

## Nutritional and processing aspects of carrot (*Daucus carota*) - A review

Haq Raees-ul and Prasad K\*

Department of Food Engineering and Technology,  
S. L. I. E. T., Longowal-148106, Punjab, India  
(\*Email: dr\_k\_prasad@rediffmail.com)

### Abstract

Carrots are rich sources of carotene, ascorbic acid and are known as vitaminized food with moisture, protein, fat, carbohydrates, sugars and fiber. The carrots are the unique roots rich in carotenoids and have a characteristic flavor due to the presence of terpenoids and polyacetylenes. The mono terpenoids and sesquiterpenoids are the dominant terpenes and the falcarinol compounds constitute polyacetylenes. The harsh carrot flavor is masked to an acceptable limit by the late development of sugars in the root during growth. The variance in the pigments results in the formation of red, orange, yellow, purple, black and white roots. The pigments present in different colored roots have widespread medicinal properties towards human health, viz. lutein in the yellow carrots acts in the development of macular pigments essential for the normal eye functioning. Carrots are consumed either raw or cooked and processed into value added products viz. canned carrots, chips, candy, kheer, halwa, powder, juice, beverages, preserve and intermediate moisture products. Carrots have been already used for the preparation of soups, beverages, wine, stews, curries, pies and jams as blending agents. This paper revealed the nutritional and processing aspect of the carrot.

**Keywords:** Nutritional, processing, carotene, vitaminized, canned carrot.

Carrot is the diverse colored crop grown annually for the edible purpose belonging to *Apiaceae* (previously *Umbelliferae*) family grown throughout the world. The cultivation of the crop is favored during the months of September to November in tropical and subtropical regions whereas the temperate conditions offer a wide option of cultivation throughout the year. The crop needs a cool temperature for the production of seeds. Carrot is the lonely colored root crop with different types of pigments in the form of carotenoids and flavonoids that impart antioxidant properties in addition to color (Rodriguez-Amaya, 2001). The carrot family is recognized by the characteristic presence of the inflorescence that develops biannually whereas the root crop used as a source of food is harvested annually. The quality of the root depends mainly on the cortex core ratio that decreases upon maturity. The vascular system, xylem and phloem of the root are produced by the growth of secondary cambium towards inner side and outer side, respectively.

The bioactive components are mainly concentrated towards the exterior side of root (cortex) and the presence of handsome amount of the vitamins, bioactive components and minerals have led (Alasalvar *et al.*, 2001) to rank it among top ten fruits

and vegetables on the basis of nutrition. The carrot roots are the unique roots rich in carotenoids and have a characteristic flavor due to the presence of terpenoids and polyacetylenes. The mono terpenoids and sesquiterpenoids are the dominant terpenes and the falcarinol compounds constitute polyacetylenes. The harsh carrot flavor is masked to an acceptable limit by the late development of sugars in the root during growth. The variance in the pigments results in the formation of red, orange, yellow, purple, black and white roots (Haq and Prasad, 2014). The pigments present in different colored roots have widespread medicinal properties towards human health, viz. lutein in the yellow carrots acts in the development of macular pigments essential for the normal eye functioning (Chrong *et al.*, 2007). The lycopene present in tomatoes and the red varieties of carrot (Nicolle *et al.*, 2004) has a powerful singlet oxygen scavenging activity (de Mascio *et al.*, 1989) and its high levels in the blood plasma have an impact on lowering down the risk of various cancers (Giovannucci, 1999). The black or purple color of carrots is attributed to the presence of anthocyanins known to antioxidants (Chrong *et al.*, 2007).

The role of some carotenes towards their provitamin A has been extensively studied and still it

is a fact that the leading cause of premature death in children is deficiency of vitamin A (Maiani *et al.*, 2009). The human body is known to systematically convert the provitamin A carotenoids present in body into vitamin A (Britton, 1995). Considering the health and nutrition benefits of the carrot, its commercialization and industrialization in the form of different products is very important in fulfilling the nutrient requirements of the people particularly as a cheap source of vitamin A. The vitamin A conversion from  $\beta$ - carotene is very fast as compared to other carotenoids (Van Vliet *et al.*, 1996) and carrots are known to contribute 14% to 17% of the total vitamin A consumption (Heinonen *et al.*, 1990; Block 1994).

#### Nutritional characteristics of the crop

Carrots are rich sources of carotene, ascorbic acid and are known as vitaminized food with moisture, protein, fat, carbohydrates, sugars and fiber in the range of 84 to 95%, 0.6 to 2.0%, 0.2 to 0.7, 9.58 to 10.6%, 5.4 to 7.5% and 0.6 to 2.9%, respectively (Gill and Kataria, 1974; Holland *et al.*, 1991; Sharma and Caralli, 1998; Khanum *et al.*, 2000; Hashimoto and Nagayama, 2004). The total ash 15.32%, total protein 18.23% and total lipids 4.75%, as polyunsaturated acids (PUFA), monounsaturated acids (MUFA) and saturated fatty acids (SFA) with the levels of 921.7, 160.0 and 693.4 mg respectively, are present per 100gm of dehydrated organic grown carrot leaves with 100 days of development. The palmitic, steric, myristic, behenic and lignoceric acids are the major SFA, and the main MUFA include palmitoleic and oleic acids, and alpha- linolenic acid (ALA) and linoleic acid (LA) constituting the dominant PUFA in the carrot leaves (Leite *et al.*, 2011; de Almeida, 2009).

The chemical composition of carrot presented in Table1. Carrots contain carbohydrates 9.58 gm/100gm, protein 0.93 gm/100gm, fiber 2.80 gm/100gm, total sugars 4.74 gm/100gm of which 3.59gm/100gm is sucrose, 0.59 gm/100gm glucose and 0.55 gm/100gm fructose, vitamin C 5.9 mg/100gm, B<sub>1</sub> 0.07 mg/100gm, B<sub>2</sub> 0.06 mg/100gm, B<sub>3</sub> 0.93 mg/100gm, B<sub>6</sub> 0.138 mg/100gm,  $\beta$ - carotene 8285  $\mu$ gm/100 gm,  $\alpha$ - carotene 3477  $\mu$ gm/100 gm and Vitamin E 0.66 mg/100gm (USDA 2012). Khanum *et al.*,(2000) reported the presence of 1.65% of soluble dietary fiber and 4.1% insoluble dietary fiber in fresh carrots. The composition of protein, fat,

total dietary fiber, carbohydrates and  $\beta$ - carotene content in fresh carrot peels is 9.7 g/100g, 1.54 g/100g, 45.45 g/100g, 32.98 g/100g and 20.45 mg/100gm, respectively whereas its corresponding values upon dehydration at 60°C changed to 9.75 g/100g, 1.53 g/100g, 49.23 g/100g, 29.05 g/100g and 8.81 mg/100gm for unblanched samples (Chantaro *et al.*, 2008). The carrot powder contains moisture 8.78 %, protein 6.16 %, fat 2.43 % and crude fiber 24.66 % (Gazalli *et al.*, 2013).

The soluble solid content in carrot juice increased from 2.22 to 4.96% while as the pomace showed decrease in soluble solid content from 4.53 to 1.79% upon applying increased pressure (Haq *et al.*, 2013a). The tocopherol content of raw and frozen blanched carrots as reported by Chun *et al.*,(2006) is 0.87 mg/100gm and 0.71 mg/100gm. The dark orange variety of carrot contains very high amounts (26.55 mg/100gm) of carotenoids whereas orange and yellow varieties the range is 5.99 to 12.52 mg/100gm and 0.47-0.56 mg/100gm, respectively (Nicolle *et al.*, 2004). The purple colored carrots contain 93-168 mg/100gm of anthocyanins with cyanidin acylated with ferulic and coumaric acid as the major forms of pigments (Assous *et al.*, 2014; Algarra *et al.*, 2014). The presence of lutein in orange, purple, yellow and dark orange varieties of different cultivars of carrot ranges from 61-180 mg/100gm, 176-224 mg/100gm, 138-232 mg/100gm and 103 mg/100gm. The white cultivars were totally devoid of the pigments associated with coloring (Nicolle *et al.*, 2004).

The red variety of the carrot root has been reported to contain higher concentrations of lycopene (10 mg/100g) even higher than tomatoes (Grassmann *et al.*, 2007) and almost absent in  $\alpha$ - carotene (Koch and Godman, 2005). The study based on five European countries showed ingestion of carrots in the diet contributed 60-90 % of total  $\beta$ -carotene taken by the humans (Maiani *et al.*, 2009). The total phenolics in different cultivars of carrots ranged from 10.5 mg/100gm to 267.1 mg/100gm with the highest values present in the purple colored roots (Leja *et al.*, 2013). Chlorogenic acid is the major phenolic present in carrots (Clifford, 1999) and the purple varieties have been shown to contain it in large quantities about 10 times greater than other color roots (Alasalvar *et al.*, 2001).

### Carrot Products

Carrots are consumed either raw or cooked and processed into value added products viz. canned carrots, chips, candy, kheer, halwa, powder, juice, beverages, preserve and intermediate moisture products. Carrots have been already used for the preparation of soups, beverages, wine, stews, curries, pies and jams as blending agents as reported by Lingappa and Naik (1997).

### Processed Carrot Products

To preserve the color and quality, carrots (sliced/diced/whole) are blanched with water or steam to enable enzyme inactivation, responsible for the quality deterioration of processed carrots and can be carried under high temperature (Shivhare *et al.*, 2009) or low temperature (Mohammed and Hussein, 1994). Blanching at 87.5°C for short time results in poor color and quality than at 71°C for 3 to 6 minutes which provided better quality of canned product (Ambadan, 1971). Thermal degradation of  $\beta$ - carotene during blanching causes decrease in its content (Chantaro *et al.*, 2008). Negi and Roy (2001) observed lower ascorbic acid and higher  $\beta$ - carotene in blanched carrots than the unblanched ones after the drying whereas the non-enzymatic browning was unaffected by blanching. There was maximum retention of  $\beta$ - carotene in extrusion process when it was incorporated at the end of the extruder, preventing oxidative/thermal degradation (Emin *et al.*, 2012) and various studies have reported that steam blanching increased total carotenoid content (Sulaeman *et al.* 2001; Puuponen-Pimia *et al.*, 2003).

**Juice:** Fruit and vegetable juices are rich sources of vitamins, minerals and fibers with low energy value that has become a regular part of diet for many people throughout the world (Janve *et al.*, 2014). The increase in consumer awareness has led to an increase in the consumption of fruit juices in recent years as they are healthy and nutritious than their caffeine-containing counterparts such as tea, coffee and carbonated drinks (Sin *et al.*, 2006; Kaur *et al.*, 2009; Schieber *et al.*, 2001). Carrot juice as a popular  $\alpha$ - and  $\beta$ - carotene rich (Chen *et al.*, 1995; Chen and Tang, 1998) natural, healthy and nutritional drink is gaining importance due to its significant health promoting properties and is extracted by various processes viz. centrifugal basket, centrifugal pulp-ejecting, twin gear, two step triturator and hydraulic press, and mastication juice extractors (Donaldson,

1998). The conventional carrot juice extractors results in poor juice yield due to the harder texture of the root, that can be increased by enzymes or heat processing to soften the tissue (Tingtin Ma *et al.*, 2013) but can decrease the quality of the juice by imparting the cooked flavor (Siliha, 1995; Furui *et al.*, 1995). Production of cloud stable juices from carrots is enhanced by the heat treatment before extraction (Sims *et al.*, 1993).

The juice extracted by the conventional juicers is cloudy due to the presence of insoluble matter that poses storage and solid liquid separation problems viz. formation of sediments in the juice that reduces the acceptability by some consumers (Giacomo and Taglieri, 2009). The hydraulic pressed juice is clarified with minimum insoluble solids that prevents the sedimentation and pulp reduction (Bazhal *et al.*, 2001) resulting in increasing the cloud stability of juice (Sinchaipanit *et al.*, 2007). The juice production from carrots is presented in Fig. 1. The increase in cortex core ratio affects the juice yield and the hydraulic pressing of carrot shows an increasing trend in juice yield with the employment very high pressures (Fig. 2) but resulted in the formation of low quality pomace (Haq, *et al.* 2013a). Extraction of the juice using a hydraulic press has a potent advantage of controlling the percentage of extraction from the tissue that can be employed for the development of value added products from pomace with specific percentage of components (juice and solid matter). This juice extracted by hydraulic pressing is clarified with minimum insoluble solids and can be blended with any other fruit juice. Turbidity of the juice should remain homogeneously distributed, without significant clarification of the upper part of the juice bottle, during the usual one-year shelf life. The pomace recovered by the hydraulic pressing retains more carotenoids than other processes that can be used for fortification and development of value products. The fresh and thermally untreated carrot juice should be consumed within 1-2 days, as it can serve as a nutrient broth for microbes.

Nguyen-The and Carlin (1994) reported that the micro organisms present in the carrot juice are similar to the raw carrots and lactic acid bacteria are responsible for the spoilage of sliced and shredded carrots. Storage of carrot juice did not show any increase in shelf life under modified atmospheres of

nitrogen or helium while as carbonating the juice and decreasing the pH<4.0 can prolong the shelf life (Alklint *et al.*, 2004). The untreated and pasteurized carrot juices were evaluated for their rheological behavior and influence of temperature on their physio-chemical properties with untreated and pasteurized juice showing Newtonian and pseudoplastic behavior respectively (Vandresen, 2009). There has been improvement in the color of carrot juices extracted from blanched carrots (Zhou *et al.*, 2009) and acidification of the juice causes cloud particle coagulation that can be avoided by acidification of the mash before juice extraction (Martin *et al.*, 2003). Carrot juice extracted from organic carrots has been shown to possess high content of vitamin C, caffeic acid and lutein than the conventionally grown carrot (Hallmann *et al.*, 2011). Tingting Ma *et al.*, (2013) reported that antioxidant activity of polyphenols in carrot juices is retained after processing which enables carrot juices to serve as natural antioxidants for human nutrition and health.

Carrot juice and yoghurt blends will form a food rich in protein, fat, vitamins and minerals taking it to near complete. The aflatoxins produced by the *Aspergillus* are carcinogenic and mutagenic that remains stable during the processing and storage of yoghurt (Hassanin, 1999; Roy *et al.* 1996; Mishra and Das, 2003). Blending of carrot juice with yoghurt slowed down the yeast, mould and Coliform growth without affecting significantly the growth of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. The inhibition rate increased gradually with increased carrot juice (5 to 20%) blending as reported by Salwa *et al.*, (2004) whereas Cliff *et al.*, (2013) observed increase in color, carrot flavor, creaminess and chalkiness in carrot yoghurt with increasing juice levels. The use of carrot Kanji significantly showed inhibitory activity towards *Staphylococcus aureus* due to bacteriocins produced by the *Lactobacilli* species and can be used as a probiotic (Sowami *et al.*, 2012).

The blending of carrot juice with different fruits and vegetables has been reported by different studies to improve the acceptability and overall nutritional characteristics (Profir and Vizireanu, 2013; Karangwa *et al.*, 2010). The therapeutic properties in addition to nutritive value have significantly resulted in the increased consumption of yoghurt worldwide that are provided mainly by the live Lactic acid

bacteria associated with enhancement of lactose digestion, immune system and protein assimilation plus decrease in cancer along with blood cholesterol (Karagul *et al.*, 2004; Marona and Pedrigo, 2004).

**Dehydration:** Drying is one of the oldest, useful and important methods of food preservation and many shelf stable products have been developed from fresh fruits and vegetables by various drying methods (Wang, 2000; Roberts *et al.*, 2008). Dehydrated carrots are used in instant soups or meals and developing oil free, healthy snack food (Lin *et al.*, 1998). Koca *et al.* (2007) studied kinetics of color degradation and non-enzymatic browning at varying temperatures (27 to 57°C) during blanched and unblanched dehydrated. Dehydrated carrot slices can be stored upto 6 months under optimum conditions with acceptable quality (Sra *et al.*, 2011). Slinde *et al.*, (1993) reported the process of producing deep fried carrot chips after the lactic acid fermentation which considerably lowers down the sugar levels of carrot slices allowing them to be deep fried without being burnt. The drying characteristics of carrots were investigated for different slice thickness and various drying air conditions, namely temperature, air velocity and relative humidity by Kaya *et al.*, (2009).

The drying temperatures below 70°C and 90°C have stability for  $\beta$ -carotene and lycopene, respectively degradation during the dehydration process (Regier *et al.*, 2005). The porous and less shrunken product is obtained by freeze drying with better taste retention and better retention of flavor,  $\beta$ -carotene and rehydration properties than air dried products (Kalra *et al.*, 1987; Prakash *et al.*, 2004). Manjunatha *et al.*, (2003) formulated a kheer mix with dried carrot, skim milk and sugar. The dehydration of carrots to 10% moisture and then finishing dehydration by transferring to finishing bins at 44.4°C was reported by Cruess (1997). The solar cabinet drier retained the least quantities of  $\beta$ -carotene content during dehydration of carrots as compared to fluidized bed and microwave drying (Prakash *et al.*, 2004). Loss of  $\beta$ -carotene in shreds followed by powder and chops during dehydration of carrot and the three months of storage were evaluated by Suman and Kumari (2002). Soy milk the alternate of the milk for the people who suffer from lactose intolerance is a highly nutritious drink with proteins, fats, carbohydrates, vitamins and minerals in rich quantities.

The fortification of the soy milk with dehydrated whole carrot powder (Fig. 3) has been reported recently by Madukwe *et al.*, (2013) that increased its fiber, beta carotene, vitamin c and mineral content. The relative high cost of the supplementary foods (used to improve the malnutrition in children) limits its use for poor children and to fill this gap by development of low cost supplement from carrot powder, papaya powder, black gram powder and groundnut powder has been attempted by Singh and Katiyar (2014). The vitamin A micronutrient deficiency is common in children below the age group of five and can be countered by fortifying it in products preferred by children. Similar thought of work has been done by Jain *et al.*, (2012) using carrot powder along with other ingredients to develop a nutritionally sound extruded snack product for the specific target group.

**Preserve:** Carrot preserve is prepared by boiling the carrot slices in sugar syrup until the total soluble solids of the product reaches 55-70% (Crues, 1997; Lal *et al.*, 1986). Preserve is an intermediate moisture food and involves osmotic concentration. Carrot preserve has been made by pretreating boiled carrots with 40°Brix for 12 hrs, followed by dipping in 60°Brix for the same time and finally in the 70°Brix concentrations with sample to syrup ratio as 1:4 (Singh *et al.*, 1999) whereas Sethi and Anand (1982) used a solution with sugar, water, glycol, acid and preservative for the preparation of intermediate moisture carrot slices.

**Candy:** Candy is a sweet food prepared by impregnating the sugar syrup with fruits and vegetables followed by the draining the excessive syrup and drying the product to a shelf stable state. Durrani *et al.*, (2011) prepared honey based carrot candy with three combinations of carrot and honey as T1 (1000g + 750g), T2 (1000g + 1000g) and T3 (1000g + 1250g) with T1 producing the better candy based on sensory attributes in glass and LDPE packaging material. Madan and Dhawan (2005) also reported the development of carrot candies in sugar, sugar coconut powder and in jaggery with 13.3, 13.2 and 11.2 mg/100gm of  $\beta$ -carotene content respectively.

**Jam:** Jam is a product made from pulp and boiling it with the required quantity of sugar in presence of pectin at a low pH until the formation of gel like structure. The jam manufacture is favored mainly for

fruits but can be extended to some vegetables like carrot, tomato, cucumber, pumpkin and sweet potato (European Commission, 2001). The most common method of jam making (Fig. 4) involves heat treatment in boiling water to carrot slices for about 30 min to soften the slices. The development of puree by homogenizing the slices in food processor for couple of minutes follows with the addition of required quantity of sugar and cooking for about 15 min to a gel like consistency. The mild method (Fig. 4) uses lemon juice and pectin as additional ingredients required for the proper gelation of the product. The washed carrots are processed through a juicer to obtain juice and pomace that are subsequently mixed together with addition of citrus juice to prevent carotene oxidation. The mixture is cooked with sucrose and finally added with pectin to the gel consistency. The mild method of production is preferable as it retains more phenolics, carotene, color and potassium than the common method of jam production from commercial, purple, orange and yellow colored roots (Renna *et al.*, 2013). The juice from the black carrot has been used as for the enhancement of color for strawberry jams as reported by Kirca *et al.*, (2007).

#### Processed Carrot by-Products

Carrot pomace, the by-product of carrot juice extraction process, is produced in thousands of tons in the industry that poses environmental problems and to decrease the problem new technologies need to be developed for efficient by-product utilization that will decrease the environmental load (Alklint, 2004). Carrot pomace has good residual amount of all the vitamins, minerals and dietary fiber. Despite having the potential for processing and value addition, the commercial exploitation of carrot has not been taken so far in the developing countries and the proper utilization of carrot pomace left over after juice extraction has not been found. The dehydrated carrot (whole and pomace) fractions can be used in the development of beverages by altering the particle size and coarser particles have the potential to serve as prebiotic biomaterial (Haq *et al.*, 2013b).

The carrot pomace is rich source of insoluble fiber-rich fraction (IFRF) in addition to vitamins and minerals that can be used for fortification of defatted soyflour biscuits with dehydrated carrot pomace has already been reported

(Gayas, 2012). The insoluble fiber-rich fraction present in carrot pomace is mainly composed of pectic polysaccharides, hemicellulose, and cellulose (Chau *et al.*, 2004) and has been used in the production of fiber rich biscuits (Baljeet *et al.*, 2014) and rice based extruded product (Dar *et al.*, 2014). The Fig. 3 maps the process for the production of carrot powder fractions. Kumar and Kumar (2011) incorporated carrot pomace up to 6% level for the development of wheat flour based cookies as a source of vitamins and dietary fiber. The increased hydration properties of carrot pomace powder increased dough stability and dough development time and decreased loaf volume suited for the development of wheat rolls upto a level of 3% (Kohajdova *et al.*, 2012). The range of ascorbic acid and  $\beta$ - carotene in dried pomace is in the range of 13.53 to 22.95 and 9.87 to 11.57 mg/100gm respectively (Upadhyay *et al.*, 2008). Singh *et al.*,(2006) utilized the carrot pomace for the preparation of gazrella by rehydrating pomace in hot boiling water for 15 minutes followed by cooking and addition of condensed milk/khoa. Carrot pulp waste exhibited high antioxidant activity than the beet root waste as reported by Shyamala and Jamuna (2010).

#### **Other value added products from carrot**

The quality is the limiting parameter for the utilization of carrots as “carrot sticks” widely used in restaurants. The shelf life of the sticks gradually decreases to 2 weeks from 4 to 6 weeks, the latter is the case with fresh carrots. Bruemmer (1987) demonstrated the synergistic use of antimicrobials, antioxidants, cellular components and vacuum packaging in enhancing the storage period of the carrot sticks.

Gazrella or sweet meat is a carrot based sweet Indian product made from carrot shreds and condensed milk along with cane sugar and moderately frying in hydrogenated oil (Basantpureet *et al.*, 2003). Hatan and Malhotra (2012) observed that gazrella prepared from carrot shreds treated with 35g sucrose per 100g shreds followed by drying has highest sensory quality.

Carrot halwa (*gajarkahalwa*) is a sweet dish very popular in the northern India and is prepared by cooking shredded carrots in hydrogenated oil along with sugar, milk powder and dry fruits (Sampathu *et*

*al.*, 1981). Mansoor *et al.*,(2013) developed carrot dessert mix from dehydrated blanched carrots with the addition of powdered sugar, milk powder, coconut powder and dry fruits. The mix is available commercially by the brand name of “Kanwal Carrot Dessert” and prepared by mixing with three times water to fully rehydrate the product following by addition of clarified butter. Suman and Kumari (2002) utilized the dehydrated carrot shreds and powder for the preparation of curry, halwa and biscuits. The sensory quality scores of carrot kheer mix and carrot-milk cake developed by Manjunatha *et al.*, (2003) and Gupta *et al.*, (2005) respectively, decreased during the storage.

Chaturvedi *et al.*, (2013) used radiation for the development of shelf stable intermediate moisture carrot shreds with 52% of  $\beta$ - carotene, 59.8% of total carotene and 25.3% of Vitamin C retention than tray dried intermediate moisture carrot shreds. The property of carrot juice towards increasing the shelf life and acceptability of yoghurt led to the development of blended carrot yoghurt. The homogenized milk with added starter is supplemented with different concentrations (3 to 15%) of carrot juice and incubated at 45°C for a period of 7 hours and stored at refrigerated temperatures (Salwa *et al.*, 2004).

#### **Conclusion**

The relative stability of the  $\beta$ - carotene during heating below 70°C extends the utilization of the carrot as a dried product in various products as a value addition. There is a need for commercial utilization of the carrots in developing countries and can serve as a possible alternative of vitamin A ingestion in the body. The provitamin A activity of certain carotenoids along with their antioxidant properties further supports the cause of commercial utilization of the root. The production of functional foods with a range of health benefits can be developed from carrots due to the appreciable presence of compounds in the roots.

**Table 1: Composition of Carrot root**

Parameter	Component	Composition	Availability	References
Proximate analysis	Moisture	86-88.8		
	Carbohydrate	6-10.6	gm/ 100gm	Gopalan, <i>et al.</i> ,(1991)
	Protein	0.7-1.0		Holland <i>et al.</i> ,(1991)
	Fat	0.2-0.5		Thomas (2008)
Fiber	1.2-2.4			
Phenolics	Anthocyanins	1.5-126	mg/100gm	Montilla <i>et al.</i> ,(2011) Li <i>et al.</i> ,(2012) Algarra <i>et al.</i> ,(2014)
	Polyacetylenes	Falcarinol Falcarnidiol Falcarni-acetate	359-1900 154-18000 77-140	$\mu\text{g}/100\text{gm}$ Rawson <i>et al.</i> ,(2010) Pinheiro-Wenzig <i>et al.</i> ,(2009) Acworth <i>et al.</i> 2011.
Minerals	Magnesium	9-12	mg/100gm	Holland <i>et al.</i> 1991. Thomas 2008. USDA 2012. Gopalan, <i>et al.</i> 1991
	Phosphorus	25-280		
	Potassium	240-320		
	Sodium	40-69		
Terpenoids	Calcium	2-80		
	$\alpha$ -carotene	2425-3767	$\mu\text{g}/100\text{gm}$	Hart and Scott 1994.
	$\beta$ -carotene	6905-10800		Holland <i>et al.</i> 1991.
	Lutein	149-313		Granado <i>et al.</i> 1992.
	Lycopene	10000		Grassman <i>et al.</i> 2007
	Monoterpenes	2.04-16.7	ppm	Alasalvar <i>et al.</i> 1999.
Sesquiterpenes	1.49-4.83			

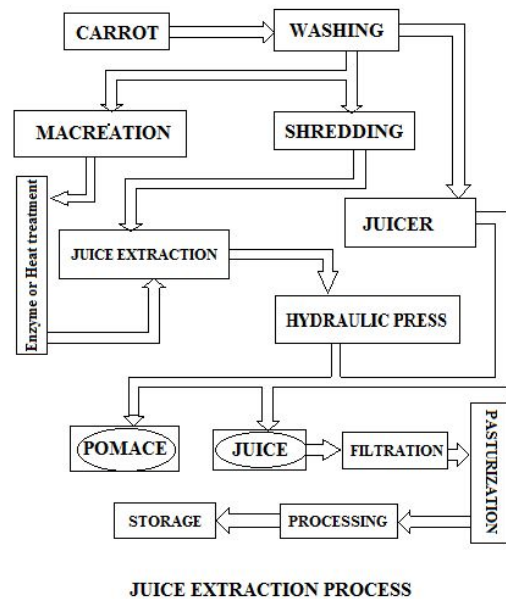


Fig. 1: Process depicting extraction of carrot juice

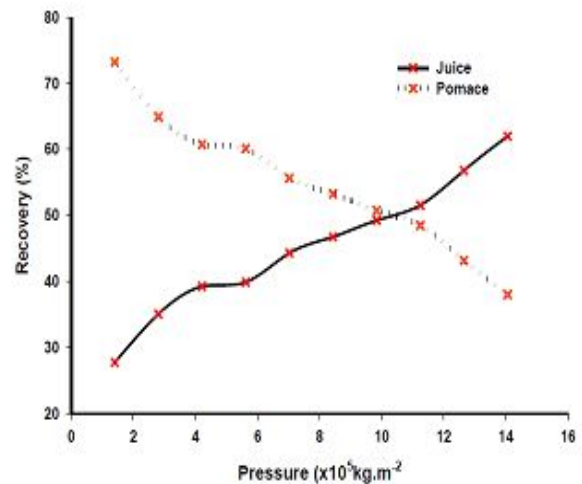
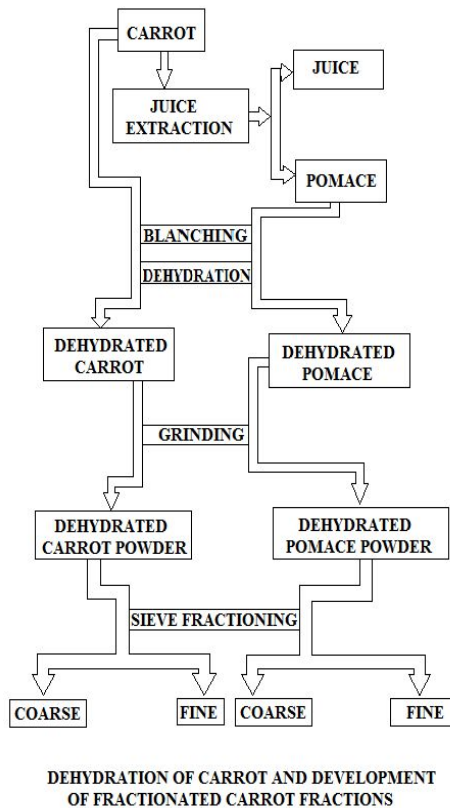
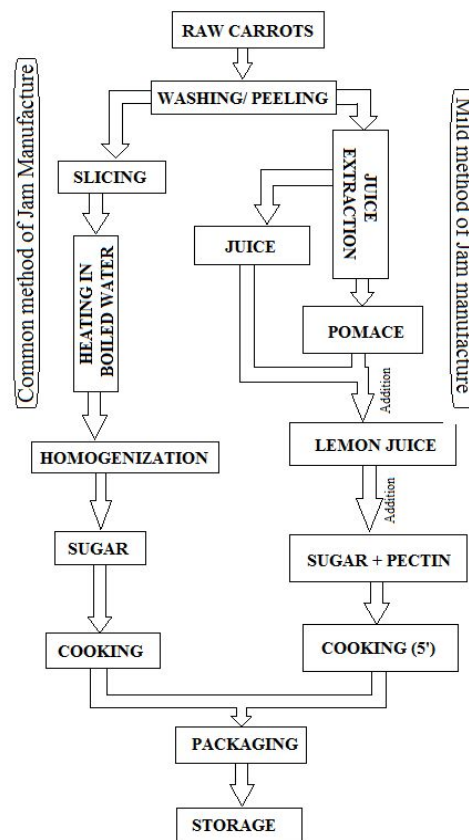


Fig. 2 Effect of hydraulic press on the extraction yield of juice and pomace.



**Fig. 3 Mapping the production of fractionated carrot powder fractions**



**Fig. 4 Process manufacture of carrot jam**

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