International Journal of Home Science 2022; 8(1): 318-322

International Journal of Home Science

**ISSN:** 2395-7476
IJHS 2022; 8(1): 318-322

www.homesciencejournal.com
Received: 01-01-2022
Accepted: 05-02-2022

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# Fruits and vegetable waste used as functional ingredients in cereal based products (Cookies): A review

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**Abstract**
"Eating dietary fiber is your way into a healthy life''
Dietary fibre itself provides several well-known health benefits. Adequate Dietary fibre intake reduces the risk of developing chronic diseases such as coronary heart disease, stroke, hypertension, diabetes, obesity, and gastrointestinal disorders. Plant foods are particularly associated with good amounts of dietary fibre. Large amount of pomace produced from juice and wine industries presents cheap source of dietary fibre. Fruit and vegetable pomace represents a novel ingredient for fibre enrichment in bakery products owing to its better functionality due to balanced ratio of soluble/insoluble fibre, better hydration properties, better fermentability and presence of phytochemicals. Fruit and vegetable pomace can be used to improve the functionality of food by the virtue of its functional properties. Variety of fruit and vegetable pomaces are used in wide array of bakery products like biscuits, buns, cookies, crackers, cakes, muffins, wheat rolls and scones. Fruit pomaces tend to combined well with bakery products and confer them better sensory properties. Thus, the incorporation of the fruit and vegetable pomace into bakery products is a way to increase the consumption of beneficial substances and can be used as effective functional ingredient for development of fibre rich bakery products.

**Keywords:** Fruit and vegetable waste, functionality, bakery, dietary fibre

## Introduction

Plant foods like cereals, vegetables, fruits and nuts are associated with dietary fibre, though the amount and composition of dietary fibre may vary from food to food (Desmedt and Jacobs, 2001) [1]. Foods rich in non-starch polysaccharides have high amounts of dietary fibre ranging from 20–35 g of fibre per 100 g on dry weight basis in contrast to starchy foods that constitutes 10 g per 100 g of dry weight. The content of fibre of fruits and vegetables is 1.5–2.5 per 100 g of dry weight (Selvendran and Robertson, 1994) [2], however it is due to high moisture content of fruits and vegetables and pomace left after juice extraction contains high amount of it. Fruits and vegetables account for nearly 90% of the total horticulture production in the country. India is the second largest producer of fruits and vegetables in the world and is the leader in several horticultural crops (Ministry of Agriculture & Farmers Welfare, 2016) [3].
The surplus fruits and vegetables can be processed in a number of ways like canning, freezing, dehydration and processing into juice. Juice processing is an important sector of fruit processing and many fruits and vegetables are used for the extraction of their use. However, juice processing industries also produce large amount of pomace as a by-product which is not finding any proper use except for the use as an animal feed or land filling (Sahni and Shere, 2017) [4]. Fruit and vegetable wastes represents good source of dietary fibre due to high dietary fibre content, being inexpensive, and having high water binding capacity and relatively low enzyme digestibility (Serena and Kundsen, 2007) [5]. Thus, demand for a unique fibre ingredient will continue and fibres from fruit and vegetable waste represents good prospects as novel ingredient in market shelves and for the supplementation of food products (Sloan, 2001) [6]. Hence, pomace obtained from the juice and wine industry might be useful raw materials for developing new value-added products. Thus, the Present review gives insights concerning the functionality of fruit and vegetable pomace and its implementation for determining the value of bakery products.

### Health benefits of Fruits and Vegetable waste dietary fibres

Dietary fibre has become subject of marketing owing to increase in lifestyle diseases due to inadequate consumption of fibre in the diet. Dietary fibre confers beneficial effects on human health as they are resistant to hydrolysis by the alimentary enzymes of man; with complete or partial fermentation in the large intestine; and majorly constitutes hemicellulose, cellulose, lignin, oligosaccharides, pectin's, gums and waxes (Trowell *et al*., 1985; AACC, 2000) [7, 8]. A healthy individual should consume 20-35 g of dietary fibre per day. Lack of adequate dietary fibre in the diet is associated with constipation, diverticulosis, cardiovascular disease, and cancer (Trowell *et al*., 1985) [7]. Diets constituting high amount of dietary fibre have manifestation in prevention, reduction and treatment of diseases like coronary heart diseases, colon cancer and diabetes (Figuerola *et al*., 2005; Nawirska and Kwasniewska, 2005) [9, 10].

Various studies have demonstrated the positive impact of dietary fibre in treating these diseases. Ferguson and Harris (1996) [11] reported that dietary fibre may protect against colorectal cancer by providing good intestinal health by virtue of its functional property and by products of fermentation in large intestine by bacteria. High dietary fibre intake is manifested with decreased consumption of simple carbohydrates. Although, dietary fibre contributes to the total caloric content of a diet but is much more resistant to digestion by the small intestine and even somewhat resistant in the large intestine. Also, dietary fibre tends to decrease fat digestibility. These could be associated with decreased metabolizable energy of the diet high in fibre (Baer *et al*., 1997) [12]. High Dietary fibre consumption is associated with treating diabetes due to slower rise in the blood sugar level. Strong inverse relationship exists between dietary fibre intake and diabetes when adjusted for age and body mass index. Consumption of an average of 26 g per day of dietary fibre resulted in lowering risk of developing diabetes by 22% in comparison to women only consuming 13 g per day (Meyer *et al*., 2000) [13].

Dietary fibre consumption has been correlated with colon health and is known to prevent various diseases associated with colon. Consumption of Dietary fibre alleviates constipation and facilitates regularity by adding bulk to stool and speeding up the passage of foods through the digestive system (Kahlon *et al*., 2001) [14]. Diet particularly high in water-soluble fibre protects against cardiovascular diseases. Theuwissen and Mensink (2008) [15] reported that many well-controlled intervention studies have shown that water soluble fibre (β-glucan, pectin and guar gum) effectively lower serum LDL cholesterol concentrations, without affecting HDL cholesterol or triacylglycerol concentrations. Fibres having cation exchange capacity and phytic acid (e.g., cereal fibres) have been found to depress the absorption and retention of several minerals. However, certain highly fermentable fibres like pectin, gums, resistant starches, cellulose, fructo-oligosaccharides, inulin improves metabolic absorption of certain minerals like calcium, magnesium and iron, even when phytic acid is present at lower concentrations (Tungland and Meyer, 2006) [16].

### Dietary Fibre from Fruit and Vegetable waste

Fruits like grapes, apples, orange, pineapple and guava etc. which are mainly utilized for production of juice produce significant amount of peel and pomace. This waste represents significant losses and could lead to high cost of final processed products, if not recovered by appropriate means (Schieber *et al*., 2001) [17].

Numbers of studies have been conducted for exploration of fruit and vegetable as source of fibre. Orange peel residues can be good source of dietary fibre. Fibre fraction can be obtained after pectin extraction of orange peels by nitric acid and ethanol. Fibre fraction obtained contains high amount of soluble (213 g/kg) and insoluble (626 g/kg) dietary fibre on a dry basis (Aravantinos-Zafiris *et al*., 1994) [18]. Nawirska and Kwasniewska (2005) [10] determined the amounts of particular dietary fibre fractions in samples containing apple, black currant, chokeberry, pear, cherry and carrot pomace. The results revealed that in each pomace sample, pectin's occurred in the smallest amounts, and the content of lignin was very high in black currant and cherry pomace and comparatively high in pear, chokeberry, apple and carrot pomace.

Apple has been used in juice processing as well as cider production and can produce large amount of pomace. Industrial apple pomace resulting from a modern apple juice production plant can be considered as a raw material for direct preparation of dietary fibre, since it contains above 50% of total Dietary fibre. Raw material that cannot be used for dietary fibre preparation due to its high polyphenol content can be used for production of phytochemical concentrates (Kołodziejczyk *et al*., 2007) [19]. Also, apple skin is a rich source of dietary fibre and phenolics. The blanched, dehydrated, and ground apple skin powder contains approximately 41% total dietary fibre (Rupasinghe *et al*., 2008) [20]. Pomace is rich source of dietary fibre and contains fewer amounts of other components in some fruits and pineapple pomace showed low fat and protein content and had dietary fibre as one of its major components with the insoluble fraction accounting for the majority of the fibre (Selani *et al*., 2014) [21].

### Physicochemical and Functional properties of Fruits and Vegetable Pomace

''Ideal dietary fibre'' should not have nutritionally objectionable components, should be in highly concentrated form possible, free from any taste, colour and odour, have an appropriate and balanced associated bioactive compound, have a good shelf life, have congeniality with food processing operations and exert physiological effects (Larrauri, 1999) [22]. It is very essential to understand that fibre enrichment has profound role on techno-functional properties and thus affects the overall sensory characteristics of the food by virtue of water binding and enhancement of viscosity (Kethireddipalli *et al*., 2002) [23]. Dietary fibres from fruits and vegetables have better quality in comparison to fibres from cereals. Optimizing the process of development fruit fibres will allow lesser loss of bioactive compounds. However, such losses will also be less if whole pomace will be used instead of isolated fibres (Larrauri *et al*., 1997) [24].

Sahni and Shere (2017) [4] observed highest swelling capacity in carrot pomace powder followed by beetroot and apple pomace powder. Sharoba *et al*. (2013) [25] also reported higher water holding and swelling capacity of carrot pomace as compared to orange waste, potato peels and green pea peels. Sahni and Shere (2017) [4] studied particle size distribution of apple, carrot and beetroot pomace powder and found that pomace powders majorly consisted of particles sized less than 150 µm and lowest percentage was of particles sized 150 µm. The hydration properties of fibre are important for its physiological role as well as for its interventions in techno functional properties of the food. Hydration property of fibre governs its efficacy in stool bulking. Water holding capacity, water retention capacity and swelling capacity provide information regarding the hydration capacity of fibre and give insights regarding its behaviour during gut transit and food processing (Dhingra *et al*., 2012) [26].

Good hydration properties of pomace powders will allow its use as functional ingredient in food products as high-water holding capacity tend to exert their physiological effect by absorbing water in the gut and resulting in stool bulking (Sahni and Shere, 2017) [4]. However, studies have shown that high affinity to water could have detrimental effect on the texture of the processed food (Sharoba *et al*., 2013; Sahni and Shere, 2016) [25, 45]. Washing during the preparation of dietary fibre powder enhance the water holding capacity along with reduction of browning during the drying of pomace (Lario *et al*., 2004) [28]. Kohajdova *et al*. (2012) [29] observed that carrot pomace powder has good hydration properties and tend to influence water absorption, dough development time and dough stability; and mixing tolerance index of dough. Fruit and vegetable pomace have high amount of crude fibre content which justify their use for fibre enrichment in the food products.

Sahni and Shere (2017) [4] observed high crude fibre content of 21.51%, 17.94% and 11.12% in apple, carrot and beetroot pomace powder respectively. In some cases, fruit and vegetable pomaces can have fair amounts of lipids and high ash content; and thus, their supplementation in food will also increase mineral content along with enrichment of fibre (Shyamala and Jamuna, 2010; Sahni and Shere; 2017) [30, 4]. Figuerola *et al*. (2005) [9] evaluated some functional properties of fibre concentrates from apple and citrus fruit residues and found that all fibre concentrates had a high content of dietary fibre, with a high proportion of insoluble dietary fibre. Protein and lipid contents ranged between 3.12 and 8.42 and between 0.89 and 4.46 g/100 g dry matter respectively. Shyamala and Jamuna (2010) [30] reported that moisture content of pulp waste from carrot and beetroot ranged from 79 - 84% whereas protein content was 6.21mg/100g and 13.23 mg/100g respectively. The antioxidant activity was 40% and 78% for carrot and beetroot pulp waste respectively.

**Functionality of Fruit and Vegetable Pomace in Bakery Products**

Fruit and vegetable pomace powders can be used as inexpensive, non-caloric bulking agents in food for partial replacement of flour, fat or sugar, as they tend to improve the functionality of food by enhancement of water and oil retention and improved emulsion stability (Elleuch *et al*., 2011) [31]. Recent trend in development novel fibre sources due increased importance of fibre in diet has high level to exploration of new sources of fibre and its incorporation in food (Chau and Huang 2003) (32). Supplementation has been focused on cookies, crackers and other cereal-based products, enhancement of fibre content in snack foods, beverages, spices, imitation cheeses, sauces, frozen foods, canned meats, meat analogues and other foods has also been investigated (Hesser, 1994) [33].

Baked products are often employed for incorporating new sources of functional compounds such as dietary fibre and bioactive compounds (Ktenioudaki, 2013) [34]. Variety of plant fibres are added to various baked products to increase their fibre content (Masoodi *et al*., 2001) [35]. Baked products, particularly biscuits and cookies are good carrier for fibre enrichment, since they have become indispensable part of our life and are ideal for supplementation due to palatability, compactness, convenience and long shelf life of the product and being widely consumed by every individual irrespective of age (Sahni, 2017) [36] observed same trend for colour of crackers incorporated with apple pomace. Fruit pomaces tend to improve taste and aroma of bakery product by amalgamation of fruity and baked taste and aroma of the baked product. Apple pomace has been found to impart its typical flavour to bakery products and tend to improve its acceptability. Increase in taste and flavour score of cakes and cookies with apple pomace powder is attributed to peculiar fruity taste and flavour of apple. However, further supplementation decreased the taste score due to slightly bitter after taste due to high polyphenol content of apple pomace powder (Sudha *et al*., 2007; Sahni, 2015) [37, 38].

Numerous studies have been carried out that documented the effect of incorporation of fruit and vegetable pomace on bakery products. Huge quantities of apples are being processed by juice processing and thus number of studies reported utilization of apple pomace in bakery products. Reis *et al*. (2014) [39] developed functional extruded snacks and baked scones using apple pomace and it was successfully added up to 20% in extruded snacks and 30% in baked scones. The incorporation in baked products increased the fibre content with no effect on the chemical composition of the products when compared to the control. Studies have been conducted for utilization of carrot pomace along with other ingredients in the cookie formulation.

Gayas *et al*. (2012) [40] prepared carrot pomace powder enriched defatted soy flour fortified biscuits and reported increase in moisture, ash and beta carotene and decrease in protein content in biscuit with increase in the level of carrot pomace powder. Baljeet *et al*. (2014) [41] utilized of carrot pomace powder and germinated chickpea flour in biscuits and observed increase in the spread ratio and protein content of the biscuits with the increase in carrot pomace powder and germinated chickpea flour in the blends. It is important to note that in contrast to aforesaid studies, the protein content and spread ratio increased by increased in level of incorporation and thus it gives insights for utilization of blends with multiple ingredients to fine tune the required nutritional and sensorial properties. Mango processing also produces significant amount of waste in the form of peels that can be used for fibre enrichment. Mango dietary fibre concentrate can be used as effective bakery ingredient. Bakery products prepared with mango dietary fibre have well balanced soluble and insoluble dietary fibre, anti-radical efficiency and low glycaemic index (Vergara-Valencia *et al*., 2007) [42]. Incorporation of 20 % mango peel powder decreased spreading, increased hardness and soluble dietary fibre in soft dough biscuits whereas mango peels and kernel powder could be utilized up to 30% in cookie formulation to enhance its nutritional quality without affecting the textural and sensory properties (Ajila *et al*., 2008; Bandyopadhyay *et al*., 2014) [43, 44].

Orange waste and carrot pomace can be used for valorisation of cakes at 5 and 10% without affecting the quality attributes. However, water absorption, dough stability and dough development and resistance to extension values increased and extensibility values decreased significantly by increasing the level of incorporation from 0 to 20% (Sharoba *et al*., 2013) [25]. Beetroot pomace can be excellent source of phytochemicals along with dietary fibre. However, beetroot pomace powder rendered the cookies dark and thus can be used only up to 10 % level where it improved the acceptability of cookies due to better taste and flavour. The incorporation of beetroot pomace resulted in poor spreading of cookies except for 5 % where it resulted in higher spreading. The moisture, crude fibre, protein and ash increased whereas carbohydrate content decreased with the increase in the level of incorporation (Sahni and Shere, 2016) [45]. Fruit and vegetable pomace contains bountiful of bioactive compounds including antioxidants that confer added health benefit. However, the effect of pomace powders on the storage quality of cookies has been documented by Sahni and Shere (2017) [4] in a study where fruit and vegetable pomace powders were found to exert strong influence on the sensory attributes of cookies during storage. Predominantly the detrimental effect was only observed in the colour of cookies which were incorporated with pomace powders; otherwise, cookies maintained better sensory attributes as compared to control. Cookies incorporated with pomace powder demonstrated better storage stability and need of comparatively simple packaging requirements as compared to control cookies.

## Conclusion

Current scenario of low fibre in diet is driving force for investigation of dietary fibre as novel ingredient in food products. The interest in the implementation of fruit and vegetable pomace powder for fibre enrichment is due to its better functionality owing to the presence of balanced amount of soluble and insoluble dietary fibre and association of bioactive compounds with them. Fruit and vegetable pomaces can be incorporated in bakery products where their optimum level does not affect the quality attributes and also tend to improve the sensory attributes of the product. Being a cheap source of dietary fibre, it will help in determining the value of the food products and can be used for designing new 'functional foods.'

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