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A review on conversion of food wastes and by-products into value added products

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Abstract
Food production and processing in developing countries generate high levels of waste and byproducts, causing a negative environmental impact and significant expenses. Conversion of these food wastes and by-products into value added products is very important for not only economic aspect but also social and environmental sides. 3R's concept, i.e., Reduce, Reuse, and Recycle should be follow to overcome food waste issue in food industry. However, these biomaterials have ample potential for generating food additives which in turn will minimize malnutrition and hunger in the developing countries where it is produced. Many of these biomaterials are a source of valuable compounds such as proteins, lipids, starch, micronutrients, bioactive compounds, and dietary fibers. In this context, the use of these biomaterials is a challenge and provides great opportunity to improve food security. The purpose of this review is to project the potential of food waste and byproducts as a sustainable alternative to reduce malnutrition and hunger in developing countries.

Keywords: Food waste, food by-product, hydrothermal carbonization, value added product

Introduction

Agricultural production and agro-industrial processing generate a high amount of byproducts and waste. Fruit byproducts such as bagasse, peels, trimmings, stems, shells, bran, and seeds account for more than 50% of fresh fruit and have at times a nutritional or functional content higher than the final product (Ayala *et al*., 2011) [3]. Fruit and food waste is also generated by damage during transportation, storage, and processing. The growing popularity of fruit juices, nectars, frozen and minimally processed products has also increased the production of byproducts and wastes in recent years. Social impacts may be attributed to an ethical and moral dimension within the general concept of global food security since 805 million people across the globe suffer from hunger (FAO, 2014) [21]. To manage the nutritional problems of today's society; we require more composite nutritional sources. Food wastes and byproducts are of paramount importance here due to the presence of sufficient quantities of proteins, lipids, starch, micronutrients, bioactive compounds, and dietary fibers. Protein deficiency and associated malnutrition is one of the serious problems in most of the developing countries (Müller and Krawinkel, 2005) [38]. Food fortification serves as a crucial strategy to fight malnutrition and important initiatives have been undertaken to utilize residues and byproducts in Europe and USA (Mirabella *et al*., 2014; Girotto *et al*., 2015) [36, 23]. Poorer nations where the problems of malnutrition and hunger exists at a higher level, there is a greater potential of exploitation of these biomaterials as they generate large quantities of byproducts. The main raw materials used in the industries in such countries are fruits, vegetables, dairy products and fish. Tropical and subtropical fruits like mango, pineapple, banana, grape, and citrus are important fruits used in processing in poor countries (Schieber *et al*., 2002) [45].

The utilization of residues and byproducts generated in the poor regions of the world for the formulation of novel foods will directly benefit the local communities. Food and beverage production is an industry with the main raw materials generally obtained from plant and animal sources and the industry has always aimed to convert these raw materials to a value added products. During this conversion processes, voluminous and serious amounts of food wastes and by-products are generated. Unfortunately, one-third of the global food production is wasted worldwide every year (Gustavsson *et al*., 2011) [26]. Vandermeersch *et al*. (2014) [49] explained the effects of such a high amount of food waste generation considering there different approaches, for instance crop losses during harvest or storage (economic), hunger in

Low-income countries (social), and the deprivation of natural resources without accomplishing its final purpose (environmental). FAO (2016) reported seriously worrisome findings about food wastes, for example every year, consumers in rich countries waste almost as much food (222 million tonnes) as the entire net food production of sub-Saharan Africa (230 million tonnes). Memon (2010) [34] suggested 3R's concept, i.e., Reduce, Reuse, and Recycle to overcome food waste issue throughout the world. Value-added product generation can benefit infrastructure development, transportation, food processing, and packaging industries. This contributes to the reduction in waste accumulation and results in significant financial benefits. Tropical fruits, dairy, and fish are an important commercial food and crop enterprise, which plays an important role in the socio-economic development of rural and urban populations in countries in Africa, Asia, and America.

That's why waste management systems also begins with waste minimization. Riemer and Kristoffersen (1999) [43] suggested four ways to achieve perfect waste minimization in the industry as follow;

1. Waste prevention with using more efficient production technologies
2. Internal recycling of production waste
3. Source-oriented improvement of waste quality
4. Reuse of products. A number of by-products are also somewhat discarded in food industry without any process although they can be used to produce valuable products. In this review, the methods that have been generally preferred to convert by products to value added products are investigated.

Proper use of food waste and byproducts as raw materials or food additives, could generate economic gains for the industry, contribute to reducing nutritional problems, would produce beneficial health effects and would reduce the environmental implications that generate mismanagement of waste. Presently, the industries are interested in innovations so as to obtain zero waste, where the waste generated is used as raw material for new products and applications. These actions can directly impact the Millennium Development Goals, the upcoming Sustainable Development Goals, the Post 2015 Agenda and the Zero Hunger Challenge. In this context, the main goal of this review article is to present the potential of food waste and byproducts as a sustainable alternative to reduce malnutrition and hunger in developing countries. The following examples have been chosen as being a contrasting set of materials for which much information is available and for which clear improvements and opportunities are envisaged.

1. Food Waste and By-Product Conversion

1.1 Thermal Conversion

The thermal conversion of food by-products or waste especially solid form bases on production of fuel and chemicals that are generally used to operate steam turbines for energy production or for heat exchangers used to heat up process streams in industry [7]. Hydrothermal carbonization is a wet process that converts food wastes to a valuable, energyrich resource under autogenous pressures and relatively low temperature (180-350 °C) compared to pyrolysis (Pham *et al*., 2015) [41]. Parshetti *et al*. (2014) [39] used hydrothermal carbonization method to prepare hydrochars from urban food wastes for removal of textile dyes from contaminated water. The basic thermal conversion processes are pyrolysis and hydrothermal carbonization. Food wastes are burned at temperatures less than 450°C and become gaseous at temperatures above 800 °C during pyrolysis.

1.2 Chemical Conversion

In food processing industry, hydrolysis and oxidation reactions are mostly used as chemical conversion methods for food wastes and by-products. Valuable parts of food wastes and by-products can be also extracted by green extraction techniques where water is mostly preferred as extraction medium instead of organic solvent extraction. Barba *et al*. (2016) [6] reviewed in detail alternative extraction methods such as pulsed electric fields, high voltage electrical discharges, pulsed ohmic heating, ultrasounds, microwave-assisted extractions, sub- and supercritical fluid extractions, as well as pressurized liquid extraction for the recovery of antioxidant bioactive compounds from winery wastes and by-products. Zungur *et al*. (2016) [51] was also used water to extract melon seed milk from melon seeds that generally referred as waste. Amado *et al*. (2014) [1] tried to extract antioxidant from potato peel waste with ethanol. They investigated the effect of extraction process conditions in terms of temperature, time and ethanol concentration on antioxidant extraction from potato peel. Goula & Lazarides (2015) [25] reported how valorized the olive mill and pomegranate waste. They suggested different approaches for complete utilization of pomegranate seeds and peels based on ultrasound-assisted extraction of oil and phenolics from seeds and peels and conversion of olive mill waste into live paste spread or olive powder (to be included in food formulations) and encapsulated polyphenols.

1.3 Biological Conversion

Energy and bioactive compounds recovery from food wastes and by-products through biological treatment is currently gaining increased interest throughout the world. Food waste has a high content of moisture and organic matter, and thus is an ideal substrate for anaerobic digestion. The process of anaerobic digestion consists of four steps: hydrolysis, acidogenesis, acetogenesis, and methanogenesis. PH, temperature, and organic loading rate have an effect on the acidogenesis of food waste (Jiang *et al*., 2013) [29]. Chandrasekaran (2012) [12] reported that anaerobic digestion created biogas, primarily made of methane and carbon dioxide, which could be used as a source of energy similar to natural gas. Besides anaerobic digestion, composting of food wastes and by-products is also one of biological conversion method. Composting is a biological process in which organic materials are broken down and nutrients and minerals are released.

2. By-Products and Wastes of Fruit Processing

2.1 Mango

Mango (*Mangifera indica L.*) which belongs to the family *Anacardiaceae*, is grown naturally or mainly cultivated in tropical and subtropical regions. Mango is one of the most important fruits in the world, thanks to its delicious flavor, attractive fragrance, beautiful color, and nutritional value (Ibarra *et al*., 2015) [28], so it enjoys the status of "the king of fruits." India, China, Thailand, Mexico, Indonesia, and Pakistan are the main producing countries at the world level. Asia is the main continent in mango production (75.6%), followed by America (13.3%) and Africa (11%) (FAOSTAT, 2017) [22]. Moreover, to know in detail about the chemical characterization of mango peel, it is advisable to read a complete review article written by Serna-Cock *et al*. (2016)

[46]. This review document will present some basic aspects of the main nutritional components and their possible applications. The mango peels have high levels of soluble dietary fiber (Serna-Cock *et al*., 2016) [46]. Dietary fiber is an important additive for the formulation of functional foods. As also shown in Table 1, the dietary fiber composition of mango peel ranges from 51.2 to 78.4%. Dietary fibers are non-digestible carbohydrates present in plants and considered as an important component of the healthy human diet (Juarez Garcia *et al*., 2006) [30].

2.2 Banana

Banana is a fruit that is widely grown around the world; which is mostly found in places with the tropical and subtropical weather. This fruit belongs to the *Musaceae* family. Bananas are native to Southeast Asia and are cultivated in over 130 countries (Mohapatra *et al*., 2010) [37]. The edible part of the fruit represents only 12% of the plant's total weight, generating a large amount of agro-industrial waste such as peel which is mostly used for industrial processes for the production of new products (chips, dried pulps, jams, wine, beer, and sauces). Banana peels represent 30–40% of the total weight of the fruit (Bankar *et al*., 2010; Babbar *et al*., 2011) [5, 4]. After the processing of bananas, a large amount of peel is collected and treated like garbage since it is considered as a fruit waste. These residues represent a serious pollution problem as it is dispersed in the planting area or burned.

A large number of applications for these byproduct are reported in literature (Bankar *et al*., 2010) [5] banana peels can be used to feed on cattle and poultry, as fertilizer, for the production of ethanol and biogas, for extraction of banana oil (Mohapatra *et al*., 2010) [37], as adsorbent for heavy metal removal in water purification systems, for the production of proteins, for the production of biomass for conversion into energy (Bankar *et al*., 2010; González Montelongo *et al*., 2010) [5, 24] and for developing neutraceuticals because if its antioxidant properties (Babbar *et al*., 2011) [4]. The potential applications of banana peels depend principally on their chemical composition (Pelissari *et al*., 2014) [40]. Ripening in bananas is an important aspect, which influences the compounds present in the peel since it has been reported that when the fruit ripens, the starch and hemicellulose content is reduced. This is believed to be due to the activity of endogenous enzymes, increasing the number of soluble sugars such as glucose, fructose, and sucrose, as well as proteins and lipids (Happi Emaga *et al*., 2007; Mohapatra *et al*., 2010) [27, 37].

2.3 Grape

Grape is a fruit which is nutritious and having an impact on the economic status of the producing countries. These fruits are used as table grapes, raisins, and juices and also used for wine production. The consumption of table grapes and wine has numerous nutritional and health benefits for humans because of the presence of antioxidant polyphenols such as resveratrol. According to FAO (2013) [20], annual global production of grapes is over 21.9 million tons. Derived from its diversified consumption, grape is characterized by its high economic value, and currently, 31% of the world production is destined for the fresh market; 67% to the elaboration of wine and other alcoholic beverages; and 2% is processed as dry fruit.

Grape is a fruit of extensively researched because of the health benefits in many respects. Grapes are an excellent source of manganese and a good source of vitamins B6, thiamine (vitamin B1), potassium, and vitamin C (Kammerer *et al*., 2004; Corrales *et al*., 2009) [31, 16]. In addition, grapes are one of the richest sources of bioactive compounds such as phenolic acids, flavonoids, anthocyanins, and proanthocyanidins. These compounds are responsible for the color and smell of grapes and are found mainly in the skin of the grape. Grape seed is another byproduct that is generated in most of the wine industries and it represents a maximum of 5 to 6% by weight with respect to the grape bunch. The oil obtained from grape seed is characterized by its richness in linoleic acid (60–70%), as well as in tocopherols, which hinder their oxidation. Grape seed oil also has important dietary properties which benefit human health, for preventing the formation of atheromatous lesions, and also for reducing cholesterol and lipidemia (Cao and Ito, 2003; Maier *et al*., 2009) [11, 33]. It is being widely used for non-food sectors including cosmetic industry for the manufacture of soaps or even lipoquimia for the production of fatty acids. Seeds are also rich in proanthocyanidins (catechin polymers) or procyanidolic oligomers (OPC) which are having the property of assuring certain vascular protection and a partial cholesterol scavenging action (Cao and Ito, 2003; Maier *et al*., 2009) [11, 33].

2.4 Citrus Fruits

Citrus fruits are a family of widely consumed fruits worldwide. They have their origin in Southwest Asia and are currently distributed mainly in countries with warm and temperate climates, at temperatures ranging between 23 and 34°C (Amaro *et al*., 2015; Micheloud *et al*., 2016) [2, 35]. Tropical and subtropical countries such as China (21%), Brazil (18%), India (6%), and Mexico (4.6%) are some of the main producers. Vitamin C is another characteristic component of this fruit family. This is an abundant nutrient in citrus, which is a widely used antioxidant. In addition to these major compounds, we can also find a lot of fiber and minerals like potassium, calcium and magnesium (Rezzadori *et al*., 2012) [42]. Global production and consumption of citrus fruits have recorded strong growth since the mid-1980s. an recent years citrus residues have been shown to contain a high amount of polyphenols such as phenolic acids and flavonoids, mainly poly methoxy flavones, flavanones, and glycosylated flavanones (Domínguez, 2016; Sormoli and Langrish, 2016) [17, 47]. Although flavonoids are generally considered to be non-nutritive agents, the interest in flavonoids has been found to be associated with increased interest in drug research to combat multiple serious chronic diseases (Roussos, 2011; Chen *et al*., 2017) [2]. Furthermore, Tomato residues are a good source of bioactive molecules, especially carotenoids, such as β-carotene and lycopene, which confers not only high nutritional value but also beneficial health properties, due to their high antioxidant content. They also contain proteins, sugars, waxes, ois, lycopene, β-carotene fiber, and seed oil (Colle *et al*., 2010) [15].

2.5. Tomato

Tomato has a very important social importance, since a considerable part of the economically active population is directly or indirectly related to tomato cultivation. It has a low caloric value of 17 kcal/100 g and is characterized by a high-water content (90–94%), an important content of soluble sugars (fructose, glucose, and sucrose), lower proportion of proteins, fiber, and organic acids (citric and malic) and a significant contribution of vitamins (A and C), carotenoids and mineral elements. The fruit produced by this plant is an oval, round or peripheral berry. There are three ways to classify the tomato, according to its shape, maturity, and color. According to their shape, there are five types, from smallest to largest: cherry, saladette, pear type, standard ball, and large ball. Lycopene is the primary pigment responsible for the red color in tomatoes (Borel *et al*., 2015) [8]. It comprises approximately 80–90% of the pigments present (Basuny, 2012) [7]. It is structurally different from carotene (Campos *et al*., 2017) [10]. Unlike β -carotene, lycopene is not a precursor of vitamin A (Zeng *et al*., 2015) [50]. Lycopene has a high antioxidant power against singlet oxygen ($^1O_2$) and high free radical scavenging ability (Boyacioglu *et al*., 2016) [9].

3. Anti-nutritional Factors of Food and Waste Product

The waste byproducts are a good source of protein, carbohydrates, vitamins, and minerals. However, the use of these products is limited in the food industry mainly due to the content of anti-nutritional factors (ANF) such as condensed tannins, saponins, trypsin inhibitors, phytates, isoflavonoids, among others (Ee and Yates, 2013; Tresina *et al*., 2017) [18, 48]. ANF are substances that are generated by the secondary metabolism of plants to protect themselves from predators. ANFs reduce the nutritional value of foods in which they are present by interfering with the digestibility and bio availability of proteins, carbohydrates, and minerals, with which they bind. ANF can be divided into two groups: thermolabile and thermostable. Among the thermolabile are protease inhibitors, amylases inhibitors, D, E and B_{12} antivitamins; and among the thermostable are the saponins, cyanogens, phytates, alkaloids, oligosaccharides, and tannins (Elizalde *et al*., 2009) [19]. Among the biological treatments, fermentation has been identified as one of the processes with greater efficiency because the ANF has been reduced and the digestibility of the protein has been increased substantially by this process. Microorganisms most used here are lactic acid bacteria (LAB) and filamentous fungi of the genus *Aspergillus* and *Rhizopus*. One of the special characteristics of these microorganisms is that they are recognized as safe (GRAS) since they are not producers of mycotoxins. During fermentation, lactic acid bacteria play an important role in the reduction of ANFs due to its capacity to produce enzymes. There are some experiments done using filamentous fungi under solid state fermentation processes (SSF). Londoño *et al*. (2016) [32], used the strain *Rhizopus oryzae* (MUCL 28168) in an SSF process using sorghum as substrate an under optimized conditions of temperature 32.97° C, air velocity 84.11 mm 3 min-1, wheat bran 1.16% and particle size 0.82 mm, a reduction of about 86% of condensed tannins was achieved. Soybean is a legume with highest protein value, however, its FAN content is very high. Many research studies have focused on reducing these compounds. Chen *et al*. (2014) [13], used the strain *Aspergillus oryzae* (ATCC, 9362) in an SSF on soy meal to reduce phytic acid. At 50°C 41% moisture and inoculum size of 1.7 mL, 57% phytic acid was degraded. Likewise, the protein content was increased by 9.5%.

Conclusion

Food wastes are one of worrisome issue for people and environment. That's why valorization of food wastes and by-products is very important due to social, economic and environmental reasons. Food wastes and by-products can be converting into valuable products through thermal, chemical and biological methods. The appropriate conversion method is selected with respect to composition of food wastes and by-products and the aim of recovery process. With the nutritional problems facing society today (hunger indicators and the growing world population), the use of food waste for human food should be a priority. Wastes and byproducts produced in developing countries have a powerful nutritional and functional use in their formulation and a powerful tool in minimizing of hunger. In addition, the added value generated by the diversification of the productive chains can create job opportunities for the residents generating an additional social benefit.

References

1. Amado IR, Franco D, Sánchez M, Zapata C, Vázquez JA. Optimisation of antioxidant extraction from Solanum tuberosum potato peel waste by surface response methodology. Food Chem. 2014; 165:290-299.
2. Amaro J, Hernández O, Olivencia J. Cálculo del campo de velocidad de un flujo laminar de agua al interior de una tubería, enfriándose con el medio ambiente después del completo desarrollo hidrodinámico. Agroind. Sci. 2015; 5:127-132. doi:10.17268/agroind.science.2015.02.04
3. Ayala J, Vega V, Rosas C, Palafox H, Villa J, Siddiqui W *et al*. Agro-industrial potential of exotic fruit byproducts as a source of food additives. Food Res. Int. 2011; 44:1866-1874.
4. Babbar N, Oberoi HS, Uppal DS, Patil RT. Total phenolic content and antioxidant capacity of extracts obtained from six important fruit residues. Food Res. Int. 2011; 44:391-396. doi: 10.1016/j.foodres.2010.10.001
5. Bankar A, Joshi B, Ravi A, Zinjarde S. Banana peel extract mediated novel route for the synthesis of silver nanoparticles. Colloids Surf. A Physicochem. Eng. Aspects. 2010; 368:58-63. doi: 10.1016/j.colsurfa. 2010.07.024
6. Barba FJ, Zhu Z, Koubaa M, Santana AS, Orlien V. Green alternative methods for the extraction of antioxidant bioactive compounds from winery wastes and by-products: A review. Trends in Food Science & Technology. 2016; 49:96-109.
7. Basuny AMM. "The anti-atherogenic effects of lycopne," in Lipoproteins-Role in Health and Diseases, eds S. Frank and G. Kostner (Rijeka: In Tech), 2012, 489-506.
8. Borel P, Desmarchelier C, Nowicki M, Bott R. Lycopene bioavailability is associated with a combination of genetic variants. Free Radic. Biol. Med. 2015; 83:238-244. doi: 10.1016/j.freeradbiomed.2015.02.033
9. Boyacioglu M, Kum C, Sekkin S, Yalinkilinc HS, Avci H, Epikmen ET *et al*. The effects of lycopene on DNA damage and oxidative stress on indomethacin-induced gastric ulcer in rats. Clin. Nutr. 2016; 35:428-435. doi: 10.1016/j.clnu.2015.03.006
10. Campos KKD, Araújo GR, Martins TL, Bandeira ACB, Costa GP, Talvani A *et al*. The antioxidant and anti-inflammatory properties of lycopene in mice lungs exposed to cigarette smoke. J. Nutr. Biochem. 2017; 48:9-20. doi: 10.1016/j.jnutbio.2017.06.004
11. Cao X, Ito Y. Supercritical fluid extraction of grape seed oil and subsequent separation of free fatty acids by high-speed counter-current chromatography. J Chromatogr. A. 2003; 1021:117-124. doi: 10.1016/j.chroma.2003.09.001
12. Chandrasekaran M. Valorization of food processing by-products. Boca Raton, CRC Press, USA, 2012, 836.

13. Chen L, Vadlani PV, Madl RL. High-efficiency removal of phytic acid in soy meal using two-stage temperature-induced Aspergillus oryzae solid-state fermentation. J Sci. Food Agric. 2014; 94:113-118. doi: 10.1002/jsfa.6209
14. Chen XM, Tait AR, Kitts DD. Flavonoid composition of orange peel and its association with antioxidant and anti-inflammatory activities. Food Chem. 2017; 218:15-21. doi: 10.1016/j.foodchem.2016.09.016
15. Colle IJ, Lemmens L, Tolesa GN, Van Buggenhout S, De Vleeschouwer K, Van Loey AM, *et al*. Lycopene degradation and isomerization kinetics during thermal processing of an olive oil/tomato emulsion. J Agric. Food Chem. 2010; 58:12784-12789. doi: 10.1021/jf102934u
16. Corrales M, García AF, Butz P, Tauscher B. Extraction of anthocyanins from grape skins assisted by high hydrostatic pressure. J Food Eng. 2009; 90:415-421. doi: 10.1016/j.jfoodeng.2008.07.003
17. Domínguez MT. Flavonoides extraídos de la cascara de naranja tangelo (*Citrus reticulata* x *Citrus paradisi)* y su aplicación como antioxidante natural en el aceite vegetal sacha inchi (*Plukenetia volubilis*). Sci. Agropecuaria. 2016; 7:419-431. doi: 10.17268/sci. agropecu.2016.04.07
18. Ee KY, Yates P. Nutritional and antinutritional evaluation of raw and processed Australian wattle (*Acacia saligna*) seeds. Food Chem. 2013; 138:762-769. doi: 10.1016/j.foodchem.2012.10.085
19. Elizalde ADD, Porrilla Y, Chaparro DC. Factores Antinutricionales en Semillas. Facultad de Ciencias Agropecuarias. 2009; 7:46-57.
20. FAO. FAO Statistics, Food and Agriculture Organization of the United Nations. FAO, 2013. Available online at: http://www.fao.org (Accessed July 13, 2017)
21. FAO. Panorama de la Seguridad Alimentaria y Nutricional en América Latina y el Caribe 2014, 2014. FAO. Available online at: http://www.fao.org/docrep /018/i3068s/i3068s.pdf (Accessed July 18, 2018).
22. FAOSTAT. FAO Statistics, Food and Agriculture Organization of the United Nations. FAOSTAT, 2017. (Accessed September 13, 2017). Available online at: http://www.fao.org/faostat/en/#data/QC/visualize
23. Girotto F, Alibardi L, Cossu R. Food waste generation and industrial uses: a review. Waste Manage. 2015; 45:32-41. doi: 10.1016/j.wasman.2015.06.008
24. González Montelongo R, Lobo MG, González M. Antioxidant activity in banana peel extracts: testing extraction conditions and related bioactive compounds. Food Chem. 2010; 119:1030-1039. doi: 10.1016/j.foodchem.2009.08.012
25. Goula AM, Lazarides HN. Integrated processes can turn industrial food waste into valuable food by-products and/or ingredients: The cases of olive mill and pomegranate wastes. Journal of Food Engineering. 2015; 167:45-50
26. Gustavsson J, Cederberg C, Sonesson R, van Otterdijk R, Meybeck A. Global food losses and food wastes: extent, cause and prevention. Interpack 2011 FAO, Dusseldorf, Germany, 2011, 1-37.
27. Happi Emaga T, Andrianaivo RH, Wathelet B, Tchango JT, Paquot M. Effects of the stage of maturation and varieties on the chemical composition of banana and plantain peels. Food Chem. 2007; 103:590-600. doi: 10.1016/j.foodchem.2006.09.006. http://www.fao.org /save-food /resources /keyfindings/en/
28. Ibarra I, Ramos P, Hernández C, Jacobo D. Effects of postharvest ripening on the nutraceutical and physicochemical properties of mango (*Mangifera indica* L. *cv Keitt*). Postharvest Biol. Technol. 2015; 103:45-54. doi: 10.1016/j.postharvbio.2015.02.014
29. Jiang J, Zhang Y, Li K, Wang Q, Gong C *et al*. Volatile fatty acids production from food waste: effects of pH, temperature, and organic loading rate. Bioresource Technol. 2013; 143:525-530
30. Juarez Garcia E, Agama Acevedo E, Sáyago Ayerdi SG, Rodríguez Ambriz SL, Bello Pérez LA. Composition, digestibility and application in breadmaking of banana flour. *Plant* Foods Hum. Nutr. 2006; 61:131-137. doi: 10.1007/s11130-006-0020-x
31. Kammerer D, Claus A, Carle R, Schieber A. Polyphenol screening of pomace from red and white grape varieties (*Vitis vinifera* L.) by HPLC-DAD-MS/MS. J. Agric. Food Chem. 2004; 52:4360-4367. doi: 10.1021 /jf049613b
32. Londoño L, Bolívar G, Aguilar C, Ramírez C. Optimización del proceso de fermentación sólida para la disminución de taninos condensados en el sorgo. *Agronomía Colombiana*. 2016; 1:545-548. doi: 10.15446/agron.colomb.sup.2016n1.58344
33. Maier T, Schieber A, Kammerer DR, Carle R. Residues of grape (*Vitis vinifera* L.) seed oil production as a valuable source of phenolic antioxidants. Food Chem. 2009; 112:551-559. doi:10.1016/j.foodchem. 2008.06.005
34. Memon MA. Integrated solid waste management based on the 3R approach. J Mater Cycles Waste. 2010; 12(1):30-40.
35. Micheloud NG, Buyatti MA, Gariglio NF. Response of some Citrus species to frost damage at the central area of Santa Fe, Argentina. Rev. Fac. Cienc. Agrar., Univ. Nac. Cuyo. 2016; 48:43-56.
36. Mirabella N, Castellani V, Sala S. Current options for the valorization of food manufacturing waste: a review. J Clean. Prod. 2014; 65:28-41. doi: 10.1016/j.jclepro. 2013.10.051
37. Mohapatra D, Mishra S, Sutar N. Banana and its by-product utilimsation: an overview. J Sci. Ind. Res. 2010; 69:323-329. Available online at: http://nopr. niscair.res. in /handle/123456789/8581
38. Müller O, Krawinkel M. Malnutrition and health in developing countries. *Can*. Med. Assoc. J. 2005; 173:2000-2003. doi: 10.1503/cmaj.050342
39. Parshetti GK, Chowdhury S, Balasubramanian R. Hydrothermal conversion of urban food waste to chars for removal of textile dyes from contaminated waters. Bioresource Technol. 2014; 161:310-319.
40. Pelissari FM, Sobral PJDA, Menegalli FC. Isolation and characterization of cellulose nanofibers from banana peels. Cellulose. 2014; 21:417-432. doi: 10.1007/s10570-013-0138-6
41. Pham TPT, Kaushik R, Parshetti GK, Mahmood R, Balasubramanian R. Food waste-to-energy conversion technologies: Current status and future directions. Waste Manage. 2015; 38:399-408.
42. Rezzadori K, Benedetti S, Amante ER. Proposals for the residues recovery: orange waste as raw material for new products. Food Bioprod. Process. 2012; 90:606-614. doi: 10.1016/j.fbp.2012.06.002
43. Riemer J, Kristoffersen M. Information on waste management practices. A proposed electronic framework.

European Environmental Agency, Copenhagen, Denmark, 1999.
44. Roussos PA. Scientia horticulturae phytochemicals and antioxidant capacity of orange (*Citrus sinensis* (l.) Osbeck cv. *Salustiana)* juice produced under organic and integrated farming system in Greece. Sci. Horticult. 2011; 129:253-258. doi: 10.1016/j.scienta.2011.03.040
45. Schieber A, Stintzing F, Carle R. By-products of plant food processing as a source of functional compounds—recent developments. Trends Food Sci. Technol. 2002; 12:401-413. doi: 10.1016/S0924-2244(02)00012-2
46. Serna Cock L, García Gonzales E, Torres León C. Agro-industrial potential of the mango peel based on its nutritional and functional properties. Food Rev. Int. 2016; 32:346-376. doi: 10.1080/87559129.2015.1094815
47. Sormoli ME, Langrish TAG. LWT - food science and technology spray drying bioactive orange-peel extracts produced by soxhlet extraction: use of WPI, antioxidant activity and moisture sorption isotherms. LWT Food Sci. Technol. 2016; 72:1-8. doi: 10.1016/j.lwt.2016.04.033
48. Tresina PS, Paulpriya K, Mohan VR, Jeeva S. Effect of gamma irradiation on the nutritional and antinutritional qualities of Vigna aconitifolia (Jacq.) Marechal: an underutilized food legume. Biocatal. Agric. Biotechnol. 2017; 10:30-37. doi: 10.1016/j.bcab.2017.02.002
49. Vandermeersch T, Alvarenga RAF, Ragaert P, Dewulf J. Environmental sustainability assessment of food waste valorization options. Resour Conserv Recy. 2014; 87:57-64.
50. Zeng J, Wang C, Chen X, Zang M, Yuan C, Wang X *et al*. The lycopene β-cyclase plays a significant role in provitamin a biosynthesis in wheat endosperm. BMC Plant Biol. 2015; 15:112. doi: 10.1186/s12870-015-0514-5
51. Zungur BA, Tomruk D, Koç M, Ertekin KF. Spray dried melon seed milk powder: physical, rheological and sensory properties. J Food Sci Technol. 2016; 53(5):2396-2404.