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Mango product diversification and waste utilization

The global processed mango products market size in 2019 was estimated to be USD 17.4 billion and projected to register a CAGR of 6.4% during the next year. India though, leader in mango production, is far behind in global trade of the fruit. Mexico is the leading supplier of mango and its products globally with a share of 16%, while India's share is only 9%. In India, Chittoor and Krishnagiri are the main processing hubs of mango. In Chittoor, there are about 67 registered units in the mango pulp industry, of which 55 were operational in 2018. Most mangoes produced in Chittoor are processed into pulp, which accounts for about 70% of the region's total pulp production. The main varieties Totapuri and Alphonso are processed into aseptic mango pulp or pulp concentrate. The total number of mango pulp/puree industries in India are about 100 in which about 4% industries are large scale, 20% medium and 76% small scale running in India. India produces about 0.5 million tonne of mango pulp and exports about 10.1% of it.

MANGOES are processed into many products at two stages of maturity i.e. green fruit and ripe mangoes. Pulp, the primary processed product of mango, is used mainly for manufacturing mango beverages and concentrates. However, recently use of pulp has increased in puddings, fruit meals for children, bakery fillings, and ice-cream mixes, etc. Recently IQF mangoes have shown substantial use in manufacturing confectionary products, frozen salads, and smoothie mixtures. These fruits have a longer shelf life due to instant quick freezing of the fruits. Dried or dehydrated mango is another product having numerous applications in skin care products used for soothing inflammations and minimizing appearance of spots, blemishes, and wrinkles.

Secondary processed mango products include juices, squashes, powder mixes to be used with milk or water for preparing refreshment drinks, canned and frozen slices, fruit bars and candies, jellies, jams, pickles, and fruit-based cosmetics containing fruit extracts, etc. Raw mangoes are also used to produce condiments like chutneys and pickles, curries and dehydrated products. These products are increasingly becoming popular owing to their taste and long shelf-life, contributing to the segment growth. ICAR-CISH has developed fermented mango products including cider, wine, vinegar, ketchup, yoghurt, probiotic mango pulp and RTS drink.

Mango processing waste

One major factor leading to less profitability of mango processing industry is non-utilization of mango processing waste. During processing of mango for pulp, huge quantities of solid and liquid wastes are generated. Solid waste is comprised of mango peel, stones, and stalk, trimmings and fibrous materials obtained during preparation of raw material. This constitutes about 40-50% of total fruits waste, of which 12-15% is peel, 5-10% is pulper waste and 15-20% is kernel. This waste could be used in two ways. Firstly, it is used either as such or after drying for animal feed; secondly it is converted into a higher valued product either by chemical treatment or by fermentation.

Mango peel

Mango peel is generally termed as total waste. If a factory is processing 5 tonnes of Totapuri mangoes per hour, say working for 8 hours a day, about 6 tonnes of peel would be available as waste. This waste is either used as cattle feed or is dumped in open areas where it adds to environmental pollution. Since 2-5% of total produce is processed, bulk of waste comes from table consumption of mango fruits which is difficult to collect as most of it is thrown in the garbage.

Mango peel is a rich source of pectin and fibre. Pectin is an extremely versatile ingredient that is used to improve the quality of many food and pharmaceutical products. Pectin obtained from peel of mango cultivars cv. Chausa and Saheb Pasand has good jelly grade and the yield is also high, hence can be commercially exploited to extract pectin. Among the varieties used for fibre extraction, Chausa peel contained maximum fibre (5.4%) while it ranged between 3.0 to 3.6% in peel of other varieties. Mango peel is difficult to decompose because of its complex ligno-cellulosic composition. However, good quality compost could be prepared in

Mango processing

Mango pulp

Mango waste

40 days by co-composting it with cow dung in 3:1 ratio. Mango peel can also be used for biogas production after adding urea in 20-30:1. The biogas yields obtained using mango waste as one of the substrate, was 0.6 m^3/kg volatile solids added with methane generation of 52%. Mango peel could be used as a substrate for mushroom cultivation after supplementing it with rice straw. Mango peel as animal feed has poor nutritive value because of its low protein content. However, its protein value could be enhanced five folds by solid-state fermentation using *Aspergillus niger*. Citric acid and lactic acid are used widely in processing and pharmaceutical industries, and could be produced from mango peel using *A. niger* and *Rhizopus oryzae*. The peel could also be utilized for wine and vinegar production after partial precipitation of tannins to reduce the astringency. At ICAR-CISH, vinegar was produced from mango peel using immobilized cells of *Acetobacter aceti*. In fruit processing industries various enzymes such as cellulases, pectinases and amylases are invariably used for pulp liquefaction, juice clarification, etc. There is now increased interest in enzyme production from food processing wastes. At ICAR-CISH, Lucknow, cellulases and pectinases could be produced from mango peel using *A. niger*. At ICAR-CISH, Lucknow good quality herbal tea infusion, and antioxidant enriched capsules were prepared from mango peel.

Kernel

Kernel is obtained by breaking the hard seed coat of mango stone. It is rich in fat, starch, protein, tannins, vitamins, fibres, sterols and triterpene alcohol. It has been found that stearic and oleic acid constitute about 85% of total fatty acid while palmitic, linoleic and arachidic acids are present in minor quantities. ICAR-CISH has developed good quality face and body scrub using mango peel and kernel. The fat extracted from kernel are used mainly for manufacturing soap while small quantities are used during preparation of other cosmetic products. The quality of lipid extracted from mango kernel has been found comparable to those of other edible oils like sunflower, sesame and groundnut, and has been found to be suitable for human consumption. It has also been found as suitable substitute to coca butter in the preparation of confectionary products. The kernel is a rich source of protein that varies from 5.6 to 9.0% but its nature and properties are less defined. The total amino acid content in proteins have been found to be 88-97% of which 31-35% are glutamic acid, aspartic acid and leucine, while sulphur containing amino acid acids are present in small amounts. The essential amino acid content except that of methionine and isoleucine of mango kernel have been found to be higher than in reference proteins identified by FAO. The kernel proteins could be used to produce food mixtures of high nutritive value due to higher content of essential amino acids. The tannin content in kernel varies from 10.6 to 18%. ICAR-CISH has developed coffee powder from mango kernel. In some parts of the country kernel is eaten after boiling and baking. The flour made from tannin removed or defatted kernel could be utilized for making chapattis etc. by replacing the wheat flour to the extent of 40%. The cake made from mango kernel could be used as alternative to wheat and maize flour. However, if the mango kernel has to be used for human consumption these have to be hygienically processed and stabilized. Mango kernel is a rich source of starch (approximately 60% on dry weight basis) which could be utilized for industrial purpose. At ICAR-CISH, mango kernel was used for ethanol production by co-culture fermentation using *A. niger* (amylolytic fungus) along with *Saccharomyces cerevisiae*. About 10% alcohol could be obtained by this method. Mango kernel can also be used for amylase production using amoylolytic microorganisms. Pre-treatments like steeping or defatting of mango kernel result in increased amylase production. *Aspergillus oryzae* and *Syncephalastrum racemosum* have been found to be efficient amylase producer using mango kernel as substrate. Mango kernel can also be used for citric acid production using *A. niger*.

Pulper waste

The peel and fibrous material of the pulp after juice extraction from whole fruit is termed as pulper waste. This material could be utilized to manufacture juice, nectar, etc. by treating it with pectic enzymes for better liquefaction. The recovery of the juice was found to be 75-80% from the waste pulp and 51% from peel. The quality of the nectar prepared from the pulp supplemented with juice, recovered from mango waste, was found acceptable. ICAR-CISH has developed fibre enriched biscuits from this waste after some pre-treatments.

Utilization of waste is both a necessity and challenge. This will not only economize the cost of finished product, increase profitabilty and reduce the pollution level, but also lead to more complete utilisation of the raw material.

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