Review Paper

Advances in technology for production of fruit bar: A review

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ABSTRACT : Fruits serve as a source of energy, vitamins, minerals, and dietary fiber. One of the barriers in increasing fruit and vegetables consumption is time required to prepare them and the high perishability. Processing these high value foodintofruit bars or fruit leather can be a good, convenient and better alternative.Fruit bar is the product prepared by blending fruit purees or pulp extracted from ripe pulpy fruit, sugar or other nutritive sweeteners and other ingredients and additives desired for product and dehydrated to form sheet which can be cut to desired shape and size.Fruit bars can also be nutritionally improved through fortification such as concentrated protein sources to improve its food value. Further, fruit bars can also act as suitable matrix for incorporation of prebiotics as well as probiotics. Sugar is an important ingredient in traditional fruit bar preparation. There are possibilities of use of alternate sweeteners and other sugar substitutes for preparation of fruit bar to meet the increasing demands of low calorie snack food. There is also great potential for use of solar energy as well as alternate drying techniques for popularization of fruit bar processing in rural areas.

Key words: Fruit leather, fruit bar, fortification, blending, guava, papaya, mango

Fruits and vegetables are an important source of health promoting components such as vitamins, minerals, antioxidants and fiber. These high value commodities play an important role in providing food and nutritional security. Consumption of fruits and vegetables significantly contribute in providing us a well-balanced and healthy diet. Therefore, there is more and more demand from culturally conscious consumers for the healthier food products made from fruits and vegetables, which can improve their health and well-being. Consumption of more fruits and vegetables is known to prevent many non-communicable life style disease such as obesity, bone diseases, diabetes, cardiovascular disease and stroke (Lydia *et al*., 2002;Yahia *et al.,* 2019).

Fruits and vegetables contain very high moisture making it highly perishable leading to very high post harvest losses. Therefore, they need to be stabilise as prevention of such food losses and waste should be an ideal strategy for meeting the ever increasing demands of food (Godfray and Garnett,2014). The Food and Agriculture Organization of the United Nations (FAO) has estimated loss or wastage of one third of the produced food globally which is a significant loss of the inputs required for production, processing and distribution of that food, and a threat to food security (FAO, 2011). Therefore, there is a need for exploring alternate way to reduce these loss or wastage of fruits and vegetables. Among various methods, converting fruit pulps into fruit bar or fruit leather is a good alternative. Fruit bar is adehydrated and shelf stable product used as confectionary. Development of fruit bars from various fruits viz. mango bar (Gowda *et al.,* 1995; Mir &Nath, 1995; Gujaral and Khanna, 2002; Singh *et al.,* 2005; Sangeetha and Laskmi, 2007), jackfruit bar (Chowdhury *et al.,* 2011), banana bar (Narayana *et al,* 2007),apple leather (Ghadiri and Oshtari, 2012), pear (Huang and Hsieh, 2005), grape pestil (Maskan *et al.,* 2002), wild apricot (Sharma *et al.,* 2013),pomegranate bar (Yılmaz *et al*., 2017) have been reported. Fruit bars are natural and nutritious product which can be eaten as snack as a healthy alternative to other sweets, cookies, cakes which contain very high fat or sugar. Fruit bar is highly convenient product in terms of packaging and transportation, easy to eat and delicious product which can be consumed and distributed any where. Therefore, processing of fruits into fruit bar or fruit leather is very advantageous, as fully ripe fruits having higher sugar, superior colour, flavour and carotenoid content can be used, in addition to use of culled and over-ripe fruits. As the pulping process can be mechanised, it makes this process less labour-intensive. Further it offers a scope for full utilisation of pulp and added ingredients resulting in negligible waste generation and processing losses in comparison to other methods of processing. Fruit leathers add value to fruit which may otherwise be not acceptable for the fresh

produce market (Lee and Hsieh, 2008). Development on fruit bars have been recently reviewed by other workers (Natalia *et al.,* 2011; Diamante *et al.,* 2014 and Orrego *et al.,* 2014). Diamante *et al.* (2014) have given an account of various methods used for making different types of fruit bars and their relative advantages and disadvantages while Orrego *et al. (*2014) highlighted the trends in unit operations for processing of fruit bars. Fruit bars basically made from fruit pulp will retain most of the nutrients, minerals and flavour constituents thus forming a good nutritional supplement. In addition, fruit bars are much sought products after confectionery products (Patel and Kulkarni, 2017). In the present review an effort has been made to highlight the recent trends towards development of fortified fruit bars as well as use of alternate sweeteners with aim to get healthier and low energy fruit bars.

Fruit bar

Fruit bar or leather are dehydrated and shelf stable product used as confectionary. Fruit purees along with added ingredients are dried into a thin layer to make fruit bars (Quintero *et al*., 2010). It is prepared by addition of sugars, citric acid, pectin, and permitted preservatives then drying it in cabinet drier in the form of sheets. Use of natural ripe fruit pulps results in bars having improved flavour along with other nutritious component viz. dietary fibers, vitamins and minerals. The specification for fruit bar are moisture less than 20.0%, total soluble solids less than 75.0 %, fruit content not less than 25.0 % and yeast & mould count positive in not more than 100 count/gm as per 'Food Safety and Standard Authority of India' (FSSAI, 2010). Fruit bars are dehydrated fruit product with low water activity and low moisture content (15-25%), high sugar content as well as concentration of natural acidity making its pH low.

Mango pulp is commonly used for making fruit bar as mango fruits are usually available in market. It is also known as *Ampapar* (Hindi) or *Tandra* (Telugu). However, other fruit pulp bar can also be made from guava, papaya, apricot, banana, etc. Different fruits like apple, berries, kiwifruit, and a range of tropical fruit pulp has already been used for making fruit leathers and these are consumed as popular snack (Raab&Oehler, 2000; Huang & Hsieh, 2005; Garden-Robinson, 2011). Blending of different fruit pulp is also done to make blended/mixed fruit leathers. Fruit bars are usually promoted as natural snacks in health food market. Even dehydrated fruit pulp can be alternatively rehydrated in water after cutting into small pieces to prepare RTS juice by blending (Nanjundaswamy *et al.,* 1976). Dehydrated fruit-based snacks such as fruit bars have the advantage of being perceived by consumers as healthier food. Therefore, they can be a potential carrier for prebiotics and probiotics (Rego *et al.*, 2013). Reynolds (1993) stated that an ideal fruit bar can be prepared from fruits such as apples, pears, pineapples, and strawberries, apricots, cherries, nectarines, berries and peaches etc. (almost repeat, may be merged)!!!

Product similar to fruit bar is also known as pestil in some part of world. Yılmaz et. al. (2017) stated that pestil is a traditional fruit product commonly produced in Anatolia, Arabia, Armenia, Lebanon, Persia and Syria. Pestil is a sweet product with high nutrient content such as mineral, vitamins and considered as a rich energy source because of its high carbohydrate content. It is also known with different names such as 'Bastegh', 'Qamar eldeen', 'Bestil', and 'Fruit Leather'. Pestil is made from different fruits such as apricot, kiwi-fruit, grape, mulberry and pear.

Preparation of fruit bar by blending technique

Fruit bar is known for its superior nutritive and energy values because it is a dehydrated and concentrated product having long shelf life. Fruit bars can be liked and consumed by any one as it is a wholesome nutritious food with good taste. Being easy to carry it is suitable to be used as instant food or 'food on go' as it can provide required dietary fiber, vitamins, minerals and other bioactive compounds which supports human nutrition.

For preparations of fruit bar apart from fruit purees or pulp, one may require other ingredients such as sugar, additives, preservatives, binders, etc. Conventional steps of making fruit bar starts from fruit being converted into pulp or use of fruit pulp or puree, mixing of ingredients, heating for concentration, spreading on tray and drying using suitable drying system. However, there are other possibilities such as development of gelled fruit matrices, extruded form or as dried gels or sponges as new trends for processing products similar to fruit bars. For making fruit bars different types of sugars (sucrose, maltodextrin, glucose, juice concentrates), pectin as binder and other additive or ingredients (e.g. acids, preservatives, colours and flavours) are necessary. For drying of fruit pulp different types of dryers like electrical driers or convective driers, convective-solar drier, or microwave as well as vacuum driers can be used.

Development of fruit bars by blending technique

Generally reports on fruit bars are based on use of single type of fruit or pulp. Beside usual process of fruit bar preparation, blending of different fruit pulp for preparation of fruit bars has also been reported. The main purpose of choosing two or more fruits for blending is improvement in nutritional qualities, sensory qualities (colour, texture and flavor) and storage stability as per the contribution from different fruits during product formulation (Tiwari, 2000). Further, it also gives an opportunity to utilize fruit which are available throughout the year. Good blended fruit bar from mango-guava pulp has been reported by Hemakar *et al.,* (2000). Cherian and Cheriyan, (2003) carried out works on acceptability study on blended papaya leather. Bharambhe *et. al.* (2009) successfully made sapota leather using 75% sapota puree, 10% soya paste and 15% of other fruit pulp. Other works relating to acceptable blended fruit bar have been reported by Sreemathi (2008) in sapota-papaya bar; Kaushal and Bhat (1999) in blended fruit leather using sprouted soya slurry with peach, plum and apricot and Chauhan, *et al.,* (1993) in apricot-soy fruit bar. Narayana *et al.,* (2007) reported improvement in the moisture content in banana fruit bar after addition of pectin.

Blended fruit bar made from 60% papaya pulp with 40% guava pulp was best with improved nutritional and sensory attributes besides being very cost effective (Kumar *et al.,* 2010). Similarly, purees of apple, banana and pineapple have also been used for making mixed fruit leathers. (Blessing *et al.,* 2015).

Development of fortified fruit bar

Fruits and vegetables are not a good source of protein, therefore many attempts have been made to develop protein rich bar through fortification of fruit bar with concentrated protein sources. Food fortification commonly means addition of essential nutrients such as vitamins which are originally deficient or lost during food processing. Therefore, production of highly nutritional and functional fruit bar could be possible through fortification with protein which improves the final food value (Castro *et al.,* 2017). Consumers from the field of sports and dieting are looking for high-protein snack bars which can also serve as meal replacers. It could be possible to develop such products as alternatives to conventional snacks by fortification of bars with high levels of protein (15-35%, w/w) ingredients with nutritional significance (Hogan *et al*., 2012). Sun-Waterhouse et. al. (2010) has also conducted comparative study on various functional snack bar. There are wide uses of high-protein nutrition bars in areas such as athletic food, military food, space food and emergency food during natural calamities. Functional food relevance of whey protein has been reviewed in detail by Patel (2015). Whey protein concentrate or isolate as well as soya protein concentrate are most commonly used protein source for formulating protein rich nutrition bars (LuPengZhou, 2014). However, sensory problems remain the main focus area of concern to be addressed so that fortification with proteins becomes a common practice for making nutrition bars. Protein fortified mixed fruit bar (banana, cactus and pear) has been developed by Patel and Kulkarni (2017).

Sever workers have reported addition of soya protein concentrate and whey protein concentrate which are also an excellent and economical source of quality protein (Chauhan *et al*., 1993,). An increase in protein content in the mango leather by adding whey protein isolate and soy protein isolate have been reported (Mir &Nath, 2000; Mir &Nath, 1993, Sangeetha and Lakshmi, 2007). Production of inulin and fructooligosaccharides fortified papaya and banana bars has been reported (Megala and Hymavathi, 2011). Fortified date bars have been reported by Alhooti *et al.,* (1997) and Sawaya *et al.,* (1983).

Several types of fruit bars have been developed by various workers as stated above. These bars have the potential for further fortification without much modification in other desirable characteristics such as colour, taste, smell, texture as well as shelf life (Parekh *et al.,* 2014). With change in consumer attitudes and demands there is an emergence of new market for innovative and novel products development. There is increasing concern on the prevailing cases of ever problems of protein energy malnutrition (PEM) and micronutrient deficiencies among the growing young population. As per ICMR, an ideal food should have 0.7-1.0 g protein/kg for adults and 1.2-2.0 g/kg for children. Therefore, development of protein fortified fruit bars have great potential in opening a new channel for introducing protein enriched products to fight malnutrition and to provide nutritional security.

Gujral and Khanna (2002) studied fortified mango leather mixed with soy protein concentrate, skim milk powder and sucrose and have reported that addition of these ingredients significantly reduced the drying rate of mango leather. It also reduced the elasticity of fruit bar.

Mango leather made using 4.5% skim milk powder and 4.5% sucrose produced organoleptically most superior products. However, addition of soy protein concentrate reduced the sensory score. Chauhan et. al.(2008) reported preparation apricot-soy fruit bar by blending of 70% apricot pulp with 30% soy slurry adjusting the TSS to 30^0B by addition of 70^0B syrup. The pulp was also mixed with 50 ppm SO_2 then dried at 65 ± 1^0C in mechanical drier for 14 hr to increase its storability. There was an increase in protein and fat content in apricot leather blended with soy slurry. In case of mango leather formulation, effect of sucrose, soy protein concentrate and skim milk powder improved the textural and sensory quality of mango leather as reported by Singh and Khanna (2002).

Mir and Nath (2000) have reported that fortification of mango bar with soy protein concentrate resulted in higher protein content in mango bar (11.8%) as compared to control sample (2.2%). Additionally it also increased Ca, P and Fe content, while carotenoids content decreased (Mir and Nath, 2007). Kaushal and Bhat (1999) stated that for preparation of blended fruit leather from peach, plum and apricot, use of 85% fruit pulp and 15% sprouted soya slurry with 20°B was found ideal. Fortification of guava cheese with 2% soya protein isolate or 2% whey protein concentrate having TSS of 80º Brix and acidity 0.61- 0.64 %, were found to be best nutritionally as well as microbiologically safe up to six months of storage (Sethi *et al*., 2007).Improved protein content in fortified mango and guava bar by fortification has been reported by Kourany *et al.,* (2017).

Nadeem *et al*. (2012) have found that addition of 6.05% whey protein concentrate and 4.35% vetch protein isolates in date bar considerably improved texture, and taste without affecting any sensory characteristics during storage.

Gujaral and Brar (2003) stated addition of guar gum or pectin in mango bar, skim milk powder in banana fruit leather and protein fortification of papaya fruit bar as health food have been reported (Kulshrestha *et al.,* 2012). Protein fortified sapota papaya fruit bar was found to be rich in protein and it can be used as supplement to malnutrition (Take *et al.,* 2012).

Che Man, *et al.,* (1992) prepared sapota leathers having 3 months shelf life using sapota puree, rice flour, sucrose, sodium metabisulphite, sorbic acid; while Che Man and Taufik (1995) made jackfruit leathers with added sucrose and sorbic acid.

Use of alternate sweeteners

Sucrose is the most commonly used sugar normally added in fruit purees to make fruit leather or fruit bar as well as in the other food industry to incorporate sweetness in various food preparation (Jamieson, 2008). Sucrose acts as a bulking agent besides being texture and mouth feel modifier and also as flavor enhancer. It also acts as preservative (Afoakwa *et al.,* 2007; Salminen & Hallikainen, 2002). However, many sugar replacers are also available which are giving new opportunities for product development (Aidoo *et al*., 2013; Grembecka, 2015). Sugar replacers are classified as nutritive and non-nutritive sweeteners. Sugar alcohols, including sorbitol, xylitol, isomalt, lactitol, and mannitol are nutritive sweeteners while aspartame, saccharin, sucralose, stevia, and acesulfame-K are examples of non-nutritive sweeteners (Martínez-Monteagudo *et al.,* 2019).Most polyols are poorly absorbed due to their partial digestion. This is the primary reason why their caloric values are lower than that of sugar(Kroger *et al.,* 2006). Inulin and oligofructose which are made from chicory and Jerusalem artichoke belong to a class of carbohydrates known as fructans. Role of inulin and oligofructose has been established for reduction in the risk of many diseases. Therefore, they are considered as functional food ingredients for developing healthier food products (Abbasi & Farzanmehr, 2009; Kaur & Gupta, 2002).

Maltodextrin

Maltodextrin is a carbohydrate polymer with low-digestibility can be a potential sugar alternatives for making fruit bars. Corn starch is used for making maltodextrin after treatment with heat and acid. The molecules of maltodextrin are typically large in size and highly branched allowing them to be very soluble.

Gonz_alez-Herrera (2016) have found that addition of various additives such as oligofructose, inulin, mixtures of agave fructans, resulted in alteration of textural properties like hardness and stickiness of dehydrated apple bars as compared to control sample resulting in poor consumer acceptability. However, fruit bar made using agave fructans had better texture. Addition of maltodextrin for making apple leather, decreased the hygroscopicity of apple leather strip which was also crispy at low moisture level. The addition of 15% maltodextrin was effective in reducing the moisture uptake by 45% in samples conditioned at 44%RH (Valenzuela and Aguilera, 2015). Development of

nutritionally enriched mango bar using 32% jaggary, pulp TSS 45° Brix and drying at 70°C resulted in highly acceptable mango fruit bar by Sharma *et al.,* (2015).

Use of preservatives for improved shelf-life

Browning of fruit bars and increase of microbial load is normally experienced specially during storage of fruit bars. Therefore, addition of preservatives becomes an essential step to increase the storability of fruit leathers. Chan and Cavaletto (1978) stated that addition of sucrose in papaya leathers has reduced browning during storage when it was treated with SO_2. The addition of sodium metabisulphite in fruit pulps before drying has effectively reduced the enzymatic browning in fruit bars of papaya (Chan & Cavaletto, 1978) and apple leathers (Quintero *et al.,* 2012). Che Man *et al.,* (1992) added sucrose, rice flour and sorbic acid in sapota pulp for making sapota bar with 3 months shelf life using sodium metabisulphite as preservatives.

Dehydration

Dehydration of fruit pulps leads to loss of nutritional value of the product e.g. loss of vitamin C and changes of color and appearance, textural property that might not be desirable to the consumers. Now a days food industry is looking for high-quality dehydrated products with high level organoleptic and nutritional qualities. A thorough understanding of the factors responsible for adversely affecting the quality of the product during the dehydration must be investigated. Usually hot air oven are used for making fruit bars in which pulp is subjected to convective hot air drying. Fruit puree dehydration is usually carried out below 80°C and more ideal at 55 to 65°C, to maintain superior quality in final dried fruit bars (Bains *et al.,* 1989; Vijayanand *et al.,* 2000).

Great strides have been made in development of various drying system for improving quality of fruits and vegetable products as reported by Zhang *et al*. (2017). In orderto make superior quality fruit bar, vacuum drying has been found suitable as it reduces processing times, under less oxygen exposure and helps in retention of vitamins and other phytochemicals (Demarchi, 2018). Effect of temperature under hot-air-drying has been reported in case of apple leather (Demarchi, *et al.,* 2013).

Azam *et al*. (2019) reported that for making peach dried leather microwave-assisted hot air drying took 180 min which was shortest followed by infrared drying (210min), hot air-assisted radio frequency drying (210min) and air drying (300min). However, product made using infrared drying resulted in the best quality product among the four drying techniques.

Packaging and storage of fruit bars

Occurrence of browning as well as fruit bar quality deterioration during storage is also an important issue in form of biochemical changes or microbial spoilage, therefore, preservatives such as Potassium metabisulphite or sodium benzoate are used while preparing fruit bars which also helps in increasing the shelf life during storage (Kalra and Revanthi, 1983; Sagar and Maini, 1993). Changes in physico-chemical properties like acidity and vitamin C during four months storage of papaya tomato fruit bar has been reported (Ahemed, et. al. 2005).Vijayanandet. al. (2000) reported the NEB of both guava and mango bars stored at accelerated conditions increased significantly after 60 d of storage. The NEB of the bars stored at ambient conditions also increased during storage but the increase was significantly less than that observed at accelerated storage. Among various packaging material (PP, BP, MPP and aluminium foil) for storage of guava leather, samples packed in MPP during storage proved the best packing material in terms of nutrient retention and low microbial growth (Sagar and Kumar, 2007).

To know the packaging requirements as well as storage quality evaluation of mango and guava fruit bar, sample was assessed for storage stability at 27 °C under different RH. Vijayananad *et al.,* (2000) found that biaxially oriented polypropylene and polyester-polyethylene laminate were an ideal material for packaging of guava bars for storage at ambient conditions for 3 month.

Fruit bars of aonla enriched with different fruit (mango, papaya, jackfruit) were studied. High impact polystyrene boxes were found to be more effective in reduction of non-enzymatic browning for storage of fruit bars as compared to low-density polyethylene and areca plate over wrapped with cling film (Deepika *et al.,* 2016).

Different types of packaging materials i.e., laminated aluminium foil (LAF), low-density polyethylene (LDPE), high-density polyethylene (HDPE), and polypropylene (PP) for storage of durian fruit bar at ambient condition was studied by Irwandi (1997). There was an increase in non-enzymatic browning in all films and found that low-density polyethylene and laminated

aluminium foil proved to be the best material for durian leather storage.

Kumar, *et al* (2007) evaluated different packaging materials for storage quality maintenance of guava fruit bar at ambient and low temperature conditions (10±1°C). Among various packaging material of polypropylene, butter paper, metalized polyester polyethylene and aluminium foil, the guava bars stored in metalized polyester polyethylene was effective in retaining nutritional quality with minimum microbial counts and reduced non-enzymatic browning at the end of 90 days storage. Usually fruit bars are wrapped in BOPP sheets and again properly packed in air tight container or wrapper. Fruit bar can have a shelf life of 6- 9 months (FPT, 2009). Vijayanand *et al.,* (2000) produced guava leathers having shelf life of 3 months by use of sucrose and metabisulphite. Quality of mango bar stored using different packaging has also been reported (Singh *et al.,* 2002).

CONCLUSION

Fruits serve as a source of energy, vitamins, minerals, and dietary fiber. One of the barriers in increasing fruit and vegetables consumption is time required to prepare them and the high perishability. Hence, fruit bars can be a good, convenient and natural alternative to junk foods or foods which are with high salt, sugar and fat. Fruit bars are concentrated form of food source with rich nutritional value as compared to fresh counterparts. Nowadays, health conscious consumers are looking for products which support health, wellness and functional properties which may be met through fortified fruit bars. Therefore, fruit leather may be fortified with concentrated protein sources such as whey protein concentrate or soya protein concentrate etc. Further, fruit bars can also act as suitable matrix for incorporation of prebiotics as well as probiotics. Sugar is an important ingredient in traditional fruit bar preparation. However, there is lot of scope to use of alternate sweeteners and other sugar substitutes for preparation of fruit bar to meet the increasing demands of low calorie snack food. There is also great potential for use of solar energy as well as alternate drying techniques for popularization of fruit bar processing in rural areas.

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