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Review Article

# Food Processing Residue Analysis and its Functional Components as Related to Human Health: Recent Developments

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**Abstract**

By-products of fruits and vegetables from food processing industry have recently enormous concern because of their pharmacological properties and great nutritional approach. These food processing by-products serve a cocktail or a soup of phytochemicals with health promoting properties. These are claimed to possess many reusable substances of high value and can be money-spinner if they are appropriately utilized. This chapter articulates that by-product of fruits & vegetables have a potential to be used as a functional agent in cosmetics, medicines and functional food application either as raw material for secondary processes, as operating supplies or as ingredients of new products.

**Keywords:** Phytochemicals; Functional food; Nutrition; Nutraceuticals; Human health

## Introduction

The modern life style and growing health concern have led to an increase in the demand for food and food products, which provide health benefits beyond the crucial nutrition. Natural products obtained from medicinal and food plants are used as a prominent source in primary health care since long time. Rapidly growing body of literature covers the role of plant secondary metabolites and their eventual effects on human health. Nowadays human being are gradually more conscious of diet related health troubles and demanding natural ingredients which are expected to be safe [1]. Large quantities of by-products from fruits & vegetables are discarded every year at food processing plants resulting from the production, preparation and consumption of food. These by-products represent a major disposal problem. Food processing residues are those end products of various food processing industries that have not been recycled or used for other purposes. Industries simply dispose of these byproducts by dumping, burning or land filling. This is neither good for the environment, nor is a sustainable behavior if we are to preserve the earth for the future generations. Serious environmental problems emerge by these residues, such as water pollution, unpleasant odors, explosions, combustion, asphyxiation, vegetation damage and greenhouse gas emissions.

Thus the problem of disposing food industrial waste is becoming grave. Proper management of these wastes is both a regulatory requirement as well as an economic necessity. Research show that these by-products are promising sources of compounds which may be used because of their nutritional and medicinal properties. Researchers have shown a strong correlation between the therapeutic properties of these residues and their health promoting or disease preventing effects [2]. It has been evident that by-products are good source of various phytonutrients with a wide range of pharmacological actions which includes antitumor, antiviral, antibacterial, cardio protective and antimutagenic activities. The purpose of this chapter is to emphasize the potential of food processing residues as a source of functional compounds for new products.

## Phytonutrients

Phytonutrients, within the context of natural health and nutrition, has come to refer to certain bio-active plant chemicals that humans eat and have or may well have significant positive effects on human metabolism. Most phytonutrients are not essential for life, but more and more they appear to be essential for optimal health and longevity. They therefore may properly be classified as micro-nutrients, along with vitamins and minerals. The technical classification of the major groups of phytonutrients found in our diets includes: terpenes, amines, organosulfurs, phenols, polysaccharides, and organic acids. One food can contain several classifications of phytonutrients. For example, an orange contains Terpenes (carotenoids and limonoids) and phenols (bio flavonoids). Briefly, the major groups and sub-groups of phytonutrients and how they may contribute towards optimal biological function are as under:

### The terpenes

Terpenes are the powerful antioxidants for cancer prevention and cardio-vascular disease. Terpenes are any of various unsaturated hydrocarbons, found in essential oils and resins of plants and may be categorized as:

a. Carotenoids: Carotenoids are fat soluble group of naturally occurring plant pigments of yellow, orange and red spectrum. Carotenoids function as potent antioxidant and immune potentiators. These are considered membrane antioxidants due to their reactivity with singlet oxygen. Diet rich in carotenoids are linked with a decreased risk of heart disease, cancer, and degenerative eye diseases such as macular degeneration and cataracts [3]. They may be different type and occurs in different type of plants such as Alpha- carotene,




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beta-carotene, and cryptoxanthin, as found in carrot, orange, sweet potato and squash etc. Leafy green vegetables contain mostly lutein and zeaxanthin. Lycopene is most abundant in tomato and in small amount in pink grapefruit, watermelon, guava, and rose hips. Astaxanthin, found mostly in red yeasts and red algae, is now fed to salmon, trout, crabs, krill and shrimp in "fish farms". Some carotenoids rich food are carrot and tomato yield more beta-carotene and lycopene respectively, when cooked.

b. Limonoids: Limonoids are found in yellow and orange citrus fruit peels. Limonoids may be chemo preventive agents, especially directed toward protection of the lungs.

c. Saponins: Saponins are found in abundance in many beans, alfalfa, aloe and quinoa (keen-wah) seed. Saponin containing plants have a soapy texture, and are often called "natural detergents". Saponins inhibit the multiplication of cancer cells by interfering with their DNA.

d. Chromanols: Chromanols are the vitamin E complex tocotrienols and the tocopherols. These two naturally occur in palm oils and whole grain germ and bran, yet research has shown that the biological functions of tocopherols and tocotrienols are unrelated. Tocotrienols appear to inhibit breast cancer cell growth, whereas tocopherols have been most studied for their cardiovascular health effects.

## The phenols

Chemically phenolic acids can be defined as substances that possess an aromatic ring bound to one or more hydrogenated substituent, including their functional derivatives [4]. Phenols protect plants and humans from oxidative damage. They block specific enzymes that cause inflammation and allergies, and modify the prostaglandin pathways and thereby protect platelets from clumping. They help the liver detoxify and inhibit specific enzymes such as the Angiotensin-Converting Enzyme (ACE) that raises blood pressure [5]. Flavonoids are low-molecular-weight compounds consisting of 15 carbon atoms, arranged in a C6-C3-C6 configuration. Essentially, the structure consists of 2 aromatic rings joined by a 3-carbon bridge, usually in the form of a heterocyclic ring [6]. They are perhaps best known for their ability to enhance the effects of ascorbic acid. Along with Vitamin C, flavonoids are well known for their ability to protect the vascular system by strengthening, maintaining and repairing capillaries. Flavonoids, including the isoflavones, may reduce the risk of cancers, either by enhanced detoxication, or as in the case for isoflavones, by occupying estrogen receptor sites. The group of phenols may be categorized as under:

a. Anthocyanidins: Anthocyanidins are phenols that provide cross-links that connect and strengthen intertwined strands of collagen protein. Collagen protein is the most abundant protein in the body as it makes up a large proportion of muscle sheaths, skin, tendon, ligament, and bone matrix. Their blue pigment, as in blueberries, help protect the retina from macular degeneration. Anthocyanidins are also powerful water-soluble antioxidants. Larger doses are often useful in conditions wherein there is a profuse free radical cascade, such as trauma, inflammation, allergic reactions, and heavy exercise.

b. Catechin: Catechin is the polyphenolic compounds that provide the antioxidant activity. These are found in abundant amount in black, green and white tea. The most common Catechin is gallic esters and Epigallo Catechin Gallate (EGCG). These are known for their protective benefits including promotion of apoptosis of cancer cells in prostate, stomach, skin, lung, breast and colorectal tissues.

c. Lignins: Lignins are found in seeds and grains, especially flaxseed. The lignan found in flaxseed is called Secoisolariciresinol Glucoside (SDG). The another class Lignans are also have antiviral, antibacterial, antifungal, antioxidant, and immune enhancing properties. These are weak phytoestrogens. Lignans are not to be confused with lignins which are a non-carbohydrate dietary fiber that, along with polysaccharides, occur in the cell walls of plants.

## The polysaccharides

Polysaccharides are complex carbohydrates, made up of chains of multiple sugar molecules. Examples of polysaccharides include cellulose, starch, and dextrin. Both soluble and insoluble fibers are made from polysaccharides. The former absorb cholesterol and lower glycemic response, while the later promote bowel movements. The immune enhancing effects of ginseng, aloe-vera or beta glucan from oats or mushrooms comes in large part from sugar-protein-receptor complexes on their cell wall, now called glyconutrients.

Phytosterols: Phytosterols are polysaccharide-lipid complexes are known particularly for their cholesterol lowering abilities. Nuts and seeds are the richest source of phytosterols in the western diet. Phytosterols are poorly absorbed. They lower cholesterol by interfering with its absorption in the small intestine. Just three gram of phytosterols daily shows significant lipid lowering effects. Phytosterols can also mimic hormone precursors or modulate hormones. For example, Swedish tree pollen, pumpkin seeds, pygeum, and saw palmetto are all used in cases of Benign Hypertrophic Prostate disease (BHP) and prostatitis. These phytosterols inhibit the conversion of testosterone to Dehydroxytestoterone (DHT).

## The organosulfurs

Organophosphorous are organic compounds containing sulfur (-SH). As phytonutrients, they provide sulfur vital for phase II enzymes activities. Specifically, organosulfur provide glucosinolates which are converted into several bio-transformation products in the human body, particularly indole-3-carbinol, isothiocyanates, and thiosulfonates. The indoles and isothiocyanates are most especially found in the cruciferae family of Brassica and mustard plants. These include horse radish, cabbage, broccoli, brussels sprouts, cauliflower, mustard seeds and turnip greens. These help the liver break down toxins and potential carcinogens, especially toxic estrogen metabolites. The thiosulfonates are predominant in the allium family where garlic, onion, leek, asparagus, shallots, chive and scallion are representative. Though the thiosulfonates are also able to assist Phase II detoxication, and thereby enhance protection against carcinogenesis, they are perhaps better known for their ability to promote a more favorable HDL- LDL ratio, lower blood pressure and stimulate non-specific immunity.

## Organic acid

Phytochemicals in this group are commonly found in grains, herbs, teas, in a few vegetables and some fruits. They include oxalic acid found in spinach, tea and coffee; tartaric acid in apricots and apples; cinnamic acid in aloe and cinnamon; caffeic acid in burdock and hawthorn; ferulic acid in oats and rice; gallic acid in tea, coumaric acid in turmeric; salicylic acid in spearmint; and tannic acid in nettles, tea, and berries. They are powerful antioxidants, anti-inflammatories, and support liver detoxication. The most current interest is ellagic acid, which is found in guava, currants, apples, grapes, strawberries, and most particularly in red raspberries and wild chart cherries. According to the Hollings Cancer Institute at the University of South Carolina, ellagic acid is a proven anti-carcinogen, anti-mutagen, and anti-cancer initiator.

### The amines

Amines are organic compounds that contain nitrogen (-NH) as the key atom of the functional group. The amines include both chlorophyll (as in chlorella, spirulina, hydrilla, and the leafy greens and grasses) and plant enzymes (as in papain and bromelain). Chlorophyll is well known to detoxify carcinogens found in cooked muscle meats (heterocyclic amines), smoked or barbecued foods (polycyclic hydrocarbons), and peanut mold (aflatoxin). Chlorophyll has also been recognized for its anti-inflammatory, anti-mutagenic, and antioxidant properties. Amines may be two types:

a. Chlorophyll: Chlorophyll has been cited as strengthening the immune response, therapeutic for inflammation of the ear and the mucous membrane of the nose and sinuses, supportive of normal kidney function, accelerating wound and ulcer healing, and reducing fecal, urinary, and body odor in geriatric patients.

b. Plant enzyme: Plant enzyme is well accepted as useful in assisting digestion, having the advantage of being active in a wide pH range. Taken in between meals, they assist in injury resolution by increasing the blood enzymes available to digest proteins related to fibrolytic and inflammatory process and immune responses.

Researchers have shown the high consumption of fruits and vegetables with a decrease in the incidence of cancer and cardiovascular disease. The role of antioxidant phytochemicals in the prevention of these diseases has been mainly attributed to the prevention of LDL oxidation through a scavenging activity against peroxyl and hydroxyl radicals [7]. These phytochemicals are also responsible for different quality characteristics, including colour, flavor and aroma of fruits and vegetables. Thus phytochemicals play a major role and requisite in a huge amount. Therefore phytochemicals are preferentially synthesized synthetically. But researches show that phytochemical, which are produced artificially may cause loss of nourishment and even produce toxic substances to harm people's health. Thus, it is more important to discover novel sources of natural phytochemicals to supply the present needs. By-products of fruits & vegetables during handling and processing are emerged in large amount and have been proven good sources of natural phytochemicals. The production of by-products from the fruit and vegetable also originate in the food processing industries where, low quality products are discarded. The packing houses dealing with fruit & vegetables produce, large amounts of wastes and residues (leaves, stems, etc.). Sometimes these by-products could reach 50% of the harvested material as in lettuce and cauliflower. These residues are very perishable products which management is not always easy and are accountable for environmental management problems in the industries. Minimizing their environmental impact has been the subject of an increasing concern in the past recent years.

An interesting approach to give an added value to these materials is their use as sources of phytochemicals and natural antioxidant compounds. A number of by-products have been previously studied as potential sources of antioxidants. Natural antioxidants are in great demand nowadays due to both consumer preference and health concerns. In addition, modern lifestyle needs an increase of consumption of the "ready to eat" foods (canned, refrigerated, etc) that generally contain small amounts of health-promoting compounds. Nutraceutical and Functional foods try to contribute a proper dietary habit by providing foodstuffs with 'added-value': adding new ingredients that increase their health-promoting properties by increasing bioavailability of active compounds.

## Functional Food

There is no one definition of the term functional food. It is used in many contexts, including references to technological advances, food marketing, and food regulatory norms [8]. Several working definitions used by professional groups and marketers have been proposed by various organizations in several countries. In the United States, functional foods are not officially recognized as a regulatory category by the FDA. However, several organizations have proposed definitions for this rapidly growing food category, most notably the International Food Information Council (IFIC) and the Institute of Food Technologists. The IFIC considers as functional foods those that include any food or food component that may have health benefits beyond basic nutrition (IFIC 2009). Similarly, a recent report of the Institute of Food Technologists (IFT 2009) defined functional foods as "foods and food components that provide a health benefit beyond basic nutrition. These substances provide essential nutrients often beyond quantities necessary for normal maintenance, growth, and development, and other biologically active components that impart health benefits or desirable physiological effects." The European Commission (EC) Concerted Action on Functional Food Science in Europe regards a food as functional if it is satisfactorily demonstrated to affect beneficially one or more target functions in the body, beyond adequate nutritional effects, in a way that is relevant to either an improved state of health and well being or reduction of risk of disease. In this context, functional foods are not pills or capsules, but must remain foods and they must demonstrate their effects in amounts that can normally be expected to be consumed in the diet [9]. The concept of functional food is complex and may refer to many possible aspects, including food obtained by any process, whose particular characteristic is that one or more of its components, whether or not that component is itself a nutrient, affects the target function of the organism in a specific and positive way, promoting a physiological or psychological effect beyond the merely nutritional [10]. The positive effect of a functional food may include the maintenance of health or well being, or a reduction in the risk of suffering a given illness [11]. Functional food may be obtained by modifying one or more of the ingredients, or by eliminating the same [11]. To develop these types of products, one must evaluate consumer perceptions, the most important quality aspects being that they taste good, appear wholesome, and have nutritional value [12]. Also, Alvarez et al. [11] describe that any functional food must be safe, wholesome, and tasty. Functional foods and nutraceutical represent an important, innovative and rapidly growing part of the overall food market. Consumers are increasingly interested in the health benefits of foods and have begun to look beyond the basic nutritional benefits to the potential disease prevention and health enhancing compounds. This interest combined with a more widespread understanding of how diet affects disease, rising health-care costs and an aging population are driving a growing and robust market for nutraceutical and functional foods. According to market statistics, the global functional food market is growing at a rate that is outpacing the traditional processed food market. Functional food are considered to be one of the fastest growing areas of interest for human health and disease prevention according to the College of Agriculture, Food and Natural Resources at the University of Missouri-Columbia [13]. These substances are non-specific biological therapies used to promote good health, prevent malignant processes and control symptoms. The health benefits of these substances are primarily in several areas, including cancer, atherosclerosis and other Cardiovascular Disease (CVD), the aging process and immune response-enhancing effect, diabetes and mental health. The effects rendered by nutraceuticals and functional foods are due to a cocktail or a soup of phytochemicals and bioactive present in the products of interest. Many industries manufacture are market the nutraceutical and functional food, where the side effects not reported or often unproven. Companies Marketing Nutraceuticals in India are GlaxoSmithKline consumer healthcare, Dabur India, Cadila Health care, EID Parry's, Zandu Pharmaceuticals, Himalaya herbal Healthcare, Amway, Sami labs, Elder pharmaceuticals and Ranbaxy.

The development of food processing by- products in the formulation of nutraceutical or functional food can be very attractive to this growing market and would also add economic value. The beneficial effects of these food processing by- products are due to various phytochemicals. These compounds directly contribute to the antioxidant capacity and are usually used in the prevention of oxidative rancidity [14]. Antioxidant polyphenols play an important role as health protective factor, since they neutralize the hazardous effect of free radicals in the cell. Excess amount of free radical in human body can lead to oxidative stress, resulting in DNA and protein damage and an increase risk of chronic disease. It has been estimated that there are 10,000 oxidative hits to DNA per cell per day in humans [15]. All these compounds are directly associated with a number of health-promoting properties such as anticarcinogenic, anti-inflammatory, antidiabetic, antithrombotic and vasoprotective activities [16].

Generally, these valuable compounds are highly present in the outer layers of fruits & vegetables. During the processing stage, these parts are usually removed and retained in the press residues or by-products. From only juices processing industries an enormous quantity of processing residue are yielded. Juice recovery from citrus fruit is only about 40-55%, and processing residue emerged in the form of pomace. Citrus-juice processing is one of the important food industries of the world. Peels and stones are major waste of mango processing, amounting to 35-60% of the total fruit weight. Sometimes these by-products are found more precious than main products. Some of the examples from literature are as follows:

## By- Products and their Industrial Valorization

### Citrus by-products

Citrus-juice processing is one of the important food industries of the world. These citrus by-products and wastes have already drawn attention not only as important sources of dietary fiber for human consumption, but also as fermentable substrates for obtaining valuable chemicals and feedstock. Due to the large amounts being processed into juice, considerable by-products are emerged in the form of pomace peel, seeds and these represents good source of fiber-pectin, limonene and flavonoid. The main flavonoids found in citrus species are hesperidin, narirutin, naringin and eriocitrin. High antioxidant activity is present in citrus seeds and peels. Citrus by-products also contain large amount of coloring material in addition to their complex polysaccharide content. Hence, they are a potential source of natural clouding agents, which are in great demand by soft drinks industry. Commercial clouds presently used in the soft drinks industry are very expensive.

### Apple by-products

Production of pectin is considered the most reasonable way from apple pomace residues both from an economical and from an ecological point of view. Apple pomace has been shown to be a good source of polyphenols [17]. Major compounds isolated and identified include catechins, hydroxycinnamates, phloretin glycosides, quercetin glycosides [18].

### Grape by-products

Grapes are the world's largest fruit crop with more than 60 million tons produced annually. In wine making approximately 20% of the weight of grapes produces as a pomace. Many products such as ethanol, tartrates, citric acid, grape seed oil, hydrocolloids and dietary fiber are recovered from grape pomace [19]. The principal phenolic constituents of grape pomace are anthocyanins, catechins, flavonol glycosides, phenolic acids, alcohols and stilbenes [20].

### Banana by-products

Banana represents one of the most important fruit crops, with a global annual production of more than 50 million tons [21]. Worldwide production of cooking bananas amounts to nearly 30 million tons per year. Peels constitute up to 30% of the ripe fruit banana waste is used for the production of edible starch and protein, ethanol, α-amylase, hemicellulases and cellulases [22,23]. Most of the carotenoids found in banana peels.

### Guava by-products

Guava seeds contain about 5–13% of the fruit and are rich in essential fatty acids [24]. The results of very recent investigations indicate that peel and pulp of guava fruits could be used as a source of antioxidant dietary fiber.

### Papaya by-products

Papain, is recovered from the latex of papaya fruit. Furthermore, papaya fruits may also be used for the production of pectin. The seed oil is low in polyunsaturated fatty acids, but defatted papaya seed meal contains high amounts of crude protein (40%) and crude fiber (50%) [25].

### Passion fruit by-products

The waste resulting from passion fruit processing consists of more than 75% of the raw material. The rind constitutes 90% of the waste and is a source of pectin (20% of the dry weight). Passion fruit seed oil is rich in linoleic acid (65%) [26].

### Kiwifruit by-products

The total dietary fiber content of kiwifruit pomace amounts to approximately 25% on a dry weight basis [27]. Phenolic acids, flavanol monomers, dimers and oligomers, and flavonol glycosides have recently been characterized in kiwifruit pulp.

### Tomato by-products

About 3–7% of the raw material is lost as waste during tomato juice pressing. The seeds account for approximately 10% of the fruit and 60% of the total waste, respectively, and are a source of protein (35%) and fat (25%). Tomato seed oil has attracted interest since it is rich in unsaturated fatty acids; especially in linoleic acid [28]. Furthermore skin extract is rich in lycopene and β-carotene.

### Carrot by-products

Carrot pomace is a major part of valuable compounds such as carotenes, uronic acids, and neutral sugars are retained in the pomace after juice extraction. Juice yield is reported to be only 60–70% [29]. Total carotene content of pomace may be up to 2 g per kg dry matter, depending on processing conditions.

### Onion by-products

The amount of onion waste produced annually in the European Union is estimated at approximately 450,000 tons. Onion wastes are a source of flavour components and fiber compounds and particularly rich in quercetin glycosides [30]. The major flavonoids of mature onion bulbs are quercetin 3,4´- O-diglucoside and quercetin 4´- O-monoglucoside, accounting for more than 85% of the total flavonoids [31]. Since quercetin from onions is rapidly absorbed and slowly eliminated, it could contribute significantly to antioxidant defense.

### Peach and apricot by-products

Bitter apricot seeds are by-products of the apricot processing industry. Apart from the use of apricot seed oil in cosmetics, peeled seeds serve as a raw material for the production of persipan. Pomace of wild apricot proved to be a rich source of proteins besides apricot seeds, peach seeds may also be used for the production of persipan. Recently, the recovery of pectin from fresh peach pomace has been described. Quality evaluation revealed that peach pectin is highly methoxylated and has favourable gelling properties [32]. While storage of dry powdered pomace led to significantly higher pectin yields, quality parameters of the pectins deteriorated.

### Mango by-products

Mango is one of the most important tropical fruits. Mango and mango products are popular worldwide and have gained increasing relevance also in the European market. The major wastes of mango processing are peels and stones, amounting to 35–60% of the total fruit weight [33]. 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 antioxidants [34]. Ethanolic extracts of mango seed kernels display a broad antimicrobial spectrum and are more effective against Gram (+) than against Gram (-) bacteria. Mango peels are also reported to be a good source of dietary fiber [33].

### Potato by-products

While consumption of potatoes has decreased, processed products such as French fries, chips, and puree have experienced growing popularity. Peels are the major waste of potato processing. Losses caused by peeling range from 15 to 40%. Aqueous peel extracts were shown to be a source of phenolic acids [35]. The antioxidant activity of freeze-dried water extracts of potato peels was comparable to that of butylated hydroxyanisole [36].

### Cauliflower by-products

Cauliflower by-products mainly consist of leaves and stems. Regarding the edible portion of the cauliflower, this is rather poor in phytochemicals and only small amounts of some hydroxycinnamic acid derivatives such as caffeic, sinapic, and ferulic acids were identified and quantified. The HPLC analysis of cauliflower by-product extracts revealed the presence of both flavonoids and hydroxycinnamic acids (caffeic acid and sinapic acid) [37]. Different combinations of flavonols such as kaempferol and quercetin with sinapic acid and glucose have been identified being the main compounds kaempferol-3-O-sophoroside- 7-O-glucoside and its sinapoyl derivative (kaempferol-3-O-(sinapoylsophoroside)-7-O-glucoside [38].

In this context, addition of phytochemical enriched extracts derived from by-products could be a feasible strategy to develop functional foods and at the same time would contribute to valorize of these by-products. These wastes can contain many reusable substances of high value and can be converted into commercial products either as raw material for secondary processes, as operating supplies or as ingredients of new products. The use of by-products of fruit and vegetable as basis of functional compounds and their function in food shows potential, which requires interdisciplinary research. But the extraction of phytochemical is actually very less developed for the exploitation of fruits & vegetable' by-product commercially.

Consequently, now the main emphasis is on the recovery of phytochemical from fruits & vegetables by-products as a low expenditure. All these wastes materials (kernels, seeds, pomace and stones) emerged from different fruits & vegetables processing are prone to microbial spoilage; hence, drying is essential before further exploitation. Cost of drying, storage and transport acquire added economical restriction to wastes utilization. These wastes could be considered valuable by-products if there are appropriate technical means and if the values of the subsequent products are to exceed the cost of reprocessing. Residues in this case cannot be regarded as wastes but become an additional resource to augment existing natural materials. Recycling, reprocessing and eventual utilization of food processing residues offer potential of returning these by-products to beneficial uses rather than their discharge to the environment which cause detrimental environmental effects. Successful food waste reprocessing involves (a) rendering recovered by-products suitable for beneficial use, (b) promoting marketability to ensure profitable operating, (c) employing reprocessing technology, and (d) creating an overall enterprise that is acceptable and economically feasible.

If, effective utilization of food residues to occur, food manufacturers be supposed to invest in specific secondary industry to employ these residues. Efforts are needed to develop new technologies and to institute suitable measures to promote waste reclamation; this can only be achieved if food residues are considered as complementary resources rather than as undesirable wastes.

Therefore, in view of the growing interest in these compounds, there is a need to identify and quantify these important compounds to supply the present needs from the natural sources. Utilization of these industrial by-products may be economically worthwhile. The use of fruits and vegetables by-products can contribute to lower production costs in the food industry and to create new food sources for human consumption. The exploitation of by-products of fruit and vegetable as a source of functional compounds and their application in food as a nutraceutical or functional food is a promising field. There is a need for specific analytical methods for the characterization and quantification of these important bioactive compounds and other functional compounds and it is necessitate to be carefully assessed the bioactivity, bioavailability and toxicology of these compounds by *in vitro* or *in vivo* studies.

## Technical Difficulties

By-products from fruit and vegetable are often rich in potentially food-grade and non-food-grade components. Scientists continue to expound the potential economic virtues of exploiting these "high value" components from these by-products. However, there are several key areas of technical and scientific difficulty which serve to attenuate the economic rationale for up-grading by-products. Two major technical difficulties are as under:

### Extraction process

The extraction processes used for the preparation of these phytochemical extracts have to meet some requirements. Some of the points should be considered such as it should be preferred the use of fresh raw materials for extraction. It is also necessary to use food compatible solvents as water, ethanol or mixtures of them. Thermal treatments are generally necessary to inactivate enzymes that can degrade the phytochemicals during the extraction process. The extracts obtained need to be concentrated and spray drying or freeze drying is feasible technologies that could be applied depending on the price of the obtained extract in the market. In some cases extract purification through non-ionic polymeric resins can be used to concentrate the phytochemicals before drying. In these cases, the water extract (or a water solution of the ethanol-water extract) is filtered through the resin column and the phytochemicals are retained in the stationary phase. Then these compounds are eluted with ethanol, and this extract concentrated. The extracts obtained are generally prepared in dried form although liquid extracts is another possibility. These extracts can be used for the preparation of pills (dried extracts) or to prepare functional juices [28] or other new foods such as soups, sauces, margarines, etc. to which liquid or dried phytochemical extracts can be added.

### Microbiological instability

Many by-products have high water content, particularly those derived from trimmings of fruits and vegetables. These residues provide a high quality breeding ground for fungi and bacteria and will rapidly lose any potential as a source of food-grade materials as they start to undergo biodegradation. Such is the case when by-products are left for more than a few hours at ambient temperature. Hence there is an immediate requirement for stabilization using, for example, processes such as drying, refrigeration or freezing.

## Needs of Research

The use of these extracts, however, presents some concerns. Before producing these phytochemical extracts from agri food residues it is essential to evaluate the potential market and price for these products. Another topic of concern is safety. It is essential to make sure that the pesticides and other agrochemicals are not intensive in the extracts in the same way the phytochemicals are. It is therefore essential a routine analysis of pesticides in all these products. It is also important to establish the risk/benefit balance of using these phytochemical extracts for health-related purposes. In addition it is necessary to control the content of the bioactive phytochemicals in the extracts by appropriate analytical methods. It is not unusual to find in the market pills, extracts and other preparations based on specific bioactive compounds in which the bioactive phytochemicals are only present as traces. This is the case of many grape extract preparations that claim a significant content of resveratrol, when the real content is very small or is even undetectable. It is necessary to give figures of the content of the main bioactive components. The biological activity of these phytochemical extracts needs to be demonstrated by *in vivo* studies and clinical assays, as the bioavailability of many phytochemicals is rather small and in many cases the natural compounds are transformed into other metabolites by the gut microflora, and these metabolites, but not the original phytochemicals, are then absorbed and circulate in plasma to reach the target tissues where the biological action takes place. Thus, efficient, inexpensive and environmentally sound utilization of these materials is becoming more important especially since profitability and jobs may suffer [39].

## Conclusion

It can be concluded these by-products serve a cocktail or a soup of phytochemicals and have powerful antioxidants including great nutritional approach. A large number of phytochemicals and other bioactive compounds as well as nutritional elements are important factors to consider these by products in the formulation of functional foods and nutraceutical compounds. However, it is essential to guarantee the product safety in terms of pesticides and risk assessment of increasing phytochemical concentration. The expansion of food processing by- products in the formulation of nutraceutical or functional food is very attractive to the growing market and would add economic value.

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