# Doubling income through advance approaches for fruits and vegetables in the arid region

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# Content

# WASTE UTILIZATION FROM ARID HORTICULTURAL CROPS FOR SUPPLEMENTING FARMERS' INCOME

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## 1.0 INTRODUCTION

The Indian arid zone covers nearly 31.8 million ha country's geographical area. It mainly spreads in parts of Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Punjab and Rajasthan states of India. Six of the eleven districts in Western Rajasthan i.e.Barmer, Bikaner, Churu, ShriGanganagar, Jaisalmer and Jodhpur lie wholly in the arid zone. High temperature, low precipitation and high velocity winds are some of the main culprits ofArid zone which limit the scope for higher crop productivity in these areas. Under this situation, arid horticulture based farming practices has ample scope to raise the productivity and living standard of peoples of the hot arid and semi-arid regions. Arid horticulture based farming practices greatly favor the development of high quality produce in many fruit and vegetable crops. Horticulture based farming practices are now considered to be the most ideal strategy to provide food,nutrition and income security to the people especially in Arid and Semi-arid region of the country (Chundawat 1993; Chadha 2002).

Today India is the world largest producer of many fruits and vegetables.Wastes and byproducts generated from fruits and vegetables are organic in nature and contribute a major share in soil and water pollution. Also, greenhouse gas emission caused by fruit and vegetable wastes (FVWs) is a matter of serious environmental concern. Proper disposal and handling of these wastes can help reduce pollution risks, at the same time be a source of several useful and commercially valuable by-products. Organized processing of wastes can help farmers achieve higher incomes.

## 2.0 PRESENT STATUS IN INDIA AND GLOBAL SCENARIO

There exists a huge gap between per capita demand and supply of fruits and vegetables due to enormous waste during post-harvest storage and handling. According to recent estimate around 18% of India's fruit and vegetable production – valued at INR 133 billion – is wasted annually. In developed countries, 40-60% of production is processed, thus reducing wastage, and at the same time providing wastes in bulk for utilization in making other by-products. However in India, around 1.8% of horticultural produce is processed mainly by small-scale units, with no controlled method of waste disposal.

Most of the vegetables and fruits are sources of fibre, oils, and other useful products. Composition of different fruit and vegetable wastes are given in Table 1. In general, seeds containbioactive lipids and polyphenols while peels are a rich sourceof dietary fibres.

Table 1. Composition of different fruit and vegetable wastes (per 100g)

| Waste | Moisture (g) | Protein (g) | Fat (g) | Minerals (g) | Fibre (g) | Carbohydrate (g) |
|---|---|---|---|---|---|---|
| Banana peel | 79.2 | 0.83 | 0.78 | 2.11 | 1.72 | 5.00 |
| Sweet orange | 4.00 | 15.8 | 36.9 | 4.00 | 14 | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| seeds | | | | | | |
| Watermelon seeds | 4.3 | 34.1 | 52.6 | 3.7 | 0.8 | 4.5 |
| Muskmelon seeds | 6.8 | 21 | 33 | 4 | 30 | - |
| Pumpkin seeds | 6 | 29.5 | 35.4 | 4.55 | 12 | 12.53 |
| Apple pomace | - | 2.99 | 1.71 | 1.65 | 16.16 | 17.35 |
| Mango seed kernal | 8.2 | 8.5 | 8.85 | 3.66 | - | 74.49 |

(Source: Maini and Sethi, 2000)

To some extent, value-added products are extracted from thiswaste, but the majority of the waste is currently unutilised and discarded.At present there are few possibilities for the utilization or recycling for most ofthese wastes, the residues are thus disposed of or fed to animals.There are at present fewexamples small scale industries which utilize fruit and vegetable wastes and generate income.

- Mandarin essential oil is extracted in small quantity at different processing units at Bangalore, Nagpur, Abohar and Sikkim. Lime oil is also extracted at small quantities.
- Watermelon rind after removing green portion is used to prepare 'Tuti-fruiti' in UP.
- Seed kernals of watermelon, muskmeloncucumber, pumpkin are used in sweets, beverages and bakery.
- Dietary fibre, Vitamin C and antioxidant enriched biscuits have been developed by incorporation of aonlapomace (a byproduct generated during aonla juice processing) as one of the biscuit ingredients by researchers at CIST, Lucknow.

## 3.0 GAPS IN PREVAILING SYSTEM

Currently, the fruit and vegetable processing is done in India mainly through small-scale industrieswhich mainly fall under informal sector and, thus, processing waste is considered to be of negligible value compared to the processed fruit. Also the amount of produce being processed is low and mainly consumption is in fresh form. This leads to not much waste being available at a single site for collection and utilization. Data from developing countries indicatethat large scale industries process wastes into biogas or compost, while from smaller industries is for the most part disposed ofthrough municipal waste disposal systems or just discarded near processing plants.There is neither organized system nor awareness among people of importance of collection and disposal of this biodegradable and high organic matter rich waste. Also the concept of use of wastes for purposes other than as cattle feed or compost is a novel concept in India.

## 4.0 ADVANCE APPROACHES FOR FRUIT AND VEGETABLE WASTE UTILIZATION IN ARID REGIONS

Various compositional studies of the wastesuggests presence ofa wide range of bioactive compounds in different residual fractions.The first phase of waste utilization is mainly the substance characterization. Optimal recycling and applicationareas and possibilities are based on substance characterization. The characteristics of fruit and vegetable wastes, some recoverable valuable by-products (Table 2) and their alternate uses are briefly describedin this section.

Table 2.Possible by-products from fruit and vegetable wastes (Maini and Sethi, 2000; Banerjee et al., 2017)

| Fruit/Vegetable | Type of waste | Possible by-products/usage |
|---|---|---|
| Orange | Peels, seed, pulp | Essential oil, pectin, cattle feed, peel candy, phytochemicals |
| Lime | Peels, seed, pulp | |
| Mango | Peel<br>Pulp waste (fibre)<br>Kernals | Pectin, cattle feed, alcohol, phenolic acids,<br>Wine, vinegar, juice<br>Fat, tannin, starch |

| | | |
|---|---|---|
| Tomato | Core, peel, seeds | Feed, seed oil, flavanols |
| Potato | Peel, coarse solids | Feed, single cell protein |
| Apple | Pomace | Juice, wine, vinegar, pectin, feed |
| Pomegranate | Peel | Flavanols (preservatives) |
| Guava | Seeds | Phenolic acids |
| Grape | Pomace | Anthocyanidines(Food colour additive, Antioxidant) |
| Watermelon | Rinds | Dietary fibre, food additives |
| Carrot | Peel andpomace | Dietary fibres, food additives |

## 4.1 Process fruit and vegetable culls/waste to separate juice from pulp

The method of separating the fruit and vegetable waste into juice and pulp is accomplished by using a press. Typical systems are screw presses that can effectively separate the juice from the pulp. After separation, each fraction has its benefits for different reasons and purposes. If the waste/culls are of good food quality, they can be used as juices in food applications based on available markets. The pulp can also potentially be used as a component of foods. For those culls that are not of human food quality, the separated pulp can be used as one component of compost or animal food. The juice can also be used as a feedstock for ethanol production or anaerobic digestion processes.

## 4.2 Candied peel preparation

Peel from citrus fruits (orange, lemon, grapefruit) can be candied for use either in baked goods or as a snack food. In addition, shreds of peel are used in marmalades and the process to make these is similar to candying. In summary, the process involves boiling the slices or shreds of peel in 20% sugar syrup for 15-20 minutes and then progressively increasing the sugar concentration in the syrup to 65-70°Brix (% sugar by refractometer) as the food is soaked for 4-5 days. It is then removed, rinsed and given a final drying in the sun or a hot air drier. This can therefore form a second product for a fruit juice or jam processor especially if larger food companies are available and willing to buy the candied peel as an ingredient for their foods. In one application candied melon skin has been used to substitute for sultanas in baked goods and in another, candied root vegetables have found a similar market.

## 4.3 Source of oils and fats

The stones of some fruits contain appreciable quantities of oil or fat, some of which have specialised markets for culinary or perfumery/toiletry applications. Mango kernels contain 12% fat. As per a study on mango stones, 30,000 tonnes of fat can be produced from 0.3 million tonnes of dry mango kernals available every year.

Palm kernel oil is well established as both cooking and industrial oil. In addition some seeds (eg. grape, papaya and passion fruit) contain oil which has a veryspecialised market. Tomato pomace can be used to produce tomato seed oil. Steam distillation of citrus peel oils is well established at a small-scale. Citrus wastes (mandarin, lime) are rich source of essential oils and other by-products. It is also possible that the sale of seeds or stones or peels to larger oil processors could generate additional income for small-scale fruit processors.

## 4.4 Source of pectin

Pectinis a gelling agent used in jams, sweets, pharmaceuticals etc found to a greater or lesser extent in most fruits. Mainly, pectin is extracted from citrus peel and apple pomace (the residue left after apple juice has been removed). The presence of up to 30% pectin in dried residualmatters like sugar beet pulp, carrot pomace, potato pulpor lemon peel and its availability in large quantities havemade extraction worthwhile.Some other tropical fruits contain high levels of pectin, passion fruit being a notable example. The utilisation of the 'shells' remaining after pulp removal offers possibilities for pectin extraction. India imports about 160 tonnes pectin for its processing industry, and hence there would be a good market for supplying local fruit processors with pectin to substitute for imports. Mango peels are also good pectin sources.

## 4.5 Source of starch and dietary fibre

Mango seed kernals and banana pseudostem are sources of starch. Potato peels also contain starch, the content varying with the peeling process. Steam peels contain around 28%, while abrasion peels had 51% as it led to removal of moe flesh with peels (Camire et al., 1997).Resistant starch can be obtained from mango kernels, banana peels, etc.

The high crude fibre content of the vegetable residues(like orange peels, mangopeels, soybean or oat hulls, fruit pomace, grapepomace) suggests its utilisation as a crudefibresource.Enrichmentof different products with crude fibre compoundscan thus raise the dietary fibre uptake, which is beneficial for human health. Fruit fibresalso have betterquality than cereal fibresdue to higher total and soluble fibre contents,lower phytic acid contents, colonic fermentability andwater and oil holding capacities.Carrot pomace besides being rich in crude fibreis also rich in provitamins,colour and natural acids. It can thus substitute sourdough in bread, is acidifying agent,preservative or antioxidant in several food products (Laufenberg et al., 2003). A study by Sharoba et al. (2013) reported orange waste, carrot pomace, potato peels and green pea peelscan serve as a good source of dietary fibres. It was also seen that processing of the vegetable residue by fermentation with lactic acid bacteria improved its shelf life, colour stability and nutritional value.

## 4.6 Preparation of phytochemicals

Olive pomace is used as a nematode controlling agent for tomatoes (Rodriguez-Kabana et al., 1995), citrus waste streams are used in horticulture (Widmer and Montanari, 1995) and mandarin peel flavonoids are interesting due to their fungistatic activity (Chkhikvishvili and Gogiya, 1995) may be applied naturally to protect vegetables and fruits from molding. The limonoid compounds in citrus peel and seeds have recently been found to have important pharmacological properties as well as potential in the use as an insect antifeedant for agricultural crops (Manthey and Grohmann, 1996).

## 4.7 Preparation of wine/vinegar

Many of the potentialproducts from fruit and vegetable residues have beendeveloped using the SSF technique, and such productsinclude ethanol, methane, lactic acid, citric acid, enzymes and food ingredients (ZhengandShetty, 1998).Although these products should be produced from fresh, high quality fruit juices in order to obtain high quality products, it is technically feasible to produce them from both solid and liquid fruit wastes.

## 4.8 Sources of natural flavours and food colors

Vegetable and fruit residues are good substrates for the generation of fruity food flavours and natural colors. Currently used synthetic dyes being unhealthy, are rapidly being replaced by natural colors or plant pigments.

The microbial synthesis of these natural flavours is generally carried out by SMF. In case of bioflavour production,, the SSF of residualmatter is a fairly new technology of waste utilisation,based on a very old preservation method, which bioconvertssecondary raw materials to natural flavours. Almosnino and Belin (1991) described the use of the intrinsic enzyme system of apple pomace for the biotransformation of fatty acids into potential flavors. 20-fold flavor concentrate can be recovered from mango peel (Nanjundaswamy, 1997). Onion oil flavours can be made from waste onion (Brose, 1993).

Stalk of pumpkin and paprika can be used to produce natural colors. Natural colors of fruits like phalsa, jamunetc have been studied for their suitability as food colors.Tomato skin and peels used as natural colorants (Al-Wandawi et al., 1985).In beverages, carrot pomace or citrus waste will stabilize the natural color, improve the vitamin and fiber content, enhance the viscosity (mouthfeel) (Laufenberg et al., 1996; Henn and Kunz, 1996; Henn, 1998) and enrich or adjust the cloudy appearance (Sreenath et al., 1995).Grape skin extract in powder form is commerciallyavailable as a natural food colorant. Besidesthe blue–red colour, the food will be enriched with''healthy'' polyphenols.

## 4.9 Bioadsorbents for wastewater treatment

Onion peels (Kumar and Dara, 1981, Bankar and Dara, 1982); lemon peel and pulp, olive, apple and grape pomace (Torre et al., 1995); orange peel for dye removal (Namasivayam et al., 1996), peanut shells for heavy metal removal (Randall et al., 1974), peanut skin (Randall et al., 1975).

## 4.10 Fruit and vegetable waste feed to livestock

Feeding fruit and vegetable waste to livestock may be a good option based on the overall management system of the livestock operation. The sale of fruit and vegetable waste for feed can produce income.Farmers should consult with veterinarians to confirm the effects of feeding fruit and vegetable waste to livestock (Table 3).

Orange wastes can be fed to cattle. Ripe banana peels and mango seed kernel may be used as poultry feed after drying. Dried mango kernals and peels make high class energy food for animal feed. Egg size and production enhanced withcarrot and orange peels. However, not all wastes may be fed to animals. Laufenberg et al. (1996)described that a protein concentrate made of potato fruit water could only be fed tocattle due to the high potassium content, while olive cakeis not recommended for feeding due to its low digestibility (Clemente et al., 1997).

Table 3.Effects of fruit and vegetable processing co-products (either as bulk material or high value component) on farm animal product quality (Kasapidou et al., 2015)

| Waste type | Animal species | Effect |
|---|---|---|
| Grape pomaceand seed extract | Broilers | Antioxidant |
| Tomato extract | Broilers, quails | Antioxidant, Yolk colour enhancement |
| Citrus pulp | Broilers | Improved fatty acid composition |
| Pomegranate by-products | Broilers<br><br>Goats, Cows | Antioxidant, Improved fatty acid composition,Hypocholesterolemic<br>Improved milk fatty acid composition |
| Tomato pomace | Sheep | Improved milk fatty acid composition |
| Olive leaves | Sheep | Improved milk fatty acid composition |
| Olive cake | Sheep, lamb | Antioxidant,Improved milk fatty acid composition |
| Tomato waste | Goats | Improved milk fatty acid composition |
| Citrus (orange) pulp | Goats | Improved appearance, taste and texture (cheese) |

## 4.11 Compost fruit, vegetable culls and Biogas

Composting culled fruits and vegetables is one option that can reduce the volume of culls as well as other waste materials in a community, if the land and equipment is available. The culls would be mixed with other organic materials to produce compost suitable for reincorporation into fields or for selling.The final product can potentially be sold for profit.Moreover, the product can be returned to the growing field to provide stable nutrients and organic matter for the next crop.Fruit and vegetable waste (FVW) can be used for generation of bio-methane by anaerobic digestion (AD) method.

## 5.0 POTENTIAL BENEFITS OF ADOPTION OF ADVANCE APPROACHES FOR FRUIT AND VEGETABLES IN THE ARID REGION

A good utilisation potential for solid vegetable and fruit wastes can thus be seen from above studies. There is the possibility to reduce wastages in the food production cycle and also reduce raw material costs; at the same time provide safe and ecofriendly sources of food additives. The use as bioadsorbents for wastewater treatment is a cheaper and more environment friendly substitute for commercial ion-exchange resins.Utilization of agroindustrialby-/co-products in farm animal nutrition reduces the environmental impact of the food industry andimproves profitability of the agricultural by-products since feeding food residue tolivestock is an efficient way to upgrade low quality materials into high quality foods.

Very less work has been done in this area in India. The fraction of discardedmaterials in the majority of fruit processing industries is typicallyvery high (Laufenberg et al., 2003) depending onthe location and method of harvest (e.g. mango 30–50%, banana20%, pomegranate 40–50% and citrus 30–50%).The global availabilityof this feedstock and its untapped potential has encouraged researchers to perform detailed studieson value-addition potential of fruit processing waste.

## 6.0 FUTURE SCOPE AND RESEARCH NEED

Fruit and vegetable wastes still remain an underexploited source of bio-compounds and value- addedproducts. Fruit and vegetableprocessing products as sources of phytochemicals or other by-products is a fairly area and there is limited knowledge on their availability, extractability, bioactivity,applications and functions.Other factors limiting the application of by-product productionfrom fruit and vegetable wastes isproduct inconsistency due to endogenous differences in their composition with respect to theirbotanical origin and processing conditions. The function of the co-product should be specific in orderto survive competition in the market.Simultaneously, the bioconversion of residues will become economically attractive only if high value products are produced.

Commercial application of fruit and vegetable wastes as functional foodingredients and other by-products provide challenges and opportunities for researchers. Targeted multidisciplinaryresearch on utilization aspects these residues is needed, if it is to reach farmers. The segregation and study of wastes as a particular type of food waste helps in the developmentof additional biorefinery processes and ultimately improve the economicsof food waste based bio-refinery concept.The composition of different fruit and vegetable wastes, the possible by-products that may be made, mode of extraction need to be studied and standardized for further expansion in this field. And farmers need to be made aware of the scope in this avenue, interms of economical benefits.

## 7.0 CONCLUSIONS

India is one of the largest producers of fruits and vegetables and hence, wastes and byproducts generated from fruits and vegetables are a big source of soil and water pollution due to their organic nature. Besides this, theygenerate greenhouse gases,which is a matter of serious environmental concern. Keeping in mind these problems, proper disposal and handling of these wastes can help to reduce pollution risks, and can provide useful and commercially valuable by-products. Organized processing of wastes can help farmers to achieve higher incomes by proper handling of waste and post harvest management of fruits and vegetables.

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