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REVIEW PAPER

Waste management in fruit and vegetables processing industry

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SUMMARY :

Waste management includes collection, transportation, processing, recycling or disposal and monitoring of waste matters. It is utmost important for protecting environment and public health. It is also used to recover value added products. Waste material generated from food processing and food service facilities can present treatment problems as they contain large proportions of carbohydrates, proteins, fat and mineral salts. Organic matter of the wastes must be subjected to biological stabilization prior to their disposal. Improper disposal of waste materials as practiced traditionally, is not only harmful but also uneconomic owing to unavailability of valuable components. Incineration is a commonly used method of waste disposal but it also generates toxic gases. Processing of fruit and vegetables generates varying level and kinds of wastage that can be managed differently. They can be used in composting, cattle feeding and biogas generation and certain types may also be utilized in production of value added products. With the rapid progress in establishment of agro-processing industries in our country on account of liberal government policies, the importance of waste management has become an essential and integral part of plant design as the inappropriate disposal of wastage has already caused great loss to environment and public health. Food processing is a capital intensive, high energy and water consuming, and moderate to highly polluting industry. However, one can minimize adverse effects on environment and public health and may also augment profit of processing unit by judicious disposal and utilization of waste materials.

KEY WORDS : Waste management, Composting, Biogas, Valuable component

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Now-a-days, it has become necessary to augment the processing scenario of food in India owing to its necessity and manifold benefits (Table 1). Fruit and vegetables processing industries generate maximum amount and type of wastage (Table 2), so it requires special attention. There are various methods of disposal of wastages but one with most economic management, eco-friendly and maximum potential needs to be employed. Moreover, this requires to be considered as an essential part of process plant design not only for establishing new plants but also for incorporation in existing plants. The disposal of waste material has become a challenge to the processors, as different agencies are pressurizing for an environmental friendly treatment of waste material. The utilization of waste for the production of value added products is very important in the management of foods processing waste (Table 3).

Table 1: Benefits of food processing

Sr. No.	Benefits
1.	It reduces the huge post harvest losses.
2.	It assists in stabilization of prices as that provides due remuneration to the growers.
3.	It helps to improve target markets not only in main season but also in off season.
4.	It helps in proper shipment and utilization of produce.
5.	Food can be made available to the places where it is not grown.
6.	It provides ready-to-serve or -use food to publics during the natural calamities like drought, flood, earth quack etc.
7.	It provides ready-to-serve food to army, other security forces and affected public during war and internal disturbances.
8.	It provides convenient food that save time and energy needed to prepare food.
9.	It makes the perishables available round the year thus assists in providing mixed diet that is essential to get balanced nutrition.
10.	It increases the export potential of perishables.
11.	Reduces problem of collecting wastage and its decay
12.	It helps to reduce problem of unemployment.
13.	It also encourages unemployed youths to establish their own agro industry.

Table 2 : Types of waste generated (%) from various fruit and vegetable processing industries

Commodity	Per cent waste (weight basis)	Nature of waste
Apple	20-30	Pomace
Apricot	8-25	Stone
Banana	-	Peel
Bean, green	5-20	Strings, stem
Beet	7-4	Peel
Cabbage	5-25	Outer leaves
Carrot	18-52	Peel, top portion, pomace
Grape fruit/citrus	55-60	Peel, rag and seed
Grapes	-	Stem, skin and seeds
Watermelon	40	Rind and peel
Lime	60	Peel, seeds, rags and pulp
Mango	40-60	Peel, pulp and stone
Orange	50	Peel, rag and seed
Peach	4-11	Stone
Pear	2-26	Peel, pomace
Peas	6-79	Shell
Pineapple	30-60	Peel, core and course solids
Potatoes	10-15	Peel, starch, fibre
Sweet potato	15	Peel
Tomato	20-30	Skin, core and seeds

(Raj *et al.*, 2011)

Table 3 : Benefits of waste management

Sr. No.	Benefits
1.	Prevention of environmental pollution.
2.	Maintenance of proper hygiene and sanitation.
3.	Recovery/extraction of vital substances.
4.	Production of value added food products.
5.	Can increase profit of the industry.

Waste management strategies in fruit and vegetables processing units :

Most of fruits and vegetable wastes are rich sources of vital constituents like carbohydrates, proteins, fats, fibres etc. The waste is also a rich source of several vital components which can be recovered or waste can be utilized in preparation of value added products. Therefore, the adaption of right strategy would be utmost importance for waste management. It includes:

– Adoption of good manufacturing practices.

– Use of appropriate technology to minimize wastes to reduce the pollution problem and increase the product yield and so the profit.

– Regular removal of generated wastages from the processing area to avoid pollution in plant and surroundings and reduce chances of product contamination.

– Pretreatment of wastage to avoid its degradation for proper storage and further use.

– Use of eco-friendly, feasible and economic disposal method.

Waste disposal methods:

Several method being used for disposal of waste matters are described in brief (Table 4). Most of them have a high capacity to degrade concentrated and difficult substrates (plant residues, animal wastes, food industry wastewater and so

Table 4 : Methods of waste disposal

Method	Principle	Merits	Demerits
Traditional methods			
Land filling	Control application of waste to soil or soil-vegetation system (Solid- phase treatment System)	Simple process Inexpensive	Wastage of vital component Slow degradation rates High exposure risks and may require long incubation periods
Incineration	Oxidation of combustible material in waste to produce heat, water vapor, nitrogen, carbon dioxide and oxygen	Simple process Maximum volume reduction Destruction of pathogens and toxic compounds, Energy recovery	Emission of toxic gases causing pollution and wastage of vital component
Composting	An anaerobic microbial driven process that converts solid organic wastes into stable, sanitary, humus-like material	Increase soil nutrient content and water holding capacity of sandy soil, water infiltration of clay soil Suppress certain plant diseases and parasites	Wastage of vital component Expensive operation, Toxic degradation products and their leaching difficult to find disposal sites
Cattle feeding	Use of wastage as cattle feed	Simple method Complete disposal	Wastage of valuable component
Other methods			
Bioremediation	Natural process by which microorganisms either immobilize or transform environmental contaminants to innocuous end products	Relatively inexpensive and low exposure risks	Low degradation rates Less control over environmental parameters Needs good hydrogeological site and incubation periods are months to years
Pyrolysis	Thermo-chemical anaerobic digestion of waste matter	Gas/liquid for energy production Low demand for land filling	Difficult heat transfer to feedstock Difficult control of product quality
Digestion	Enzymatic break down of large insoluble organic molecules into small soluble organic molecules which can be absorbed and used by either aerobic or anaerobic microorganisms	Low energy consumption Easy operation Recovery of more of the basic fertilizer values in the sludge Economic High capacity to degrade concentrated and difficult substrates	Operational difficulties of sludge Bulking inability of the system to treat high BOD or COD loads Unstable under variation of operation conditions & complexity
Solid state fermentation	Occurs in absence or traces of free liquid and employ an inert substrate or a natural substrate as a solid support for microbes	Favorable conditions for fungal growth By-products as source of human and microbial food Ecologically beneficial Low contamination by bacteria and yeast	Only microorganism that grow at low moisture levels can be used, Requires high inoculums volumes Very difficult to agitate.

forth). Production of value added products from fruit and vegetables industry waste is one of the most important alternatives. Depending upon the composition of the waste material they can be exploited as a source material for the production of different products. These are described as follows.

Mango :

The industrial processing of mangoes ends up with a considerable proportion of stones and peels which are discarded and end up in wastes. The stone content of mangoes ranges from 9-23 per cent with an average 15 per cent (Raj *et al.,* 2011). Mango seed kernel fat is a promising source of edible oil and has attracted attention since its fatty acid and triglyceride profile is similar to that of cocoa butter. Mango seed kernels may also be used as a source of natural antioxidant (Puravankara *et al.,* 2000). Mango peel is also a good source of pectin. Mango pulp recovered from trimmings, stone etc., can also be utilized for the preparation of mango leather, alcohol and vinegar.

Citrus:

About 50 per cent of the weight of citrus fruits is discarded as waste in the form of peel, membrane, juice vesicles and seeds when these fruits are squeezed (Crandall *et al.,* 1983). From the peel a number of by-products like candied peel, peel juice for molasses, essential oil, pectin, citric acid, vitamin C, glucosides (bioflavins used as a antioxident), D-limonine, hesperidin, narirutin and eriocitrin (used as flavouring compound) etc. can be prepared (Lal *et al.,* 2010; Mouly *et al.,* 1994). The oil of citrus is used in cosmetics, pharmaceutical perfumes and for scenting soap. Citrus waste can also be used for the production of pectinase on solid state culture. Microbial gums like xanthan can be produced from citrus waste by using *Xanthomonas compestris* (Raj *et al.,* 2011).

Banana :

It is widely used for feeding dairy and beef cattle. Banana pseudo-stem contains about 5 per cent edible starch and may be utilized as raw material for the preparation of paper pulp (Anand and Maini, 1997). The pulpy portion scraped from the thick peel of banana can be utilized for making banana cheese, alcohol, vinegar etc.

Guava:

Guava wastes constitute only 10-15 per cent of the fruit and it is a rich source of relatively low methoxylated pectin. Peel and pulp of guava fruits could be effectively used for antioxidant dietary fibre production (Jimenez-Escrig *et al.,* 2001). Fruit slices following extraction in jelly making may be used for making fruit cheese and toffee.

Pineapple:

The waste after processing is rich in fibres that include cellulose, hemi cellulose, lignin, silica and very low amount of proteins. Chopped pineapple tops and leaves could be ensiled with molasses (1 %) and urea (0.2 %) and thus useful cattle feed supplement can be prepared (Satapathy *et al.,* 1967). The pulpy waste material after juice extraction may be used for ethanol production. Trimmings produced in peeling of fruit are utilized for juice extraction. Fruit core is used for juice extraction and making candy.

Papaya :

The latex of papaya fruit is used for the production of papain (a proteolytic enzyme used as a meat tenderizer) and pectin. Defatted papaya seed meal may be used for extraction of crude proteins and crude fibres (Jagtiani *et al.,* 1988).

Apple pomace:

The most reasonable way of utilizing apple pomace is production of pectin. In comparison to citrus pectin, apple pectin is characterized by superior gelling properties (Schieber *et al.,* 2001). Apple pomace is also a good source of polyphenols such as catechins, phloretin glycosides, quercetin glycosides and procynanidins which are mainly dominant in peel (Lommen *et al.,* 2000). Seed contain good amount of β-glucosidase with higher glucose endurance (Tian, 2004). Apple pomace is also used as flavor extract and for fermentation.

Grape pomace, stem and seeds :

Grape pomace represents approximately 20 per cent of the weight of grapes processed. A great range of products such as ethanol, tartrates, citric acid, and dietary fibre are recovered from grape pomace (Nurgel and Canbas, 1998; Girdhar and Satyanarayana, 2000). Grape pomace also used for production of anthocyanins, flavonol glycosides, phenolic acids and alcohol. Catechin, epicatechin, epicatechin gallate and epigallocatechin are major tannin compound which can be recovered from grape skin (Souquet *et al.,* 1996). Pomace can also be converted into jelly and chutney while oil is extracted from seeds that are of edible quality.

Peach/ plum/ apricot :

Stone fruits kernels are also a good source of oil. The oil obtained can be used for preparation of facial cream, lip balm, soap etc. Press deoiled cake after oil extraction from apricot kernels is a good source of essential oil and protein isolate. Plum waste can be used for extraction of natural colors (Raj *et al.,* 2011).

Passion fruit :

The waste from passion fruit such as rind constitutes 90

per cent of waste and is a source of pectin and seed oil that is rich in linoleic acid (65 per cent) which may be recovered (Askar and Treptow, 1998).

Watermelon :

Watermelon rind is a rich source of citrulline (a non-essential amino acid). Citrulline is a potent antioxidant. It increases plasma arginine levels, reduces elevated total leukocyte and segmented neutrophil counts to normal limits (Rimando and Perkins-Veazie, 2005).

Potato :

Potato waste can be successfully used as an animal feed. With the help of solid state fermentation, it is possible to increase the protein content of this waste, so that these can be used as animal feed (Laufenberg *et al.,* 1996). During peeling and slicing of the potatoes starch can be obtained and can be used as thickener. Potato peels supplemented with 0.04% ammonium chloride can be used for the production of proteins by using a non-toxic fungi *Pleorotus ostreatus* (Raj *et al.,* 2011).

Olive pomace :

It is used as a nematode controlling agent for tomatoes (Rodriguez-Kabana *et al.,* 1995). Olive press cake is a good source of lignin (35 %). Olive seed is used for the production of activated carbon. Whole stones and seed husks are used for production of fermentable carbohydrates (Walid, 2001).

Carrot pomace :

Carrot pomace acts as a stabilizer in bread and bakery items, as well as in cereals and dairy products due to its certain functional properties (Ohsawa *et al.,* 1995; Lucas, 1997; Masoodi and Chauhan, 1998). Carrot pomace also used for extraction of pectin, ferulic acid and vitamins. In beverages, carrot pomace will stabilize the natural color, improve vitamin and fibre content. (Henn and Kunz, 1996).

Almond shell:

Almond shell is being used as growing media or soilless culture for growing tomato, melon crops and ornamental crops which is more eco-friendly and less expensive (Urrestarazu *et al.,* 2008).

Tomato:

Tomato pulp and pomace from processing waste can be used for production of SCP using *Aspergillus niger.*

Cabbage:

Various enzymes such as invertase (by fermenting Sauerkraut waste by using *Canidida utilis*), amylase, protease and cellulose (with the help of native flora) can be produced by fermenting food processing waste cabbage. Microbial gums like xanthan can also be produced from cabbage waste by use of *Xanthamonas compestris* (Raj *et al.,* 2011). These enzymes have industrial potential.

Conclusion:

There are several methods available for waste management which has various merits and demerits. Waste generated in fruit and vegetables processing industry may be used either for extraction of vital component or production of valuable products but that requires well planned strategy and its execution. Proper management of waste not only reduces the pollution problems but also may assist in increasing the profit.

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