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Carotenoids: Source of Food Colour and its Benefits

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ABSTRACT

Food colour or food additives are widely used in a food industries, to enhance the organoleptic (colour, flavour, appurtenance, taste and texture) quality to food. To protect and increase the shelf life of food, additives are incorporated into it, normally food additive or food colorant from synthetic origin are mostly used in food industry. Colours like yellow, orange, red, green etc. are highly preferred in soft drinks, candies, bakery products etc. which carries some adverse effects on human health such as allergic reactions, hyperactivity, carcinoma etc. An alternative is to use natural food colorant/ additive from natural sources in the form of carotenoids which can be incorporated into food with medicinal value or health benefits.

KEYWORDS: *carotene, food colours, food additive, health benefits*

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I. INTRODUCTION

Food colours are pigment, dyes or in any other form of a compound which are incorporated in food products to make it look more attractive and for the colourful appurtenance, which makes the consumer more attractive and turn their attention towards the food products and gives a tempting feel. These colouring compounds are used in two ways both as synthetic and in natural form [1].The usage of natural food colour in food doesn't carry any harmful effect to human health, but still they are less stable, attractiveness will be less, cost effective and it is difficult to find the exact shade and variety of shades of colour which are required to add in food products. Due to which synthetic food colours are cheap, easy blending, uniform colours and in different shades are available so, many industries prefer synthetic food colours in food products [2]. But these synthetic colours have undesirable taste and harmful effect to humans like allergic reactions, lower the haemoglobin count in body etc., so consumers are moving towards the naturally derived colours in food because of their health promoting properties and as an alternate solution for the usage of synthetic colours in food products [3].

With the advent of processed foods in the second half of the 20th century, many more additives have been introduced, both natural and artificial origin. Additives mostly are synthetic chemicals and now present day consumers are turning their attention towardsnatural ingredients and biobased additive s due to adverse effects caused by some chemical s [4]. Natural colour are extracted from various origins like edible plant, fruits, vegetables, seeds, root and pigments like carotenoids, chlorophyll etc. [5]. Likewise carotenoids are the pigments which are found naturally from plant and also in sea food,

and with high concentration it is found in fruits and vegetables. The most widely used carotenoids in food industry are β-carotene, lycopene, lutein, zeaxanthin, β-cryptoxanthin, and α-carotene [6]. Therefore, plant- derived substances are gaining a foothold as preservatives, colorants, flavours and even as antibacterial agents [7].

COLOURS FROM SYNTHETIC ORIGIN

. Synthetic food colours are usually water-soluble chemical substances which have been made in industries and can be used in foods without any further processing. Ponceau 4R, Carmoisine, Erythrosine, Tartrazine, Sunset Yellow FCF are the examples of synthetic food colours [8]. Synthetic colours can be easily produced and available in low cost, so widely they are used in food in the form of coating which are highly concentrated in form. Synthetic dyes are also used in food some of them are azo dye, benzidine, aniline, and napthol dye.According to the Central Committee for Food Standard (CCFS) certain food colours like Amaranth and Fast red E were banned, recommended to reduce the usage of synthetic food colour they shows the toxic effect to humans [9]. Some synthetic flavouring additive are used in food like Benz aldehyde for replacing the cherry and almond flavour and monosodium glutamate it is used as flavouring agent in many food products [4].

EFFECT OF SYNTHETIC FOOD COLOURS

The evaluation of risk to human health, the Expert Committee on Food Additives (JECFA) is an independent, international expert scientific group which is conducted by the joint FAO/WHO and it is responsible for assessing the risks to human health on consumption of synthetic food colour or food additives. Direct food additive are also added to food for its functional purpose like colouring agent, firming agent, anticaking agent etc., these type of additive are also used in diary industry. One such direct additive is aluminium, in recent years the risk and usage of aluminium leads to Alzheimer's disease and it showed that proportion of elderly people suffering from it are large [10]. The other type of additives is sodium commonly used in meat-based products like ham and bacon etc., which gives red colour to the food. It has the increase in chance of headaches. Benzoic acid is used in food items like sauces, margarine, cheese and in soft drinks [11]. It damages the CNS and cause hypertension, asthma and increased hyper activity in the children. Sodium thiosulfate and sulphites are one of artificial preservative added to food to prevent the growth of microbe, it causes some allergic reactions, kidney diseases, high blood pressure, heart problems, urinary problems etc. likewise consuming food added with sodium citrate, it tends to increase the intensity and severity of the disease [12]. Additives like oxalic acid when consumed in high dosage act like poison and forms kidney stones by combining with the calcium present in the body. It increases the chances of dystrophic calcification. Regular intake of processed food treated with food additives with increase in concentrationleads to the risk and causes many side effects [13]. The use of certain synthetic food colours has been banned due to their toxicity, which was observed during animal studies. For example, metanil yellow consumption will lead to some of the degenerative changes in stomach, rectum, kidney, liver etc., rhodamine B was shown to be haemolysis of red blood cells and it also show some adverse effect on immune system [14].

ALTERNATIVE FOR SYNTHETIC COLOURS:

Synthetic or certified food colours are widely used in food industries as a colouring agent, which give brighter, uniformity of many colour shades, less expensive and easily available. In order to overcome these adverse effect on synthetic colour, it is better to choose natural colour which they bioavailability of natural compound in carotenoid, chlorophyll pigments etc. [15]. Plant based carotenoids nearly possess red, orange, yellow colour pigments, found naturally in many flowers, leaves, root and bark. These pigments are lipid soluble and found embedded in chloroplast and chromoplast. The coloured compounds are masked by chlorophyll in photosynthetic tissue and during late stage of plant development, theses pigment contribute bright colours [16]. Likewise these natural colours can also be extracted from microbial origin as a microbial pigments. It can be extracted from bacteria, algae and fungi and used as a source of food colour. These derived pigments are stable to light, heat and possess anti-cancer and pro-vitamin A activity. These pigments can be produced in control condition in very less time [17].

Carotenoids are a group of phytochemicals from which yellow, orange, red and violet colours can be obtained from source like fruits and flowers which can be used as a natural food colorant and having an important role in maintain good health for humans without adverse sight effect. Anthocyanin pigment is normally used as a food colour extracted from red cabbage. Thus this dye is

used as a pH indicator in many pharma industries during formulations, in acidic condition it gives original red colour, in base pH it changes to deep blue [18]. The navel orange extracted from β-Citraurin which is found in *Citrus sinensis*(a sweet orange) is a type of carotenoid pigment found only in orange peel. Flavonoid is a type of phytochemical found in many flowers, fruits and vegetables. Indigoid is one of the example found in beetroot. Curcumin is the principal colour present in the rhizome of the turmeric plant (*Curcuma longa*). This imparts both flavour and colour to a food product. Safflower (*Carthamus tinctorius L.*) formerly used as a red dyestuff for textilesand now currently used as a minor colorant by the food industry [19].

CAROTENOIDS

Nearly there are about 600 compounds that belong to carotenoid group, classified as carotenes, β- carotene, lycopene, astaxanthin, lutein, zeaaxanthin, β-cryotoxanthin and canthaxanthin [20]. Each classified group of carotene has its own nature and produce some coloured compound and carries oxygenated hydrocarbons like atom, hydroxy, keto, epoxy, methoxy or carboxyl group. Carotenoids are responsible for various colours like red, orange, yellow, green etc. found in various source like plants, fruits, vegetables, flowers, insects, microbes like fungus and cyanobacteria where each possess different group of carotenoids [21]. It possess many beneficial values and carries medicinal properties too due to which it is widely used in food, nutraceutical andpharmaceutical industry [22].Carotenoids can be categorized into two classes based on their structure, one is xanthophyll which carries oxygen group in it and others are Antheraxanthin, Astaxanthin, Auroxanthin, Bixin, Canthaxanthinetc. Another one is carotenes which are purely of hydrocarbons and does not carry any oxygen group in it, some of them are α- carotene, β- Carotene, lycopene, phytoene, etc.These are the derivate of tetraterpenes, which contain isoprene molecule and 40 carbon atoms with the extensive conjugated double bond system and determines for the colour changes from yellow to orange and red [23].

EVOLUTION OF CAROTENOIDS

In the earliest twentieth century, the history of carotenoids has created a milestone. It is often stated that without carotenoids, the oxygenic atmosphere would not exist. The collection of carotenoids with the chlorophyll pigment help to protect the intricate and delicatephotosynthetic apparatus against destruction by photo oxidation. Nearly carotenoids pigments are many in numbers, they are best known for the health and some medicinal properties [24]. The isolation, separation and identification of carotenoid has expanded greatly with the advent of chromatography technique and some spectroscopy method which are widely used after they took first step in initiation of chromatographic technique (Tswett, 1906). Along with this the introduction of mass spectrometry in 1965 and high performance liquid chromatography (HPLC) in 1971 has took the first step in the chromatographic technique after which nearly 700 source of organism that possess the carotenoid pigment naturally were found out [25]. After the long term investigation with the carrot and crushed juice from carrot, which was found to be red in colour. Later in 1831 Wackenroder has described first carotene with the structure C40, the β carotene. From the autumn leaves the xanthophyll pigment was introduced by Berzelius in 1837. In the year 1843,Kraus and Millardet made the investigation on carotenoids from cyanobacteria. After the 30 years of investigation of Hartsen he isolated the lycopene from the fruits [26].

β – Carotene: It isone of the major group of carotenoids which possess the highest bioactivity of vitamin A and isomer of naturally occurring carotenoid which can be synthesised from both synthetic and natural origin source [27]. It tends to possess yellow to orange colour from source like microalgae, bacteria, cyanobacteria which are predominantly know to have anti-inflammatory, anti-diabetic, antitumor activity [28]. In some of dietary compounds where β – carotene are found to be rich are fruits and vegetables. It has the ability to protect the cornea against UV light. It also inhibits many onset of disease like cardiovascular, arteriosclerosis, cataracts etc. [29]. It is used intensely as a colouring agent in food industry with the E number (E160).

β- Cryptoxanthin: β- Cryptoxanthin belongs to carotenoid group. It is found rich in tangerines, persimmons and oranges etc. it is precursor of vitamin A and it is essential for eye sight, growth and development of immune response. It is found to be together with the α-carotene, β-carotene, lycopene, lutein and zeaxanthin. β-Cryptoxanthin is used as a colouring agent in some beverages and it is associated with the E number E161c [30].

Astaxanthin: Astaxanthin is a derivate of xanthophyll carotenoid. It consists of two terminal

ring joined by a polyene chain, this molecule has two asymmetric carbon located at 3, 3^ position of β- ionone ring with hydroxyl group at end of molecule. Astaxanthin is a lipophilic compound and it can dissolve in solvents and oils easily. It is responsible for red to pink colour pigment found mostly in various microorganism and marine animals. In the context of health benefits to human, it has anti-lipid peroxidation activity, anti-inflammatory activity, anti-diabetic activity and prevention of many cardiovascular diseases. Astaxanthin is used as a nutritional supplement in several products like tablets, capsules, syrups, oils, soft gels, creams, biomass and granulated powder. It is associated with the E number E161j [31].

Zeaaxanthin and lutein: Nearly 700 groups of carotenoids are found to be in nature, among that approximately 20-30% are identified in human blood and in tissue. Zeaaxanthin and lutein are one among them, even though they can be synthesised from plants and microorganism. In humans, they are found to be in retinal region of eye in the form of macular pigment. This macular region of retina that is responsible for fine feature of vision. These pigments does not possess any vitamin A activity, but plays a vital role in the prevention of AMD (Age related Macular Degeneration), this is one of the leading cause of blindness [32].

These pigments are found to be rich in human milk. It is also used as a colorant in nutraceutical market with the E number E161h for zeaaxanthin and for lutein it is E161b. Novel methodology has been developed for the production of these pigments in large scale level [25].

Lycopene: Lycopene is one of the derivate of the carotenoid family. It is insoluble in water due to the presence of lipophilic compound present in it and soluble in organic solvent, found in grape fruit, watermelon, and pitanga and red flesh papaya. Unlike β- carotene, it does not possess any provitamin activity. Lycopene has got his attracted attention towards its biological and physiochemical properties. Lycopene is responsible for the production of red coloured compound, the major bioactivity of lycopene is found in fresh tomato and processed tomato based products. It also protect against the formation of certain cancer like prostate, bladder, cervical, leukaemia and can reduce cholesterol levels in the body [33]. In the case of prostate cancer, lycopene is considered as one of the protective agents. Nearly 85% of lycopene is present in tomato. It can also be considered for direct consumption. In processed food it has been found mainly in the form of cis-isomer [34].

ISOLATION OF CAROTENOIDS:

Carotenoids are naturally occurring brightly coloured pigments extracted from marine origin, animal, plants etc. The identification of all carotenoid can be observed in a range of photosynthetic organism. For the identification valuable carotenoids, chromatographic technique and UV light absorption spectra, mass spectra, nuclear magnetic resonance spectra are widely used. Normally carotenoids have spectroscopic properties and have the double bond system which constitutes the light absorbing chromophore. It is sensitive to oxygen, light, heat, acids and alkali. Some precautions must be taken to avoid or minimise the losses of material because it leads to unwanted structural change. Due to their sensitivity nature for the extraction and purification process HPLC and other analytical methods are followed. The strong colour of carotenoids can mask the presence of substantial amounts of colourless contaminants which are not detected during the normal spectrophotometric assay of carotenoids but will render useless any mass spectrometry (MS), NMR analysis, etc. [35].

CHEMICAL STUDIES ON CAROTENOIDS:

After some years, later August Husemann (1833-1877) took up the study on carotenoids and finally recognised that carotene are unsaturated compound, and it is prepared as a halogenated derivative, partially insoluble in carbon disulphide and benzene and it is readily soluble in alcohol and ether. Albert Léon Arnaud (1853-1915) stated that carotene is a hydrocarbon. Arnaud dealt analysis of the sample of carotene from the carrot extract and indicated the presence of carbon and hydrogen and by his calculation he proposed the formula $C_{26}H_{38}$ [36]. He also developed the colorimeter method for the determination of carotene compound in the various sources, the 30 different compounds from the plant origin. The carotene compound can be found in the world of fruits and vegetables, seeds, maize, pulps of fruits viz., tomato, mango, orange etc., and in variety of flowers like stamina and petals of flowers.

SOURCES OF CAROTENOIDS

The most bioavailability of carotenoid compound are widespread as a lipid soluble pigment and are present in leaves, fruits, vegetables, flowers, roots,

seeds and also in concentrated fatty tissue like egg yolk in terrestrial animal. Likewise in fish they are found in the form of fat or in form of flesh. The large variety of carotenoids are also present in algae, bacteria, fungi are some of the natural source of carotenoids to be found [37].

Fruits and Vegetables: The carotenoids are found naturally in fruits and vegetable, each possess some different group of carotenoid and their major availability is in fruits and vegetables which is responsible for producing some coloured compounds like yellow to orange, bright red colour, and some in green leafy vegetables. Each class of carotenoid carries its medicinal value and profit to human health [38].

The some of the compounds are β carotene which are rich source in Avocado, cucumber, spinach, kale, broccoli, snow pea, zucchini, artichoke, mango, papaya, peaches, guava, lettuce, and kiwi. α-cryptoxanthin and zeinoxanthin are found in some of orange fruits viz., mandarin, orange, and papaya. Lycopene pigment responsible for bright red colour is one of the major group of carotene used widely in food industry and carries the anti-cancer activity which possess the bright red colour generally found in tomatoes and tomato-based products [39]. Lutein is a type of derived compound from violaxanthin and neoxanthin, which are found in green leafy vegetables like eggplant, blackberry, purple, cabbage, plum, blueberry, raisins, prunes, purple grapes, figs etc. Among 25 common leafy vegetables, amaranthus, fenugreek, tomato, spinach, pumpkinhave the highest content of β-carotene. These carotenes are widely used in food industry as a colouring agent in food and nutraceutical industry [40].

Carotenoids from Flowers: Carotenoids are found in all parts like leaf, roots, seed, and bark. They also can be noticed in flowers. The colour pigments are noticed in many yellow, orange, red coloured flowers. These coloured pigment are found in day lily (*Hemerocallis disticha*), Californian yellow poppy (*Eschscholtzia californica*) and Calendula products *Sandersonia aurantiaca*, Calendula (*Calendula officinalis L*) (sanae kishimoto, Takashi maoka, katsuhiko sumitomo & akemi ohmiya et al).Rosa damascena Mill (Rosaceae) is widely cultivated as ornamental plant and it is has blood purifying properties [41]. These extracted coloured compounds are used in cosmetic products and food products. These pigments are extracted, separated, identified and quantified for their potential use and used as low cost source in food products in food industry [42].

CAROTENOIDS FROM MICROBE: In recent development, the extraction of colour from microbial pigment has been developed, the production process is independent to environmental condition and it is cheaper. Large number of microbes like bacteria, yeast, mold and algae are used for the extraction of coloured pigment and these pigments are used as a food colorant [43]. Some of the microbes that produce natural pigments are bacteria like *Serratia marcescens*, *Agrobacteriumtumefaciens, Chromobacter violaceum etc.* yeast, which can be found in air, ocean, water, milk fruit juices it produce nearly pink to red colonies some of them are *Phaffia rhodozyma, Rhodotorula acheniorum, Rhodosporidium,Sporidiobolus, Sporobolomyces ruberrimus, Sporobolomyces shibatanus, Sporobolomyces roseus.*Mold like *Blakeslea trispora, Phycomyces, blakesleeanus.* Some examples for algae are *Dunaliella salina, Dunaliella bardawil, Dunaliella tertiolecta, Spirulina platensis, Chrysophycea.* [44].

Extraction of Carotenoids from Marine Source: The industrial exposure to bio production of carotenoid has been expanding commercially. For the production and extraction of various carotenoid from marine source are still under development. It increases the production cost on the large scale level. So the recovery of carotenoids by using conventional methods are followed by using any organic solvents or vegetal oils or some fluid for extraction process. Some of the example for the extraction process are carotenoids were extraction from *Micrococcusluteus*and*Rhodotorulaglutinis* followed by the enzymatic method or mechanical treatment. Thepigments extracted from lobster, shrimp and crab shells were taken and these samples are added along with the soybean oil and treatment was followed by using centrifugation process and the pigments were obtained. Among these extraction and treatment methods, the red lobster (*Panulirus argus*) showed the highest concentration of astaxanthin (7.73mg/100g) when compared to the green lobster (*Panulirus laevicauda*). Likewise the maximum carotenoid extracted from *R. sphaeroids* showed the best result [45].

CAROTENOIDS: A RICH ANTIOXIDANT

Carotenoids are the variety of biological mixture that are major source of anti-oxidant which are found mostly in all naturally available food items

[46]. Some epidemiological evidence shows that β – carotene can inhibit many diseases and it is rich in free radical scavenging activity [47].

For the various chronic and degenerative diseases, free radicals are the major cause. It includes diabetes mellitus, inflammation, stroke, cancer, coronary heart disease and ageing [48]. Carotenoids have the ability to protect intact cells against oxidant induced lipid peroxidation and it has the pro vitamin A activity which is rich in β carotene. It scavenges peroxy radicals at low oxygen tension [49]. Due to their structure and vitamin A, carotenoids can auto-oxidise with oxygen and increase the oxygen tension and thus act as most effective antioxidant. Carotenoids are chemical quenchers, they are effective in scavenging of Reactive Oxygen Species (ROS) and free radicals are protected against oxidative damage to photosynthetic and non-photosynthetic organism [50]. Due to the rich source of anti-oxidant present in carotenoids, it seems to be effective against high blood pressure, impaired glucose and lipid profile, LDL-C oxidation, monocyte and smooth muscle cell activity [51]. For the clinical use of carotenoids, β carotene is taken into account as more effective and has been applied to secondary effect of hereditary photosensitivity disorder of erythropoietin protoporphyria. This type of damaging agent is responsible for the skin lesions observed in diseases [52].

BENEFITS OF CAROTENOIDS:

There are nearly about 600 different research works on the effect of carotenoids on the human health. The few connection between the consumption of carotenoids to the human health says that i) these pigments are powerful antioxidant and could possess antitumor activity. ii) Certain carotenoid exist with high rate of provitamin A activity. iii) Several carotenoids demonstrate regulatory activities at several tissues. The major beneficial effect of carotenoids to the human health is described with the cell lines or animal model studies. [53] Now with the development of marine-based functional food, it has increased its beneficial effect to human health and nutraceuticals in the food industry. The processed food products like marine based products are now rich with nutritional content along with the health benefit and some dietary compounds in them. They have included some bioactive compound like antioxidant, peptide, carbohydrate and lipid etc. They also developed some health promoting foods or functional foods which are rich in bioactive compound and are effective against some diseases. These functional foods have some advantage like physiological benefit and reduce the risk of chronic diseases, prevention and treatment of some diseases like anaemia. In the consideration of health benefits to foods, the natural pigments like various coloured compounds, the bioavailability of carotenoids are all incorporated into food, to improve the nutritional quality of the food and awareness to the consumers about the processed food products [54].

VITAMIN A ACTIVITY

β carotene is an important and major source of the pro-vitamin in body which converts into vitamin A. These β carotene are found to be in most fruits and vegetables. The two carotenoids are α carotene and β carotene which constitutes nearly 5-30% of β carotene in vegetables. It has the enzymatic defence system involved in reducing effect of oxidative damage [40].

CAROTENOIDS AND IMMUNE SYSTEM:

Recent studies demonstrated that carotenoids active in immune response**.** The β- carotene has the immune response in cell mediated and humoral immune response in animals and humans.The number of lymphoid cells with surface markers for NK cells and for IL-2 and transferrin receptors also was increased substantially in peripheral blood mononuclear cells (PBMC) from individuals supplemented with β-carotene. Enhanced NK cell cytotoxicity was observed in human subjects given oral β-carotene. Similarly, long-term β-carotene supplementation to elderly but not middle-age men increased NK cell activity. It enhance the natural killer cells activity in humans at the age of 65 to 85 years.The immune-regulatory action of carotenoids has also been demonstrated through their role in tumour immunity. The antitumor activity of astaxanthin against the growth of a fibro sarcoma cell also identified [55].

ACTION OF CAROTENE ON CANCER

Carotene are one primary anticancer agent in fruits and vegetables. Many pharmacological studies have concluded that carotenoid rich fruits and vegetables are associated with decrease risk of cancer. The effect of β carotene helps to neutralize free radicals [56]. In lung cancer, the epidemiological studies showed that β carotene is a pro-oxidant rather than antioxidant. The consumption of wide variety of β carotene rich fruits and vegetables has the greater bearing of

prevention of lung cancer [57]. The lycopene is associated with the reduced risk of breast cancer by the inhibition of cell cycle in G1 phase. The dietary consumption of lycopene protect against the prostate cancer and reduce the oxidative DNA damage. Carotenoids such as lycopene, zeaxanthan and β -cyotoxantam were associated with the reduce risk of colorectal cancer [58].

SKIN PROTECTION

Carotenoids has the protective effect against ultra violet (UV) irradiation, when skin is expose to photo- oxidative damage induced by ROS. The photo oxidation damage affects cellular lipids, proteins, primitive aging of skin, photodemastose and skin cancer. Carotenoids are effective in scavenging of ROS. The carotenoids and tocophenols prevent UV light induced skin lesions and protect against skin cancer [59].

VISION

β carotene, β cryptoxanthin, lycopene, zeaxanthin and lutein are the major classified group of carotenoids. The zeaxanthin and lutein are found in the eye macula that absorbs blue light and diminish pernicious photo-oxidative effects which occur due to the extra blue light and decreasing eye chromatic aberration. Carotenoids have ability to protect eye fromphotochemical reactions and UV irradiation. The non-polar carotenoids like β-carotene and lycopene has the capability to protect the membrane structure in eye photoreceptors [60].

Role of carotenoids in macula:

Based on the structure of carotenoid Lutein and zeaxanthin are derivate of xanthophyll. This compound is accumulated in eye as a retinal macular pigment, which helps in improving vision and protect against damaging effect of light. The deity intake of these carotenoids will prevent in Age-Related Macular Degeneration (AMD) [61]. The three important dietary carotenoids like β-carotene, lycopene, and lutein plays a vital role in retinal pigment epithelial cells. But lutein and lycopene helps in the inhibition of undifferentiated ARPE cells. The macula carotenoid has a functional role in photosynthetic process in higher plants [62].

Physiochemical methods:

Carotenoid extraction from plant material and other natural source are obtained by the physicochemical process. The choosing of raw material is one important criteria for the physiochemical method of extraction. In plants it can be easily obtained from chlorophyll pigment, while in fruits and vegetables it is difficult, so it can be followed by the various physical means of extraction method likepurification and material shredding operations, juice pressing, protein coagulation, sedimentation, centrifugation and extraction with organic solvent, filtration, deodorization, evaporation, and crystallization. In some cases, depending upon the raw material it can be taken for fermentation, drying or defragmentation for the extraction of carotenoid compounds [36].

PLANT MATERIAL	EXTRACTION METHOD	SOLVENT
Carrot	Acetone, methyl, ethyl	Fat
Alfalfa	Ketone, methanol, ethanol	Hexane
Grass	Propane hexane	Fat
Urtica	Dichloromethane, carbon dioxide	-

CAROTENOID AS A COLOURANT

Carotenoids are usually tend to possess a lipophilic character and have poor solubility, due to which special formulation had to be taken for the use of as a colorant. Nearly 20% to 30% it can be formulated in the form of microcrystals, especially carotenoids are used as a colouring margarine in many cosmetic industry. The other form is water disposable one which account to nearly 10% of it, which is used in the preparation of carbonated orange drinks, candies, ice-cream, jellies, etc. similarly, preparations of Apo carotenoids and of canthaxanthin find more and more use as feed additives for improving and standardizing the colour of egg yolk and poultry meat. The colour range of aqueous solutions obtainable with carotenoids varies from a greenish yellow to a deep bluish red. The colour of the oily solutions is in most cases identical with the one obtained in organic solvents while the corresponding aqueous solutions can differ considerably from it [63].

APPLICATION OF CAROTENOIDS IN FOOD INDUSTRY

Carotenoids are used as a one of part of ingredient in food industry.Normally the functional foods have high melting point, and they form crystal during the storage. Due to which carotenoid as a food additive are unpredictable in food because they are not stable and found to be sensitive to light, oxygen and in auto-oxidation. To overcome these kind of problem carotenoids are

carried out in encapsulation form, in which the prospect production of carotenoid are in the form of food fortification and supplementations [64]. Due to the health concern and carotenoid as a colouring agent, the most required valuable carotenoid are Beta-carotene, astaxanthin, canthaxanthin, lycopene, and lutein. They are widely used as food, feed and in cosmetic industry. The production of red koji dates and the fermented rice by monascus are typically red in colour. These pigments are used as a colorant in wine, red soy, cheese, meat and by products of meat and fish. For the use of nutraceutical foods and prevention of some diseases the bioactive compounds from the carotenoids are used which possess the antioxidant power in cell protection against free radicals [65].

CONTRIBUTIONS FROM INDIA TO REDUCE ARTIFICAL FOOD COLOUR

The usage of synthetic food colour are changing in India. The maximum level of synthetic food colours that are permitted till 200ppm. The goal for reducing the synthetic food colour should take into account by reducing the total exposure to colour, data analysis on dietary intake of food colours. The consumer's role is to reduce the exposure on food colour by demanding food stuffs which are free of artificial colours. The artificial food colours that are widely used in food industry are carmoisine, poneau 4R, indigo carmine, brilliant blue FCF, fast green FCF, tartrazine and sunset yellow FCF with permitted usage levels as of 200ppm maximum, but recently they have reduced to 100ppm. According to the PFA (Prevention of Food Adulteration Act), the ingredients and colour that are incorporated in food should be prescribed on the label to bring the knowledge to the consumers. After which the surveillance shows that usage of unpermitted synthetic food colour like textile and industrial dye has be reduced. The non-permitted synthetic dye like metanil yellow, lead chromate, Rhoda mine etc., constitute a threat as public health hazard [66].

Some of the food products containing ingredients or colour which are not permitted under PFA act in India are request to follow the food laws and regulation and use of permitted food colour and additive to the packed food products. The traders are showing more interest on importing ready to eat food stuffs with artificial colour in it, again the Government's economic policy and has conducted a study on confectionery items that are available in the market. The studies show that synthetic colours like fast red, amaranth and allura red were used but not permitted under the Rule 29 of PFA act. It is justified that Indian law incorporated standard suggested by Codex Alimentarius and World Trade Organisation are to enforce more on the stringent laws on addition of colours to food and should revise the foods to which colours may be added [67].

II. Conclusion

Artificial food colours are added to draw the attention of the consumers in the production of soft drinks, confectionery, canned and vegetable products; however, the usage of artificial additives provide several adverse effects to human health [68]. The present study has proved that using carotenoid as the natural additive or colouring agent is beneficial. The field of carotenoid metabolic activity are engineered to improve the nutritive quality [69]which is rich in antioxidants, colourings, flavourings and preservatives. They have played an important role in reducing serious nutritional deficiencies among consumers. These ingredients also help ensure the availability of flavourful, nutritious, safe, convenient, colourful, attractive sources at affordable cost without any health complications [70].

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