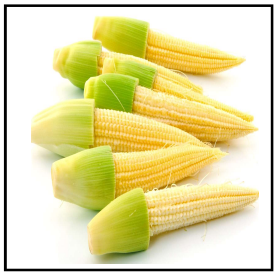
Tomato by-products: Tomato processing by-product is constituted by peel and seeds and represent around the 4 per cent of fruit weight. If the waste remaining is not used, it will increase the disposal problem and also aggravate environmental pollution. Besides the disposal on the field, at this moment, tomato by-product is mainly used for animal feeding, with no economical benefits for the industry. Tomato by-products obtained as a residue of tomato processing plants can be used to extract different compounds of high nutritional and economical values as fibre, antioxidants, or oil that can be used in food industry. Based on the interesting chemical composition of tomato by-products and fractions, the actual trends of recovery by-products propose their use in human nutrition as functional food (Valle *et al.,* 2007).

Citrus fruit waste: Most of all citrus by-products are generally used as animal fodder. Citroflavonoids, carotenoids, aromatic compounds, dietary fibre can be obtained from citrus peels. Citrus waste can be used as a clouding agent in citrus beverages or in other value added products like soup sticks. Cellulose can be extracted from citrus waste and utilized as a thickening agent. It possesses high antioxidant activity also.

Mango fruit waste: By-products from mango are peel and kernel. Mango peel powder is rich in polyphenols and can be used in baked products, snack items or extruded products. Mango seed kernel has low protein content but it is high in essential amino acids. Furthermore, it is also a good source of polyphenols, phytosterols and tocopherols. Mango seed could be used as natural antioxidants, antimicrobial compounds as a functional ingredient. The oil from mango seed kernel is very useful; it contains 44-48 per cent saturated fatty acids

and 52-56 per cent unsaturated. Mango stone can be used as an adsorbent (Kittiphoom, 2012).

Grapes: Different types of waste like stem, seeds, pomace generated during winemaking process from grapes. Grape pomace is fibrous material and because of its carbohydrate content, it is used in different fermentation processes. Grape stem extract prepared in acetone have a high level of antioxidant and polyphenols (Barros *et al.,* 2015).



Baby corn: Baby corn cob is the only edible part and other parts like corn silk (Corn hairs) the by-products (Rahman and Rosli, 2014). Corn silk is a rich source of ash, protein, and dietary fibres. It is useful in treating urinary infection and cystitis. In addition, the powder obtained from it is rich in antioxidants and, therefore, can be used for value addition also.

Almond and walnut residues: Almond and walnut residues can serve as excellent feed stocks for production of energy and value added products. The hulls adds nutrition to the animal diet and aid in healthy milk production. Almond skins (also referred to as almond bran) are industrially removed from the nut by hot water blanching and constitute 4–8 per cent of the total shelled almond weight. Almond shell can be used as growing media, heavy metal adsorbent and as dietary antioxidants (Chen *et al*., 2010).

Cereal by-products:

Rice by-products: Rice (*Oryza sativa*) is one of the main cereal crops, as well as staple food for most of the population. Frequently, rice is eaten in cooked form by humans to obtain various nutrients, as well as to supplement their caloric intake. The milling of paddy rice yields 70 per cent yield of head rice (endosperm) as its major product and are unconsumed portions such as rice husk (20%), rice bran (8%) and rice germ (2%). Most of the rice by-products, including rice husk and rice bran, are used as animal feeds. Broken rice along with rice bran and rice germ can be used in the production of beer. Broken rice-a by-product of rice milling process has nutritive value similar to whole rice and is readily available at relatively cheaper rates. It could, therefore, become an attractive ingredient in extrusion industry and other value added products. In recent years, rice bran has received increased attention as functional foods due to their phytochemical compounds such as γ-oryzanol, vitamin E, mainly tocotrienols and dietary fibre which can help to lower cholesterol. The rice bran can be utilized in the production of rice bran oil while as defatted rice bran being rich in protein (10-15%) can be utilized in preparation hypo allergic bakery products (Sairam *et al*., 2011).

Corn by-products: The milling of corn for the production of food constituents results in a number of low-value co-products. Two of the major co-products produced by this operation are corn bran and corn fibre, which currently have low commercial value. Corn bran and corn fibre contain potentially useful components that may be harvested through physical, chemical or enzymatic means for the production of food ingredients or additives, including corn fibre oil, corn fibre gum, cellulosic fibre gels, xylo-oligosaccharides and ferulic acid. Components of corn bran and corn fibre may also be converted to food chemicals such as vanillin and xylitol. The most common by-products of corn milling are normally used for animal feeding. The corn by-products can also be utilized in the production of oil and distilled alcohol (Rose *et al.,* 2010).

Wheat milling by-products: The wheat milling by-products include wheat bran and wheat middlings, 25 to 30 per cent of the total wheat. In food industry wheat bran is used as emulsifier. Usage of modified wheat bran can add several properties to the final food product and can impart functional properties to it. It increases water and oil holding capacity which helps in reduction of cooking time. In baking it is used as an additive in dough, wheat bran is known to reduce the quality of bread resulting in a lower specific volume and denser crumb texture. Added wheat bran also

causes changes in the flavour and colour, and reduces the shelf-life. Arabionxylans obtained from the fibre components of wheat bran can be used in food formulations as gelling agents, cryostabilizers and as a source of prebiotics and also in beverages to increase the amount of dietary fibre wheat bran can be used as an additive. Studies have shown that wheat bran can be modified in several operations to edible packaging material used as an inner or outer package. Edible packaging material could be used, for example, as packaging papers for burgers and sandwiches (Wang *et al*., 2011).

Dairy industry by-products: During the manufacture of different dairy products, the inevitable problem of utilization of by-products is encountered. Because of their unique and important nutrients available in the by-products, they have to be utilized in a proper manner considering the welfare of the general masses. The whey can be used with fruits for development of whey beverages. By employing suitable microbial cultures (*Bacillus megaterium*), dairy wastes can be converted to bio plastics, ethanol, bio peptides and bio surfactants. The dairy wastes can also be converted to bio fuels and bioelectricity.

Conclusion: The need to prevent and reduce food waste, while ensuring the safety of the food is a subject of growing societal, economic, environmental and political interest. Food losses and waste cost huge amounts encouraging food insecurity and malnutrition. Apart from economic losses, they have a major impact on the environment. The food that is ultimately lost or wasted consumes about a quarter of all the water used for agriculture purposes, requires a cropland area and also contributes to loss of biodiversity. The use of by-products as additives in the food chain and other purposes can result in economic growth. However, there is a lot of progress to be made relating to waste regulations to facilitate the use of former foodstuffs and innovative methods are also required for the recovery of food waste, rather than its disposal.

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