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RECENT TRENDS IN CITRUS (*CITRUS SPP.*) PEEL UTILIZATION: A REVIEW

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ABSTRACT

Citrus fruits are a widespread fruit crop and belong to the Rutaceae family. Citrus fruits include orange, tangerine, lime, lemon, sour orange and grapefruit. Citrus fruits are not only used for table purposes, but also in processing industries to make value added products such as marmalade, jams, juice, jellies, etc. which leads to the generation of waste into peel (rind) and seeds. The main fruit waste i.e. peels and seeds. The peel (skin) can be used for the preparation of sweets (candies). The use of citrus peel will not only improve the utility, but also serve to reduce the pollution load on the environment. It is nutritionally fortified with ascorbic acid, vitamin B, calcium, phosphorus, and other beneficial compounds essential for overall health. Citrus peels are enriched with pectin, cellulose and hemicelluloses, bioactive compounds and other compounds beneficial to health. The moisture content of the fresh citrus peels was 89.49% and the acidity in terms of citric acid was 0.40%. The ascorbic acid content was 87.49 mg / 100 g. The bitterness that prevails in citrus peels has limited its added value, demand and relevance. Limited work has been done on the processing and post-harvest management of citrus. In this article, we have presented and discussed the efforts of researchers around the world regarding waste use and value addition. In this review, we have tried to compile previous research information in an accurate way to improvise the benefits and full use of citrus waste.

Keywords: Candy, waste utilization, Bitterness removal, Value-Addition, Post-harvest processing

INTRODUCTION

Citrus fruits are grown all over the world. It continuously supplies in the financial state of many countries like USA, China, Brazil, India, Mexico, Spain, Greece and Iran. India is the fifth biggest citrus grower in all over the world, which includes mandarins, grapefruits, limes, lemons, oranges, mandarins, etc. In India, among the all fruits crops 10% of the entire area has been occupies by the Citrus. The citrus is 3rd fruit crop, followed by mango and banana. The citrus Group's production, including the Kinnow in India, was approximately 4.75 million tons, extracted over an area of 0.43 mha (Mahawar *et al.*, 2019). Kinnow was initially evolved at the University of California's Citrus Experiment Station in 1935. Kinnow was acquainted with India in the mid1940s. Kinnow is a cross breed between two cultivars of citrus fruits "King" *(Citrus nobilis)* and "Willow Leaf" (*Citrus deliciosa*). Predominantly Indian states like Punjab, Rajasthan, Haryana, Himachal Pradesh, Uttrakhand as well as Jammu and Kashmir with an absolute creation region of 0.33 mha and a production of 3.43 million tons produced Kinnow fruits. Punjab is the main state in the production of Kinnow. Punjab has 29% of the overall Kinnow production. Punjab produces 1.1 tons of fruit per year with an area of 0.048 mha. In Punjab, only Fazlika covers 55% of the cultivated area and contributes 58% of the total production. Citrus fruits, including all members of the citrus family, grown primarily for consumption as a table fruit and for making juices. However, this process produces 40 million tonnes of citrus waste once a year by industries involved in processing the juice that makes up 50 percent of the primary absolute organic product mass (Sharma *et al.*, 2017). Skin, seeds and pomace are evaluated to be valuable for a few purposes. Preparing citrus waste into value added products like pectin, flavonoids, fiber, cattle feed, and biofuels not only decreases the enormous volume of waste but also improve the well-being of the citrus processing industry (Mamma and Christakopoulos 2014). Citrus fruits are enrich with ascorbic acid, vitamin B complex, B-carotene, Ca, and phosphorus. Its surprising color, its unmistakable taste and its nutritional content provide an impetus for the preparation of beverages (Sogi and Singh 2001). Kinnow is also considered fresh and in processed form because of its quality features, especially Kinnow's tart taste (Rafiq *et al.*, 2018). Fruits of citrus group have a comparatively longer lifespan after harvest than other region (i.e. subtropical and tropical) fruits. Appropriate storage of citrus fruits over an increased period of time is extremely important for appropriate use during the surplus season (Sonkar *et al.*, 2008). During high production in winter, it is processed into juice by processing industries and fruit sellers (Rafiq *et al.*, 2018), which leads to the formation of peel. The most commercially produced citrus fruits account for around 50M tons (USDA, 2010). The 34% whose fruits were utilized to make juice and produced about 44% of the peel (Li *et al.*, 2006). Thus, consistently a tremendous measure of peel of citrus organic products is obtained. Citrus rind, can be a good sources of molasses, gelatin, and limes and are generally dried, blended in with dried mash, and sold as cattle feed (Bocco *et al.*, 1998). It is estimated that in the production of juice from Kinnow,

30% to 40% of the peel (albedo and flavedo), pomace (juice bag residue), lobes (membranes and grains) and seeds are expelled during the processing of citrus juice (Oberoi *et al.*, 2011). During this review, we tried to get an overview of the research information available on citrus waste treatment or citrus added value and the full use of citrus waste.

Botanical Characteristics of Citrus

The citrus fruit tree might be a little evergreen tree, 7.5 m tall and sometimes reaches in height to15 m tall. It's from China, initially. Mandarin has been grownup there for several years, however these days it's cultivated commercially to become the foremost planted flowering tree within the world within the tropics, semi-tropics, and a few heat temperate regions round the world (Nicolosi *et al.*, 2000; Ethler., 2011). Rugged, evergreen leaves of different sizes, beginning from curved to rectangular to oval, 6.5 to 15 cm long and 2.5 to 9.5 cm wide, happen in citrus organic products. Citrus natural products have white scented blossoms, detached or in whorls of about six, in regards to five cm over, with five petals and 20-25 stamens of yellow tone. Tiny, scented hermaphrodite flowers, white or purple, collect nectar for insect impregnation. The fruit, whichmay be spherical to oval, features a dimension of 6.5-9.5 cm and is orange or yellow in color. The fruit consists of 2 definite areas, anatomically speaking: the seed vessel, conjointly known as skin, peel or rind, and alsothe pulp and juice seed vessel or sac. The seed vessel that is formed from the outer flavedo or pericarp, consists mostly of parenchymal cells and cuticles. Aromatic terpenoids like valencene, terpene and alpha / beta sinsenal (Goudeau *et al.*, 2008; Sharon-Asa *et al.*, 2003) square measure fashioned by the submerged secretion glands. With its yellow, inexperienced or orange color, the flavedo is underneath the cuticle. Flavedo is really beautiful and delicate. With a spongy inner layer of mesophyll, flavedo is mostly colorless, modifying the character and thickness of all fruit innovations, properties that make peeling easier (Webber, 1989). The albedo is rich in flavonoids that offer a bitter taste if transferred into juice. The flesh or pulp of the fruit is often juicy and sweet and is available in 10 to 14 segments (although there are varieties without seeds) and in a variety of segments and color ranges, from yellow to orange to red. It is possible to test the ripened fruit as a hesperidium, a kind of berry with several

seeds. In many states, the high harvesting season for citrus fruits ranges from November (Jammu and Kashmir), December-January (Haryana), January (Rajasthan), January (Himachal Pradesh), also, January-February (Punjab), separately (Anonymous 2018). The orange of Seville can be a bitter orange used to make marmalade, liquor and wine (Ehsani *et al.*, 2007). Quality of peel is of particular factor in the economics of the orange production which are determined by the factors like shape, color, aroma, texture, and simple peeling relief the effects on the demand of the consumers. The Clementine Mandarin replaces nominal varieties in large parts because of its practical size and simple peeling (U.S. Citrus Genomics committee, 2003).

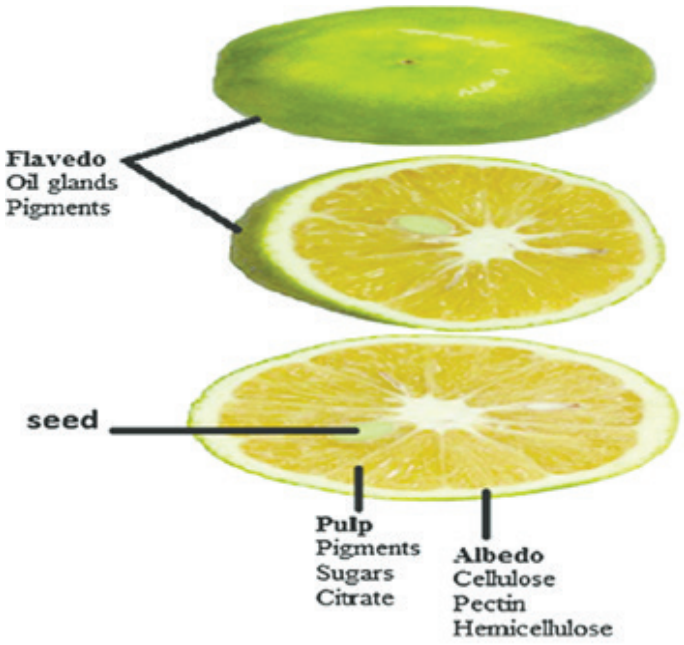


Figure1 Anatomy of edible fruit (**source:** Rafiq *et al.*, 2016).

Citrus Peel as a Source of Functional Ingredients and Health

Ascorbic acid, Retinol and other common flavonoid cell reinforcements (antioxidants), for example, alpha and beta carotenes, beta cryptoxanthin, zeaxanthin and lutein, mixes with cancer prevention agent properties, are very acceptable sources gotten from citrus organic products. In many sweets, jams and marmalades, candied peel, cakes, as well as cookies, citrus fruit and peel are included. The oil obtained from citrus peel, also in the form of flowers, leaves and twigs, is used in the perfume industry as an important oil for the production of perfumes. Citrus oil can also be used in cooking. Some biologically active and non-nutritious citrus fruit compounds are considered to be beneficial in minimizing the possibility of cancer, many chronic diseases such as arthritis, obesity, and coronary artery disease, such as phytochemical antioxidants, soluble and insoluble fibre (Crowell, 1999). Studies have shown that flavonoids are strong scavengers of hydroxyl radicals (Cillard and Cillard, 1988; Darmon *et al.*, 1990), that flavonoids may prevent hydroxyl and that they can quickly release an atom (Di Majo *et al.*, 2005, Tripoli *et al.,* 2007). As a very good reservoir of ascorbic acid, citrus fruits hold strong natural antioxidants, folic acid, fibre, and other bioactive components that prevent cancer and degenerative diseases, such as carotenoids and flavonoids (Ejaz *et al.*, 2006). Consuming vitamin C rich foods increases the immunity of the body against infectious agents. Naringin can be a good source of antioxidants, radical scavengers with anti-inflammatory properties, and system modulators that have great bioactive effects on human health. Citrus fruits neutralise free radicals that,

once formed close to DNA, encourage mutations. In mice irradiated by x-rays, this was documented. Often rich in iron, chlorine, manganese, zinc, sodium, phosphorus, iodine, calcium, vitamin B, potassium, pectin, beta-carotene, and amino acids and fibre, are citrus fruits. In one study, one citrus fruit was shown to contain approximately 170 phytonutrients and approximately 60 anti-tumor, anti-inflammatory, lumpy and antioxidant properties flavonoids. These properties contribute to the promotion of general health (Cha *et al.,* 2001). Citrus fruits are low in calories but high in fiber, pectin, which is extremely effective in overweight people. It has been shown that pectin is a mass laxative and also decreases blood cholesterol by binding to bile acids in the colon by decreasing its reabsorption into the colon (Walton *et al.,* 1945).

I. Flavonoids

Flavonoids are natural compounds (polyphenols) with a structure of phenylbenzopyrone defined by two rings of benzene (C6) bound by a linear chain of three atoms of carbon (C3) with one group in place. A class of glycosides, specifically hesperidin and naringin, includes citrus flavonoids (Li *et al.*, 2014). The rinds of all the edible parts of the fruit produce the largest concentrations of PMF in citrus fruits (Wang *et al.*, 2014; Manthey and Grohmann, 2001). Valuable anti-inflammatory anti-tumor properties remain in citrus flavonoid compounds. It is also a complementary feature of drug chemotherapy (Meiyanto and Hermawan, 2012). Several scientific studies have documented that many flavonoids, particularly flavanone glycosides and polymethoxy flavones, play an excellent role in protecting against fatal diseases such as cancer and atherogenesis (Tripoli *et al.*, 2007). In citrus fruits, three kinds of flavonoids are commonly found, and these flavonoids are flavanones, flavones, and flavonols. HPLC study of 9 extracts of flavedo showed that flavanone hesperidin glycoside is present in the most noteworthy fixations (83-234 mg/g body weight) in all concentrates (Londono-Londono *et al.*, 2010). The glycoside of flavanone naringin is found in the mandarin variety only.

II. Dietary Fibre

Dietary fibre is a combination of vegetable carbohydrate polymers, both oligosaccharides and polysaccharides, typically known as soluble fiber and insoluble fiber, e.g. cellulose, hemicelluloses, pectin-based substances, gums, resistant starch (Fuentes-Zaragoza *et al.*, 2010). The daily fiber particular is 21 to 25 g for each day for females and 30 to 38 g for every day for males (Food and Nutrition Commission, Drug Institute, 2001. Citrus peel, which is extracted from white, spongy and cellulosic fabrics, is considered a source of substantial amounts of pectin (Terpstra *et al.*, 2002). The utility of citrus peel assists with limiting plasma liver cholesterol, serum fatty oils, serum absolute cholesterol, liver complete lipids, and liver cholesterol (Terpstra *et al.*, 2002) and improving bowel function and hygiene(Chau *et al.*, 2005).

Source: (Rafiq *et al.*, 2016)

III. Phenolic Compounds

Phytochemicals, especially phenolic compounds in fruit and vegetables, are the essential bioactive compounds known for their health benefits. One of the most common fruit crops in the world, citrus, holds assortment of dynamic phytochemicals which are good for well-being. Additionally, a sufficient supply of ascorbic acid, vitamin B, potassium and gelatin is given for their phytochemical arrangement and commitment to wellbeing advancement, citrus species of different origins are evaluated (Proteggente *et al.*, 2003). Studies suggest that not only are plant phenolic compounds present in edible parts of the plant, but their existence has also been recorded in inedible parts of plants with many biological effects. Phytochemicals are the primary source of prevention of diseases for example cancer (Huang *et al.*, 2001), neurodegenerative diseases (Perry *et al.*, 2000), ageing (Hensley and Floyd, 2002). The Kinnow peel is enriched with ascorbic acid, carotene and polyphenolic antioxidants that are protective compounds (Anwar *et al.*, 2008).

Processing and Value Addition

Severe pre-harvest losses, insufficient environmental time, weak post-harvest management practices urged farmers to explore different aspects of the processing of citrus. A large quantity of waste is produced during its peak production period. Reasonable processing may help to reduce and even prolong the availability span of the supply glut. From the manufacturing point of view, the fruit is processed within particular form of products associated to juice such as squash, nectar, capable of serving (RTS), fermented products, juice powder, etc. and peel is processed in particular within the candy, peel powder, volatile oil and animal feed organisms. Probably the foremost high-flying and collectively acknowledged natural product drinks are particular sorts of citrus drinks (Alam *et al.*, 2019). A huge population around the world enjoys the sweet taste of citrus juices. However, it is a well-established incontrovertible truth that, because of the presence and initiation of harsh flavanone particles during handling, Kinnow juice goes through the strategy of postponed harshness. This has greatly influenced the reception and processing of its customers on a bussiness scale. Along these lines, so as to lessen this obstruction, debitteration of juice by different methodologies as a mixing with reasonable natural product/vegetable juices for the creation of nutritious RTS refreshments was viewed as an advantageous and practical option for effective use (Bhardwaj and Mukherjee 2011). In following segment, detailed narration on the possibilities of juice harshness and subsequently the efforts carried out to scale back harshness are quickly explained.

Debittering Technology

In the skin and seeds, the principal compounds

responsible for bitterness (naringin and limonin) are found. The deferred sharpness is because of the occurrence of limonin. A protein (limonoate D-ring lactone hydrolase, principally present in seeds) catalyzes the change of lactone from A-ring limonoate (a non-harsh antecedent) to severe limonine under acidic juice conditions, bringing about a deferred response. Following 3-4 hours of extraction, sharpness brings about juice. The best narinine content in the skin (0.422 mg/g) was accounted for by Premi *et al.*, (1994), trailed by juice (0.230 mg/g) and seeds (0.134 mg/g), however the limonine content in the seeds (9.50 mg). /g), followed by skin furthermore, crush (0.218 mg/g) (4.69mg/g). Defusing is also accomplished by absorbing bitter compounds from the resins of vinyl dodecylbenzene. AjaiPuri (1990) reported that the bitterness induced by flavanoids and limonoids, especially naringin and limonin, in lemon juice is reduced by interacting with lemon juice with a crosslinked copolymer adsorption resin, styrene-divinylbenzene. In their research, Singh *et al.*, (2009) allowed bitter Kinnow juice to be subjected to polymeric adsorbent resin layers and during storage to observe superior sensory properties. The content of naringin in juice is often managed using 1% glutaraldehyde coated chicken albumin by immobilizing naringinase, and thus the bitterness is often decreased to 68% (Puri *et al.*, 2011).

By-Product Utilization

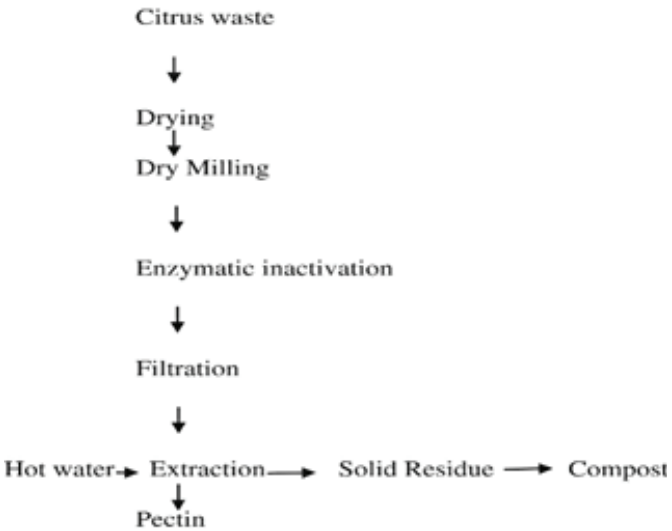
Since harshness is the primary recorded block in citrus production, analysts have investigated the choice of by-product use (rind and seeds) to enhance the general use of citrus. The key by-products of the processing industry are all citrus fruits, peel and pomace and that they together account for 55-60 percent of the fresh fruit. These by-products are also used as insecticide, fumigant and insect-pest repellent for the recovery and purification of volatile oil, seed oil, processing of pelletized dry peels as cattle feed, and citrus peel.

I. Pectin Production

Citrus rind is an extraordinary wellspring of gelatin which is dissolvable fiber and utilized in food industry as gelling specialist especially jam and jellies, in meds, desserts and as stabilizer in organic product juices (Sulieman, Khodari, and Salih, 2013). Exceptionally high measure of flavonoids present in citrus rind just as very harsh compound naringin present in albedo grants bitterness to the rind which should be eliminated before gelatin extraction (Puril, Kauri, Singhl, and Kanwa, 2008). For evacuation of these sharpness framing mixes, vacuum impregnation innovation is utilized in which albedo is vacuum infused with weakened naringinase alongside sugars and shading and flouring specialists which decreases the harshness by 81% and improves its adequacy (Baker and Wicker, 1996). Traditional strategy for gelatin extraction comprised of warming of citrus rind or apple pomace utilizing high temp water (60–100^0 C) and concurrent fermentation with mineral or natural acid. Mechanical technique for extraction of gelatin utilizes extraction of gelatin acid or hydrochloric sulfuric acid which creates huge measure of harmful material. As of late, various endeavors have been made to create elective extraction method including enzymatic extraction (Ptichkina, Markina, and Rumyantseva, 2008), microwave extraction (Fishman and Cooke, 2009), ultra-high weight (Guo *et al.*, 2012), ultrasound extraction (Zhang *et al.*, 2013) and moderate electric field (de Oliveira *et al.*, 2015).

II. Peel Utilization

Some 30-34 percent of the fruit peel is obtained as the key waste when processing citrus fruit into juice (Rafiq *et al.*, 2018). With the goal of reducing environmental risks, investigating the possible benefits of peels has been a vibrant area of research around the world. As recorded by Aggarwal and Sandhu (2003), Kinnow's skin is reported to have total solids (22.45 percent), TSS (12.50B), vitamin C (41.57 mg / 100 g), acidity (1.38 percent), total sugar (6.23 percent), sugar reduction (5.99 percent), ash (0.67 percent), carotenoids (13.65 mg / 100 g), b-carotene (7.43 mg / 100 g), pectin (1.85 percent) and fats (0.77 percent). In the skin of kinnow, which makes it ideal for the food and pharmaceutical industries. Babbar *et al.*, (2011) recorded cancer prevention agent movement (51.7 mg trolox same/ g-dry weight) and complete phenol (17.5 mg corrosive same/gdry weight). Kinnow's zest is said to be, as reported by Sidhu *et al.*, (2016), a high-end source of vitamin C (47.52 mg / 100 g), pectin (18.56 percent), naringin (358 lg / g) and limonine (60.75 lg / g). The peel has been used to extract polyphenolic compounds and to prepare value-added products as a possible source of phenolic mixes with useful, cell reinforcement and antimicrobial properties. For its molecular characterization. Puri *et al.,* (2011) acquired naringin from kinnow skin squander and utilized infrared spectroscopy. Another promising research by Safdar *et al.*, (2017), where kinnow 's skin was used with the ultrasonic assisted maceration and extraction technique to extract 11 phenolic compounds including five phenolic acids and 6 flavonoids.



Flow chart: - Pectin extraction process,

Source: - (Chavan *et al.*, 2018).

Table 1 Sources of dietary fiber (% dry matter)

Sources of fiber	Total dietary fiber content	Analytical methods	References
Lime peel	66.7–70.4	Enzymatic chemical technique: NSP + Klason lignin	
Orange peel	64.3	Enzymatic gravimetric technique	Figuerola *et al.,* (2005)
Grapefruit peel	44.2–62.6	Enzymatic gravimetric technique	Figuerola *et al.,* (2005)
Limon peel	60.1–68.3	Enzymatic gravimetric technique	Figuerola *et al.,* (2005)

III. Peel Powder

The standard parameters of the powder got through drying of kinnow rind utilizing mechanical and sunlight based drying procedures were looked at study by Sharma (2016). Better expanding index (23.78 ml water/g DM), water retention capacity (7.21 g water/g DM), solubility (37.33 percent), oil retention capacity (2.29 g oil/g DM), absolute phenols (0.510 g gallic acid/100 g DM), flavanoid content (18.80 mg reutin/100 g DM), complete cancer prevention agent limit (84.39 g ascorbic acid/100 g DM), powder acquired through mechanical drying individually. The relating sunlight based drying values were 21.94 ml water/g DM, 5.76 g water/g DM, 36.8%, 2.14 g oil/g DM, 0.488g gallic acid/100 g DM, 14.15 mg reutin/100 g DM, 80.97 g ascorbic corrosive/100 g DM respectively.

IV. Candied Peel

For the preparation of candies using varying proportions of sucrose and fructose, Aggarwal and Michael (2014) were used Kinnow for making candied peel and they found that in view of the organoleptic characteristics, sweets prepared with 25:75 (sucrose: fructose) were the best. Candied bark contains TSS (70B), vitamin C (11.7 mg / 100 g), acidity (0.18 percent), total sugar (42 percent) and limonine juice content (0.41 mg / ml) with overall acceptability (8.4).Kinnow peels contain 22.4% total solids, 12.50 degrees Brix TSS, 1.38% acidity, 13.6 mg / 100 g of carotenoids, 41.5 mg / 100 g of vitamin C, 0, 67% ash, 5.99% reducing sugar, 6.23% total sugars, 1.85% pectin, 7.43 mg / 100 g beta-carotene and 0.77% fat. It also contains 4.63 mg / 100 g of limonine (Premi *et al.*, 1994). Bhatlu *et al.,* (2014) attempted to use the skin for the preparation of candies using different treatments. The candies prepared with (70 degrees centigrade for 25 minutes cooked in a syrup solution at 60 degrees brix) achieved the best color and a color that is really considerably justifiable due to the caramelization of the sugar. Sogi and Singh (2001) prepared citrus peel candies using 300 brix syrup, cooked up to 800 brix. Sweets were good for increased TSS, acidity, and decreased vitamin C content. Sidhu *et al.*, (2016), using osmotic dehydration, prepared candy and kinnow bark powder and packaged in 4 diverse packaging materials, such as low density polyethylene (LDPE), high density polyethylene (HDPE), one laminate bag and a glass container. After 60 days of storage at room conditions (37-44^0 C, 56 percent RH) and refrigerated (4-6^0 C, 95 percent RH), the general acceptability of candies wrapped in HDPE bag and bark powder wrapped in laminate bag was greater.

V. Seed Oil

Juhaimi *et al.*, (2016) reported that due to their carboxylic acid composition and high tocopherol, kinnow seeds are considered a potential source of oil. In addition, because of its high protein, mineral and fiber content, it can likewise be utilized for consumable applications because of the creation of future Value-added products. It comprises of 98.6% carboxylic acid, which fuses pammitic acid (21.9%), octadecanoic acid (4.0%), linolic acid (43.7%), monounsaturated unsaturated fat (21.3%), arachidic acid (0.4%), cis-vaccenic acid (2.0%), omega 6 unsaturated fat (5.0%), elcosenoic acid (0-, 1%), behenic acid (0.2%) and 13.7 mg/kg of alpha-tocopherol (7.1 mg/kg) and c-tocopherol (6.6 mg/kg) containing tocopherol. Anwar *et al.*, (2008) recorded that iodine number 104.80 (g I/100 g of oil), refractive list (40 C), 1.465, explicit gravity (25 C) 0.927 mg/ml, saponification number 186 mg KOH/g of oil, unsaponifiable issue 0.48%, determined sum 1.30 mg KOH/g of oil, shading (red units) 2, 50, shading (yellow units) 20.00 had been documented from the extracted kinnow seed oil. As demonstrated by exact elimination conclusions at 232 and 270 nm (2.64 and 0.81, separately), p-anisidine list (3.15) and the peroxide number (2.40 mequiv/kg of oil) the oil displayed strong oxidative stability.

VI. Volatile Oil

Because of their solid antimicrobial, cancer prevention agent, and mitigating powers, volatile oils separated from citrus waste are helpful. Different potential applications are required, for example, food added substance fixings, deterioration additives, drugs and cosmeceuticals (Sharma *et al.*, 2017). The hydro-distillation method extracted volatile oil from new, ambient and oven-dried mandarin rind by Kamal *et al.*, (2011). From oven-dried (0.50 per cent) followed by ambient dried (0.48 per cent) and new (0.30 per cent) peel samples, the maximum amount of oil was collected. A sum of 16-27 chemical compound were perceived inside the strip volatile oils utilizing GC and GC/MS. The content of limonin was within the 64.1 to 71.1 percent range. Ahmed *et al.,* (2016) expressed that by chilly squeezing strategy followed by centrifugation (15,000 rpm at 28-30 C for 45 min), 42.73 percent of the aldehyde content, 2.21 of the number of acids and 23.70 of the number of esters are included, volatile oil extracted from kinnow peel.

VII. As Repellent

Because of the properties of volatile oil of citrus waste, is use as insect repellent. It is uncertain if repellents act in many arthropods via common mechanisms, and there is contradictory evidence within the literature. Ticks, for example, detect repellents on the tarsi of the primary pair of legs and insects on the antennae detect an analogous material. In addition, only grade variations are the affectability to an equivalent to an equal repellent between various groups, orders and families, no principal distinction is noted as form of response (Rutledge *et al.*, 1997). However, the level of differential sensitivity in mosquitoes was constant over several generations, suggesting a hereditary, inherited resistance basis (Rutledge *et al.*, 1985). Hairs on the dipteron antennae area unit sensitive to temperature and wetness. The repellent molecules act with the exteroception receptors of the female mosquito, thus suppressing the sense of smell. There is little or no knowledge of the receptors responsible for the repellent reactions in cockroaches. In death acknowledgment and death aversion (repellency) in cockroaches, monounsaturated fatty acid and linolic acid are demonstrated and the term 'necromone' has thusly been recommended to portray a compound responsible for this type of conduct (Rollo *et al.*, 1995).

VIII. As Insecticide

The physiological effects of essential oils on insects are little thought about, yet, treatments with totally unique essential oils or their parts offer ascent to manifestations that demonstrate a poison method of activity (Coats *et al.*, 1991; Kostyukovsky *et al.*, 2002). Linalool, a monoterpenoid, has been shown to perform on the nervous system and have an effect on the transport of ions and thus the discharge of acetylcholinesterase in insects (Re *et al.*, 2000). In line with medical specialty receptors, octopamine exerts its effects by interacting with a minimum of 2 teams that are known as octopamine-1 and octopamine-2 (Evans, 1981). The disruption of the octopamine mechanism leads to an entire breakdown of the nervous system in insects. The octopaminergic insect order is thus a bi-iorational insect management target (Figure 2). Kostyukovsky *et al.*, (2002) concluded that a potential competitive activation of octopaminergic receptors by volatile components of the oil was suggested. They observed significant effects in the abdominal epidermal tissue of *Helicoverpaarmigera* at low concentrations.

IX. As Fumigant

Syzygiumaromaticum, *Thymus vulgaris*, *Mentha,Cymbopogon*, *Cinnamomumverum*, *Salviarosmarinus*and *Origanum vulgare*, lime, sweet orange, lemon oils are familiar volatile oils with bioactivity, whether as an insecticide or a repellant. Bioactivity can vary widely due to chemical composition variability, but despite this variability, certain plant species are reliably bioactive, namely Thymus vulgaris, Origanum vulgare, Ocimumbasilicum, Salvia rosmarinus, and Mentha (Isman and Machial, 2006). It is important for insect control to understand how essential oils function as it offers valuable information on the most effective formulation, route of administration and management of resistance (Sim *et al.*, 2006). There is a fumigating effect of several herbal volatile oils and their segregates (Kim *et al.*, 2003). As a fumigant, lippia alba essential oil (Verma *et al.*, 2001) is well known. Some aromatic plants have the flexibility to combine chemicals that are fatal or offensive to many insect species once isolated, however nontoxic to mammals. Barriers to large-scale use in application are the physical properties of volatile oils like high boiling purpose, high relative molecular mass, and low vapor pressure (Daglish, 2006). There's an absence of awareness of single or multiple elements of volatile oils through action, contamination and leavings in food, while essential oils have the potential for small-scale treatments and for fumigating space (Rajendran and Sriranjini, 2008).

X. Animal Feed

In a stimulatory analysis, since the auto-oxidation and salt-induced lipid oxidation were decreased, the color retention and oxidation solidity of fresh minced goat meat using two percent mandarin skin powder with two percent salt was recorded (Devatkal and Naveena 2010). The effect of using mandarin and kinnow waste (KMW) in apportion on feed utilization and supplement usage in goats was investigated by Kour *et al.*, (2016). Because of its high calcium content, the inclusion of 40 percent KMW was found to broaden the Ca: P ratio, suggesting that adherence to the ratio should be carefully considered during feeding. No unfavorable outcome was there, as shown by the blood chemistry parameter, of the inclusion of Kinnow Mandarin waste in the ration on the prevalent well-being of the goats. The FAO (2017) stated that as part of the total mixed ration (TMR), Kinnow waste (KW) is frequently used raw or after sun drying. KW requires approx. 20 percent dry matter (DM) and 12 percent DM-based crude protein. At a ratio of 80:20 (on a fresh basis), fresh KW and wheat straw were mixed and ensiled for 42 days. 25 percent DM was the recommended amount of KW wheat straw silage in the TMR. The raw protein grain in the concentrated mixture can be fully replaced by the sun-dried, ground KW and can be collected from animals after mixing with Berseem hay (*Trifoliumalexandrium*) at a ratio of 50:50 to be fed on MS. The pods contain around 7% DM-based limonin and 1% has been incorporated into the commercial ration of broilers, which has significantly improved broiler performance.

CONCLUSION

Citrus Group's fruits are really important genus of Rutaceae family for food technology. Many value added products were prepared from citruses in the form of juices, marmalade, jellies, essential oils, seed oil, confectionery and sweets, and were suggested for overall

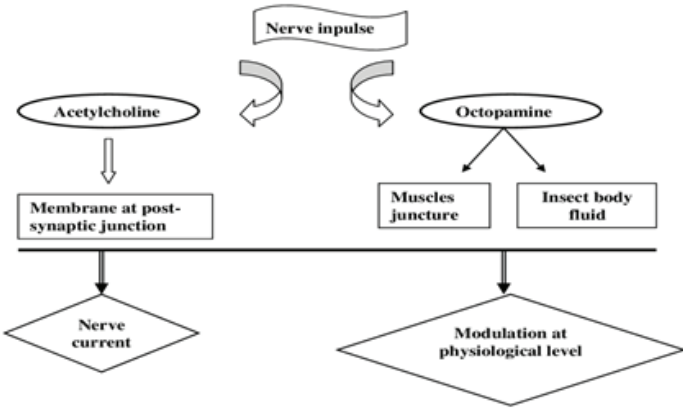


Figure 2 (Target sites in insects as possible toxic effects of essential oils mediated by neurotransmitters) **Source**: (Tripathi *et al.*, 2009).

good well-being. However, during its glut season output, a huge quantity of citrus lavish is obtained. Therefore, for its efficient use and to boost its availability during the false season, its satisfactory handling and added-value is required not just for its safeguarding and expanded storage life, but likewise as prepared reconstitution for utilization. Peel from citruses are often used for candy making and powder making. Candied peel, soft drinks, ice cream, chewing gum and confectionary goods are often flavored by the essential oils which are obtained from the citrus waste. By assembling a couple of value-added items, the large amount of waste produced during the high season cannot be handled and it would not be economically feasible. Therefore, it is worth investigating the assembly of some more alternative goods. In addition, the long-term use of citrus peel would also help reduce the problems caused by environmental pollution due to poor disposal of such residues. Therefore, further research work is needed to determine the bioaccessibility and the true advantages of these peel extracts are derived in vivo from citrus peel.

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